

MetAMINO® ATLAS

EDITION 3

Unlock
the power
of ...

65

Executive Summary

23 Trials. 10 Countries. 5 Continents. One Consistent Conclusion.

The MetAMINO® ATLAS Edition 3.0 summarizes results from 23 scientific and commercial trials across a wide range of species, production systems, nutritional specifications and geographies. The data consistently confirmed the higher nutritional efficiency of DL-methionine (MetAMINO®) and

validated the long-standing recommendation that 100 parts of MHA-FA or MHA-Ca can be replaced by 65 parts of DL-methionine without compromising animal performance, providing an opportunity to optimize feed cost and formulation efficiency.

SCIENTIFIC EVIDENCE BEYOND PERFORMANCE

Edition 3.0 goes beyond traditional performance trials by including a unique study using radiolabelled DL-methionine and MHA-Ca in Nile tilapia. The study demonstrated that in contrast to MHA-Ca, DL-methionine is:

- absorbed faster,
- incorporated more efficiently into body protein,
- associated with higher nitrogen retention,
- less subject to catabolism or excretion.

These findings provide direct evidence of the lower efficacy observed for MHA products. The physiological reasons are further explained in the video “Comparing the biological efficacy of DL-methionine and liquid MHA-FA”. The video illustrates how differences in intestinal transport, microbial degradation, oligomer utilization and metabolic conversion lead to a lower biological availability of MHA-FA, supporting the practical replacement ratio of 100 parts MHA-FA with 65 parts DL-Methionine.

As a result, nutritionists can achieve the same animal performance with 35% less methionine consumption while enabling more cost-effective feed formulations. For product handling, this means that only 65% of the volume needs to be managed when using DL-methionine compared to MHA products.

CUT LOADS WITH 65



.....
Watch the bioefficacy video
<https://evonik.click/metamino-65/bioefficacy>
.....

SUSTAINABILITY ADVANTAGES



CUT CO₂ WITH 65

MetAMINO® enables low crude protein feeding strategies capable of reducing: Greenhouse gas emissions by up to 18%, Eutrophication by up to 53%, Land-use impact by up to 16%. At the same time MetAMINO® carbon footprint is only 2.89 kg CO₂e/kg product, approximately 35% below industry average.

ECONOMIC IMPACT

Cost savings achieved by replacing MHA products with DL-methionine result from:

1. Immediate savings from correct replacement ratio

Validation of the correct bioefficacy value translated into measurable financial benefits:

- Up to **USD 567,000 annual savings** in large Peruvian broiler integrations (Trial no. 13)
- Up to **\$ 1.00 additional income per pig** in commercial USA swine production (Trial no. 8)
- **Lower methionine inclusion rates and lower feed costs** across the 23 trials, independent of the species, gender, feed specification and trial conditions.
- Direct MHA substitution with DL-Met **reduced feed cost by € 1,00/t – 3,00/t** in multiple trials.

2. Additional savings through amino acid re-optimization

Many formulations using MHA-products assume a higher bioefficacy (typically 78-88%), which can lead to an overestimation of dietary Met+Cys levels and so not only SID Lysine specifications can be reduced but other essential amino acids (Thr, Val, Ile, Arg, etc.) can also be reduced in line with the Ideal Protein concept leading to further potential savings opportunities (source: Lemme and Han, AMINONews: BE-An advanced approach, July 2026; see page 64):

CUT COSTS WITH 65



- This represents ~ **€ 7/t additional savings beyond product replacement** + direct MHA-products → DL-Met substitution reduced feed cost by ~**€2.34/t feed**
- The additional savings are independent of pricing of MHA-products and DL-Met
- Combining DL-Met replacement with a realistic amino acid adjustment (50% of theoretical potential) increased savings to **€ 9.31/t (!) feed**.

CONCLUSION

Across 23 trials and multiple species, MetAMINO® ATLAS Edition 3.0 further strengthens the scientific and commercial evidence that DL-methionine is the benchmark

methionine source. The repeated confirmation of the **65% bioefficacy concept** cuts costs, loads and CO₂ after switching to DL-methionine.



Dr. Dirk Höhler

Head of Product Line Essential Nutrition



Dr. Andreas Lemme

Global Senior Expert Poultry



Nils Niedner

Director Product Management MetAMINO®

Content

Executive Summary 2

Section 1

Trials	5
Highlights	6
Overview	7
Europe	8
North, Central and South America	22
Asia Pacific	38

Section 2

Articles & Abstracts	60
Articles	61
MetAMINO® Calculator	63
Abstracts	64
Sustainability	74



.....
Discover more online

The digital MetAMINO® ATLAS provides access to the full collection of trial data, publications, scientific resources and the MetAMINO® Calculator.

<https://evonik.click/metamino-atlas>

.....

Unlock
the power
of...

65

Section 1

Trials



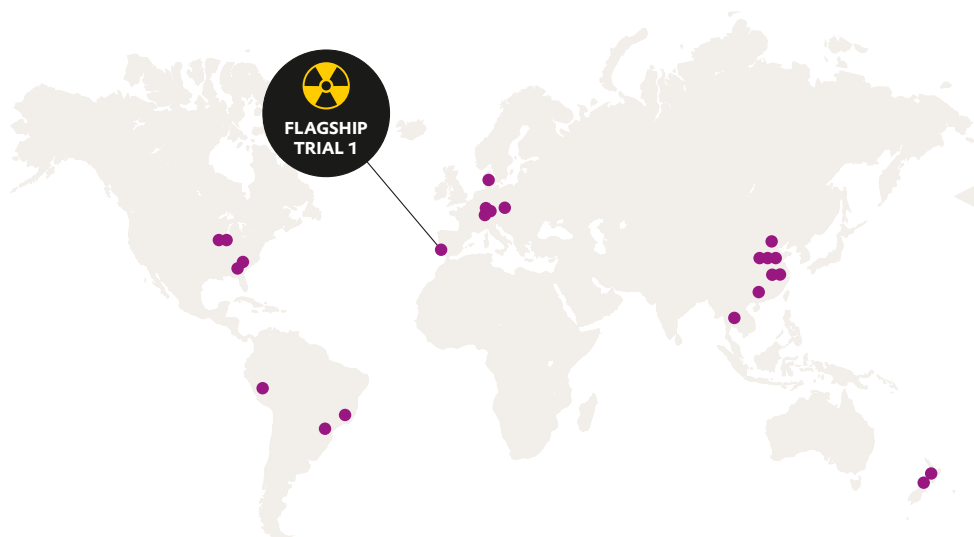
Highlights

23 Trials. 10 Countries. 5 Continents. One Consistent Conclusion.

The MetAMINO® ATLAS Edition 3.0 provides a comprehensive overview of 23 scientific and commercial trials, conducted in broiler (white and yellow broiler, slow growing broiler, broiler breeder, male and female, Ross 308, Ross 708, Cobb 500, Ranger Classic), ducks, swine, aquaculture and black soldier fly larvae.

The trials were conducted around the world in Europe, North and South America, Asia-Pacific and Oceania.

The studies demonstrated that equivalent growth performance, feed conversion, body weight, carcass yield, reproduction, nitrogen retention and nutrient utilization were achieved, confirming the practical applicability of the 65% concept.



Portugal, Czech Republic, 3x Germany, Denmark, 4x USA, 2x Brazil, Peru, 2x New Zealand, Thailand, 7x China

23
performance trials



16 broiler



2 duck



2 swine



1 aqua



2 BSF



Conducted on

5 continents

10 countries

Key Takeaways

- A unique study using radiolabelled tracer demonstrated superior absorption and metabolic utilization of DL-methionine compared to MHA-Ca.
- Repeated validation of the 65% bioefficacy of MHA products relative to DL-methionine demonstrates that producers can reduce logistics requirements, lower methionine inclusion rates, and achieve significant feed cost savings without compromising animal performance when switching to MetAMINO®.
- Research suggests a considerable additional feed cost saving potential by adjusting the entire amino acid nutrition concept after replacing MHA-products with DL-Met in a 100:65 weight ratio.
- PROXYMet™ (a product containing 65% DL-methionine diluted with an inert carrier) trials confirmed the practical validity of the 65% concept under field conditions.
- MetAMINO® combines nutritional performance with industry-leading sustainability credentials.

For practical feed formulation and purchasing decisions, these differences in nutritional value should be reflected in formulation matrixes, feed cost calculations and raw material purchasing strategies.

Overview

Performance trials comparing the nutritional value of MetAMINO® (DL-methionine) or PROXYMet™ with MHA-FA/Ca

EUROPE

- 1 **Portugal** / Response to different methionine source in Nile tilapia
- 2 **Czech Republic** / MHA-FA vs. DL-Met at various protein levels in broilers
- 3 **Germany** / Methionine supplementation in slow growing broilers
- 4 **Germany** / Methionine supplementation in black soldier fly larvae production
- 5 **Germany** / DL-Met vs. MHA-FA in black soldier fly larvae nutrition
- 6 **Denmark** / Use of methionine sources in black soldier fly larvae production

NORTH, CENTRAL AND SOUTH AMERICA

- 7 **USA** / Nitrogen retention in pigs
- 8 **USA** / Growth and carcass quality in pigs
- 9 **USA** / Broiler breeder flocks
- 10 **USA** / Effects of Met+Cys:Lys ratio and methionine sources on broiler performance
- 11 **Brazil** / Relative bioavailability for growth performance in male broilers
- 12 **Brazil** / Bioefficacy comparison of MHA-FA and DL-Met in broilers
- 13 **Peru** / Growth performance at different Met+Cys levels in male broilers

ASIA PACIFIC

- 14 **Oceania** / Performance responses of male broilers – PROXYMet™ vs. MHA-FA
- 15 **Oceania** / Performance responses of female broilers – PROXYMet™ vs. MHA-FA
- 16 **Thailand** / Bioefficacy of different methionine sources in male and female broilers
- 17 **China, Anhui** / Effects of PROXYMet™ replacing MHA-FA in white broilers
- 18 **China, Anhui** / Growth and slaughter parameters of Cherry Valley ducks
- 19 **China, Guangdong** / Growth performance and slaughter parameters of yellow broilers
- 20 **China, Hebei** / Effects of PROXYMet™ replacing MHA-FA in Peking ducks
- 21 **China, Shandong** / Growth performance of white broilers
- 22 **China, Shandong** / Equal growth with PROXYMet™ in broilers
- 23 **China, Shandong** / Broiler performance test with PROXYMet™



Europe

- 1 **Portugal** / Response to different methionine source in Nile tilapia
- 2 **Czech Republic** / MHA-FA vs. DL-Met at various protein levels in broilers
- 3 **Germany** / Methionine supplementation in slow growing broilers
- 4 **Germany** / Methionine supplementation in black soldier fly larvae production
- 5 **Germany** / DL-Met vs. MHA-FA in black soldier fly larvae nutrition
- 6 **Denmark** / Use of methionine sources in black soldier fly larvae production

Radiolabelled DL-Met and MHA-Ca to elucidate the metabolic and nutritional response of two commercial methionine sources in Nile tilapia juveniles

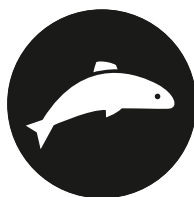
The trial was conducted by the Centre of Marine Sciences of Algarve (CCMAR), Portugal, in indoor tanks using radiolabeled DL-methionine (DLM) and methionine-hydroxy-analogue calcium salt (MHA-Ca)

Published in: *British Journal of Nutrition*, 2022; 127(2): 202–213. “Metabolic and nutritional responses of Nile tilapia juveniles to dietary methionine sources” ; *Fish Farming Technology: International Aqua Feed*, October 2021. “Growth and metabolic response of juvenile Nile tilapia demonstrate DL-Methionine is superior to MHA-Ca” ; *Evonik Animal Nutrition Aquaculture Facts & Figures* #1644

TRIAL 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
Centre of Marine Sciences
of Algarve (CCMAR),
Portugal



Project team leaders:
Karthik Masagounder¹,
Sofia Engrola²,
Rita Teodósio^{2,3},
Miguel Cabano², Rita Colen²
and Cláudia Aragão^{2,3}

TABLE 1: Trial I design: Performance response of Nile tilapia to methionine sources

Animals	Nile tilapia, 2.30 g initial body weight ; 50 fish per replicate tank
Design	3 tanks (100 L) per diet; 50 fish per tank
Diets	Basal: Diet without supplemental Met DLM: Basal + 1.5 g/kg DL-Met MHA: Basal + 1.8 g/kg MHA-Ca (equal to DL-Met dose on a molar basis)
Feeding	Three times a day over a 57-days period
Parameters	Final body weight, total body weight gain of all fish (biomass gain) per tank, Feed conversion ratio (FCR), protein efficiency ratio, nitrogen gain and nitrogen loss
Duration	57 days

TABLE 2: Trial II design: Metabolic response of Nile tilapia to labelled methionine sources

Animals	Nile tilapia, 25–28 g
Design	At end of 57-d feeding trial, 10 or 11 fish from each tank were transferred to individual metabolic chambers (2-L water) (n=31 fish for DLM; n=32 fish for MHA)
Diets	DLM: Basal + ¹⁴ C-DL-Met MHA: Basal + ¹⁴ C-MHA-Ca
Feeding	Individually fed with Met labelled feed
Parameters	1, 2, 3, 4 or 6 h post-feeding (n = 6–7 fish for each diet and period), fish were euthanized, and radioactivity (DPM, disintegrations per minute) of labelled Met source in the water and different body parts were measured.

¹ Evonik Operations GmbH, Hanau-Wolfgang, Germany

² Centre of Marine Sciences (CCMAR), Faro, Portugal

³ Universidade do Algarve, Faro, Portugal

FIGURE 1: Radioactivity of labelled Met source as a part of protein fraction detected (DPM) in different body parts at 6-h post feeding

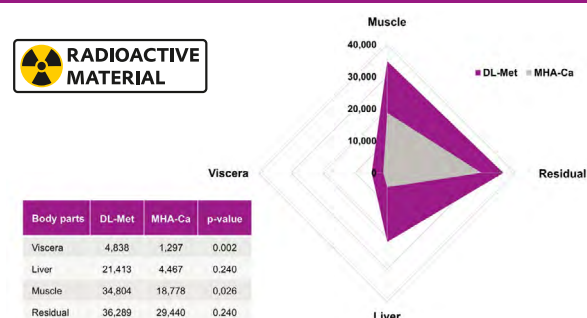


FIGURE 2: Radioactivity (DPM/g fish) of free labelled Met in muscle at 1–6 h post-feeding

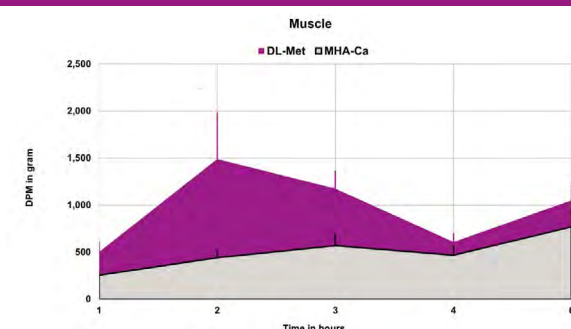
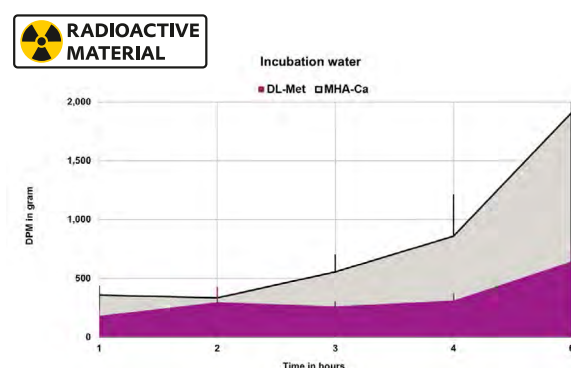


FIGURE 3: Radioactivity (DPM/g fish) of labelled Met in incubation water over 6 h



Trial Objectives

Trial I – Performance response:

Evaluates how Met sources (DLM vs. MHA-Ca) affect growth performance, feed conversion and nitrogen utilization of Nile tilapia when supplemented on an equimolar basis

Trial II – Metabolic response:

Elucidates metabolic utilization of Met sources on the fish body protein synthesis based on ^{14}C -labelled Met sources.

Trial Results

TRIAL I: Performance response of Nile tilapia to Met sources

- DLM diet significantly improved growth, FCR, and protein efficiency ratio compared to the basal diet. MHA diet showed only numerical improvements in performance, with no significant difference from the basal treatment.
- Calculated on total fish weight gain per tank, the DLM diet produced 214 g more biomass gain whereas the MHA diet produced only 124 g more biomass gain, both compared to the basal diet. Thus, the MHA diet produced 42% less biomass gain than the DLM diet when compared with the basal treatment.

Parameters	Basal	DL-Met	MHA-Ca
Final body weight (g)	24.1b	28.3a	24.8b
Biomass gain (total fish weight gain, g / tank)	928	1,142	1,052
Feed conversion ratio (kg feed / kg gain)	1.00a	0.92b	0.93ab
Protein efficiency ratio (g BW gain / g intake)	3.07a	3.36b	3.34ab
N gain (mgN / kg / d)	657b	726a	660b
N loss (mgN / kg / d)	815a	667b	722ab

a,b = Means were considered significant at $p < 0.05$, ANOVA and separated by Tukey's HSD

- DLM diet exhibited the highest daily nitrogen gain (726 mg N/kg/day) and the lowest nitrogen loss (667 mg N/kg/day), both significantly better than the basal diet ($p < 0.05$).

- MHA diet did not significantly improve nitrogen utilization compared to the basal diet and showed lower nitrogen gain compared to the DLM diet.
- The DLM diet showed significant improvement in growth, feed conversion ratio (FCR) and protein efficiency ratio relative to the basal diet. The MHA diet did not differ from the basal diet and showed numerical improvements in the performances.
- Overall the DLM diet produced better results relative to the basal and MHA diets demonstrating that DL-Met is the more effective methionine source for tilapia relative to MHA on an equimolar basis.

TRIAL II: Metabolic response of Nile tilapia to labelled Met sources

- The amount of radioactivity (disintegrations per minute; DPM) present in the incubation (Figure 3) water and different parts of fish (muscle, liver, viscera, and other parts) was determined (Figure 1).
- In fish fed the DLM diet, the tracer was available to the Residual Free fraction (Free fractions in head, heart, kidney, bones and fins) faster than in MHA fed fish. Moreover, for the 6 h trial, the cumulative Met source bioavailability in Residual compartment was higher in DLM than in MHA fed fish.
- At the end of the incubation period (six hours) a significantly higher amount of tracer was determined in the viscera and muscle protein fractions (Figure 3) from DLM fed fish as well as in their livers and residual tissues (Figure 1 and 2; $p < 0.05$). This indicates a higher bioavailability of DLM compared with MHA when fed on equimolar basis.
- MHA fed fish showed 2.4 times higher area under the curve relative to DLM fed fish for the incubation water. Higher amount of radioactivity present in the incubation water for the MHA fed fish indicates more MHA was evacuated (non-absorbed) and/or catabolized., elucidating why MHA was less deposited in the muscle compared with DLM (Figure 3).
- In sum, more DLM was available in the muscle and different body parts for protein synthesis, and less DLM was catabolized or excreted compared with MHA.

CONCLUSION

The study demonstrated that DL-methionine (DLM) is a more efficient methionine source than methionine hydroxy analogue calcium salt (MHA-Ca) for Nile tilapia, showing superior outcomes in growth, feed efficiency, nitrogen utilization, and body protein synthesis. The radiolabeled Met study further confirmed that MetAMINO® (DLM) is more effectively incorporated into body protein, namely the liver, viscera, muscle, head, heart, kidney, bones and fins, compared to the MHA product, whereas a greater proportion of MHA-Ca was catabolized and excreted into the water.

FEEDBACK

"DLM is a more efficient methionine source than MHA for Nile tilapia, showing superior outcomes in growth, feed efficiency, nitrogen utilization, and body protein synthesis, while MHA-Ca showed higher catabolism, indicating less metabolic efficiency."



Dr. Karthik Masagounder,
Aqua Expert and
Regulatory Trial Manager
Evonik Operations GmbH,
Germany

Effects of replacing liquid methionine hydroxy analogue (MHA-FA) with DL-methionine at various protein levels in broilers

Trial conducted by Poultry Testing Station, Czech Republic

Published at: 24th European Symposium on Poultry Nutrition, Maastricht, The Netherlands, 23-25 June 2025, abstract #PS3-251 and as Evonik Facts & Figures 15215.

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

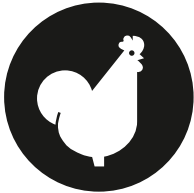
21

22

23



Trial location:
Poultry Testing Station,
Ustrasice, Czech Republic



Project team leaders:
Dr. Andreas Lemme, Jan Tyl,
Hana Kozeluhova

TABLE 1: Trial Design, Methods and Materials

Animals	5,880 mixed-sex Ross 308 broiler chicken (43.1g/chick); 140 birds per floor pen, 42 pens
Design	2 x 3 factorial feeding trial plus negative control
Housing	Floor pens, 8.15 m ² , wood shavings as bedding
Diets	Corn, wheat, soybean and rapeseed meal-based diets according to AMINOChick® - In corresponding treatments, DL-methionine (DL-Met) was supplemented 65% as much as MHA-FA on weight basis. - Diets of the negative control (Treatment 1) were formulated to meet AMINOChick® 3.1 specifications except for standardized ileal digestible (SID) Met+Cys as neither DL-Met nor MHA-FA was supplemented. - The negative control was supplemented with either DL-Met or MHA-FA to meet recommendations. - In additional treatments, the SID Lys and entire essential amino acid profile (balanced protein, BP) was increased by 10 or 20% in the grower and finisher feeds. These diets were also supplemented with either product.
Feeding	Pelleted feed; ad libitum; 3 phases: 1-10, 11-24, 25-35 days
Parameters	Body weight gain, feed per gain, productivity index, breast meat yield
Duration	35 days

FIGURE 1: Overall weight gain of Ross broilers

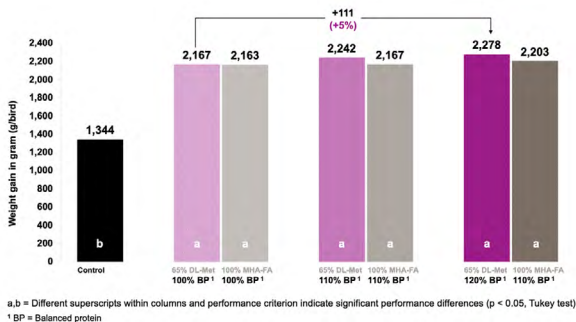


FIGURE 2: Feed per gain of Ross broilers

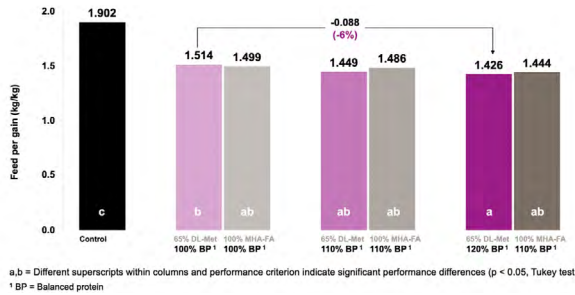


FIGURE 3: Breast meat yield of Ross broilers

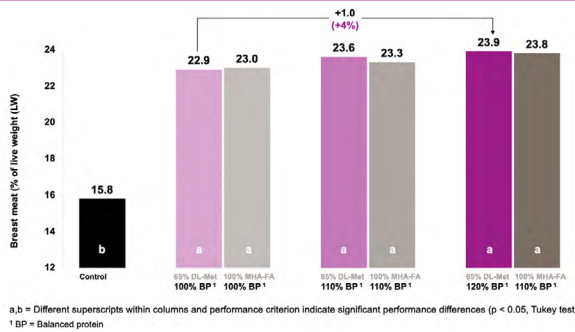


FIGURE 4: Productivity index (final body weight, kg * survival, %) / (FCR, kg/kg * final age, d)

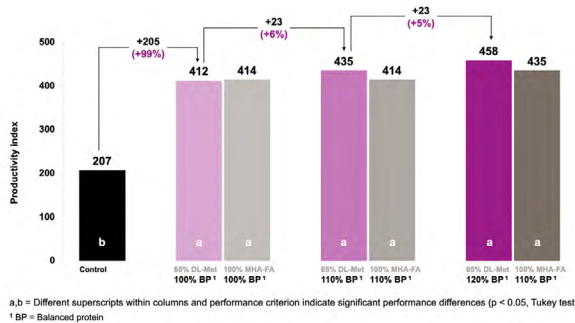
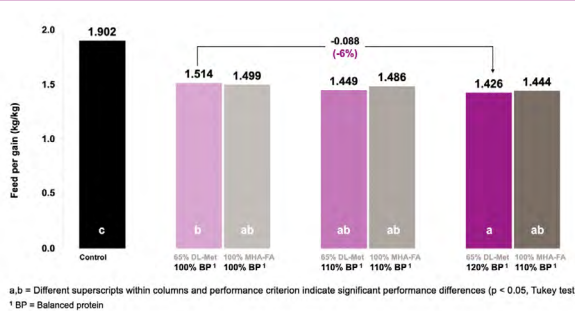


FIGURE 5: Product costs per bird



Trial Objectives

The objective of this study was to evaluate the effects of replacing MHA-FA with DL-Met in a 100:65 weight ratio at different balanced protein levels.

Trial Results

- Broiler performance was significantly impaired without supplementation of MHA-FA or DL-methionine (DL-Met, *Figures 1, 2, 3, 4*).
- Increased balanced protein in grower and finisher feeds improved performance only numerically, but by 4 to 6% (*Figures 1, 2, 3*) resulting in 11% higher productivity (*Figure 4*).
- Replacing MHA-FA with DL-Met in a 100:65 weight ratio did not impair broiler performance but reduced cost of product supplementation by 27% (*Figure 5*).

CONCLUSION

The trial showed that liquid methionine hydroxy analogue (MHA-FA) replacement with DL-methionine (DL-Met) in a 100:65 weight ratio does not compromise broiler performance but allows for economic benefits. This finding once more validates the concept of 65% bioefficacy for MHA-FA relative to DL-Met and confirms earlier conclusions that this bioefficacy does not interact with other dietary settings such as the balanced protein level.

FEEDBACK

"There is no doubt anymore that DL-methionine (MetAMINO®) is the more powerful solution for balancing dietary Met+Cys levels."



Dr. Andreas Lemme,
Global Senior Expert
Poultry, Evonik

Testing the 65% bioefficacy concept for MHA-FA in slow-growing broilers

Trial conducted by Bavarian State Research Center for Agriculture, Germany

Published as Evonik Facts & Figures 15217

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

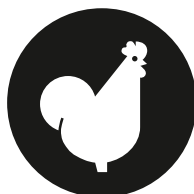
21

22

23



Trial location:
Bavarian State Research
Center for Agriculture,
Kitzingen, Germany

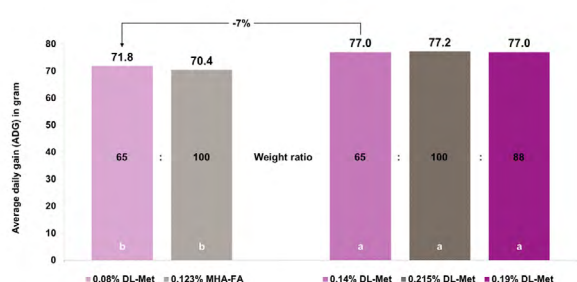


Project team leaders:
Dr. Philipp Hofmann,
Dr. Andreas Lemme

TABLE 1: Trial Design, Methods and Materials

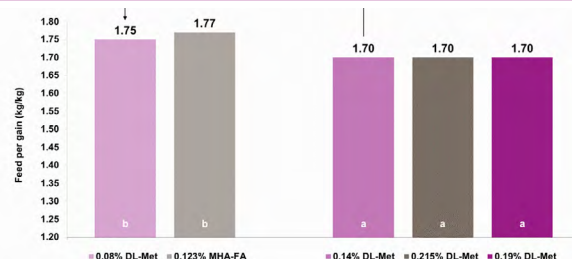
Animals	1,000 male Ranger Classic (38.7 g/chick); 40 birds per floor pen, 25 pens
Design	2 x 2 factorial feeding trial plus an additional treatment
Housing	Floor pens, 5 m ² , straw pellets as bedding
Diets	Corn, wheat, soybean meal-based diets Treatments 1 and 2 DL-Met and MHA-FA were supplemented to grower and finisher diets in a 65:100 weight ratio. Treatments 3 and 4 DL-Met and MHA-FA were also supplemented to grower and finisher diets in a 65:100 weight ratio, but at higher levels. Treatment 5 DL-Met was supplemented 114% as much as MHA- FA in treatment 4 assuming a bioefficacy of 88% for MHA-FA.
Feeding	Pelleted feed; ad libitum; 2 experimental phases: 18-35 days, 36-46 days; until day 18 commercial feed for all
Parameters	Average daily weight gain, feed per gain, breast meat yield
Duration	Days 18-46

FIGURE 1: Average daily gain of male Ranger Classic chicken from day 18 to 46



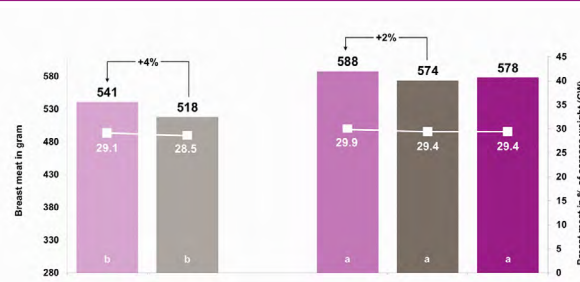
a,b = Different superscripts within columns and performance criterion indicate significant performance differences (p < 0.05, Tukey test)

FIGURE 2: Feed conversion ratio of male Ranger Classic chicken



a,b = Different superscripts within columns and performance criterion indicate significant performance differences (p < 0.05, Tukey test)

FIGURE 3: Breast meat yield of male Ranger Classic chicken



a,b = Different superscripts within columns and performance criterion indicate significant performance differences (p < 0.05, Tukey test)

TABLE 2: Product intake and costs per bird

Treatment	Ratio to MHA-FA %	ADFI ¹ g/d	Product intake 14-46 days mg	Cost of product intake Cent/bird	Cost relative to DL-Met 65 %
0.080% DL-Met	65	125.5	2,811.2	7.028	–
0.123% MHA-FA	100	124.9	4,301.5	8.603	122
0.140% DL-Met	65	130.9	5,131.3	12.828	–
0.215% MHA-FA	100	130.8	7,874.1	15.748	123
0.190% DL-Met	88	130.6	6,947.9	17.370	135

¹ ADFI = Average daily feed intake

Trial Objectives

The aim of this study was to apply the 65% bioefficacy concept where MHA-FA is replaced with DL-methionine (DL-Met) in a 100:65 weight ratio in a slow-growing broiler strain.

Trial Results

- Reduction of methionine supplementation significantly impaired the performance of slow-growing broilers (*Figure 1*).
- There were no differences between MHA-FA and DL-Met treatments at either supplementation level with respect to feed conversion ratio. (*Figure 2*).
- Breast meat yield did not significantly differ between corresponding 100% MHA-FA : 65% DL-Met treatments. However, the 65% DL-Met treatments showed 0.5 to 0.6%-points higher breast meat yield compared to 100% MHA-FA treatments (*Figure 3*).
- Compared to DL-Met-65% treatments, cost of product intake (*Table 2*) was 22% higher for MHA-FA. Supplementing MHA-FA at 88%, bioefficacy reduced feed cost by 12% relative to DL-Met. However, replacement of MHA-FA by DL-Met in a 100:65 weight ratio, reduced feed cost by 22 to 23% showing the most economic use of DL-Met.

CONCLUSION

In this trial, the replacement of liquid methionine hydroxy analogue (MHA-FA) with DL-methionine (DL-Met) in a 100:65 ratio did not impair the performance of slow growing broilers. The trial confirmed an earlier meta-analysis concluding that the bioefficacy of 65% for MHA-FA is independent of dietary settings and broiler genetics. Replacing 100% MHA-FA with 65% DL-Met has substantial cost saving potential.

FEEDBACK

"The study showed that the bioefficacy of 65% for MHA-FA relative to DL-methionine can also be applied to slow growing broiler strains."



Dr. Philipp Hofmann,
Bavarian State Research
Center for Agriculture,
Kitzingen, Germany

Impact of DL-methionine and liquid methionine hydroxy analogue in black soldier fly larvae production

Trial conducted by Institute Feed Research, Bingen, Germany

Published in: *BAB I Heft 111* | ISSN 0947-7314, page 71. "Methionine supplementation affected performance of black soldier fly larvae (*Hermetia illucens*) and microbial activity" ➡

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
University of Applied
Sciences, Institute Feed
Research, Bingen, Germany



Project team leaders:
Prof. Dr. Georg Dusel,
Nathalie Stöhr,
Dr. Andreas Lemme

TABLE 1: Trial Design, Methods and Materials

Animals	~14,000 5-day-old black soldier fly larvae per tray, 3 trays per treatment; 7.75 mg/larva in 1. run; 9.41 mg/larva in 2. run
Design	Simultaneous dose response trial
Housing	600 mm x 400 mm x 150 mm trays
Diets	Based on peas (43%), apple pomace (41%), wheat (10%), soybean meal (2%); Minerals and additives (4%), 16.2 % crude protein (CP) in dry matter (DM) 1) Negative control: Basal, unsupplemented substrate (BS); 0.48% Met+Cys in DM 2) Treatment 2a,b: BS + 0.13 or 0.27% DL-Met 3) Treatment 3a,b: BS + 0.10 or 0.26% MHA-FA
Feeding	8.75 kg substrate/tray (2.45 kg DM); ad libitum for 13 days
Parameters	Biomass gain; mass balance calculations: amino acid & nitrogen retention, nitrogen losses (lost in form of ammonia as neither captured in biomass nor in frass)
Duration	8 days

FIGURE 1: Black soldier fly biomass gain on a dry matter basis (DM) in 13 days

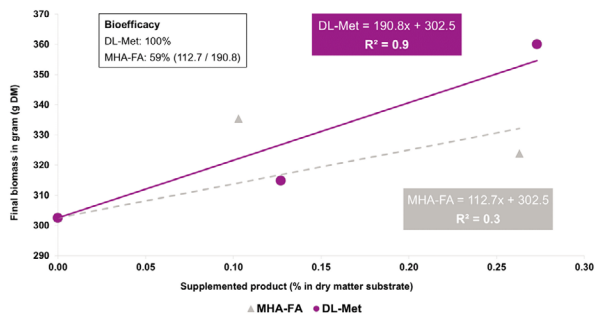


FIGURE 2: Amino acid retention in black soldier flies

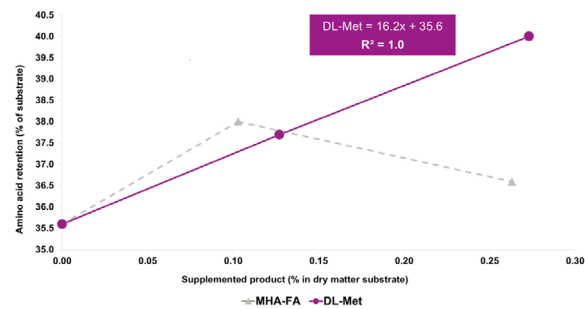


FIGURE 3: Nitrogen retention in black soldier flies

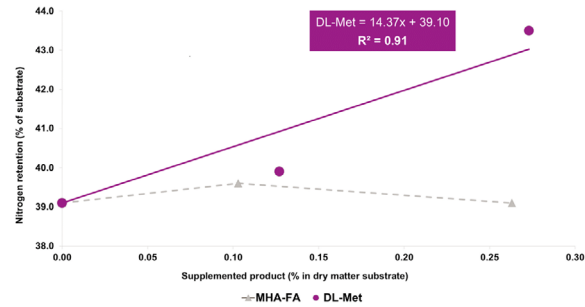
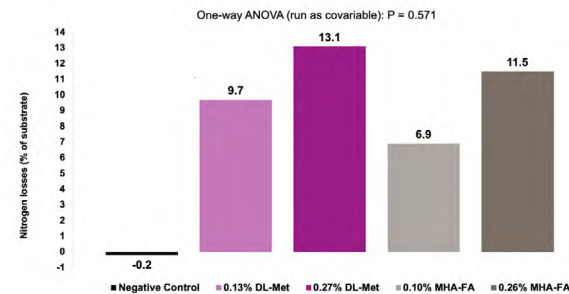


FIGURE 4: Nitrogen losses (ammonia) in black soldier flies



Trial Objectives

The objective of this study was to evaluate the impact of supplementation of either DL-methionine (DL-Met) or liquid methionine hydroxy analogue (MHA-FA) on performance and nutrient utilization of black soldier fly larvae.

Trial Results

- Data were analyzed by one-way ANOVA taking the run as co-variable and did not show any statistically significant treatment differences ($p > 0.05$).
- Final biomass increased by 19% with 0.27% DL-Met while it was 7% with 0.26% MHA-FA. Comparing slopes of two regression lines suggests MHA-FA being 59% as efficient as DL-Met but, however, R^2 especially for MHA-FA was low (*Figure 1*).
- Retention of amino acids relative to amino acids offered with the feed increased linearly ($R^2 = 1.00$) with DL-Met supplementation whereas amino acid retention was not further increased above 0.10% MHA-FA supplementation (*Figure 2*).
- Nitrogen utilization expressed as retained nitrogen relative to nitrogen offered with the feed was improved by 5.4%-points with 0.26% DL-Met following a linear trend (*Figure 3*). In contrast, MHA-FA supplementation did not affect nitrogen retention.
- Nitrogen losses, which basically mean ammonia losses and which are calculated as difference between substrate-N and (biomass-N + frass-N), were almost zero with the negative control (*Figure 4*). Increasing supplementation of either DL-Met or MHA-FA gradually increased nitrogen losses.

CONCLUSION

Although statistically not significant, the results of this study suggest that DL-methionine (DL-Met) is more effective in supporting growth of black soldier fly larvae than liquid methionine hydroxy analogue (MHA-FA). Particularly, deposition of amino acids was linearly improved with DL-Met. Supplementation of MHA-FA could not increase N-deposition relative to feed nitrogen, whereas DL-Met was effective to increase N-retention by up to 11%.

FEEDBACK

"It is interesting to learn that methionine plays an important role in black soldier fly larvae nutrition as it does in many other species."



Dr. Andreas Lemme,
Global Senior Expert
Poultry, Evonik

Comparing DL-Methionine and liquid methionine hydroxy analogue supplemented in a 65:100 weight ratio in black soldier fly larvae nutrition

Trial conducted by Fraunhofer Institute for Molecular Biology and Applied Ecology, Giessen, Germany

Published in NexAMINO™ Report 5, 2025, Balance approach to better understand sulfur amino acid nutrition of black soldier fly larvae, Evonik Operations GmbH

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
Fraunhofer Institute of
Molecular Biology and
Applied Ecology, Giessen,
Germany

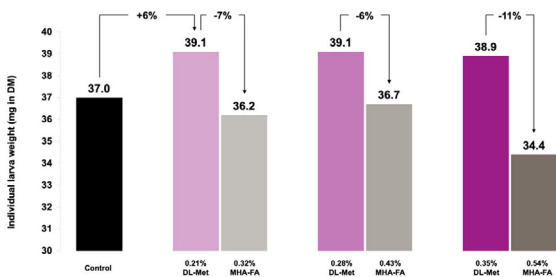


Project team leaders:
Dr. Patrick Klüber,
Dr. Andreas Lemme,
Thomas Häußner

TABLE 1: Trial Design, Methods and Materials

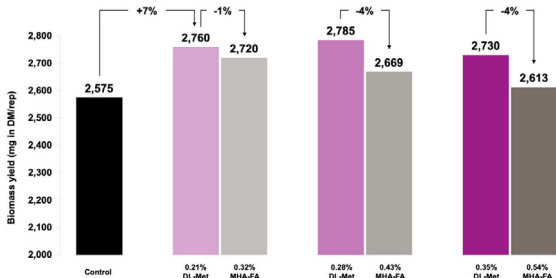
Animals	2,100 Hermetia Illucens larvae (5.7 mg/larva) distributed to 21 boxes with 100 larvae each
Design	Simultaneous dose-response design including a basal, non-supplemented dietary treatment and 3 graded levels of both DI-Met and MHA-FA
Housing	19.5 x 16.5 x 9.5 cm boxes at constant temperature of 27 °C
Diets	Apple pomace (56.6-56.9%), corn starch (32.3%), amino acid mix excluding methionine (7.3-7.6%) - Basal treatment: not supplemented with either product 3 dietary treatments with 0.21, 0.28, or 0.35 % supplemental DL-Met 3 dietary treatments with 0.32, 0.43 or 0.54% supplemental liquid MHA-FA, reflecting a 100:65 weight ratio to corresponding DL-Met treatments and in line with Evonik's 65% bioefficacy concept for MHA-FA.
Feeding	25 g dry substrate were soaked with water to achieve about 65 % moisture
Parameters	Final individual body weight, final biomass, feed conversion
Duration	Days 1-14

FIGURE 1: Average individual black soldier fly larva weight on dry matter basis after 14 days feeding experimental substrates



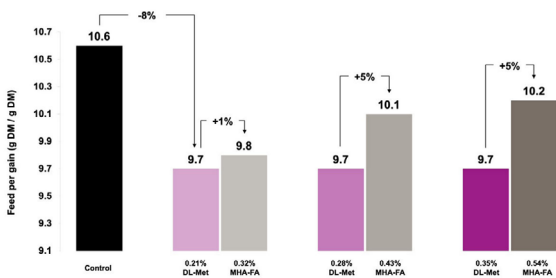
Supplemented Met-activity (assuming 65% bioefficacy for MHA-FA)

FIGURE 2: Average final black soldier fly biomass weight on dry matter basis after 14 days feeding experimental substrates



Supplemented Met-activity (assuming 65% bioefficacy for MHA-FA)

FIGURE 3: Feed conversion ratio of black soldier fly larvae after 14 days feeding experimental substrates based on apple pomace (dry matter conversion)



Supplemented Met-activity (assuming 65% bioefficacy for MHA-FA)

Trial Objectives

The aim of this trial was to investigate whether supplementing methionine to an apple pomace-based substrate can improve productivity of black soldier fly larvae. In addition, the concept of 65% bioefficacy of MHA-FA was included in the experimental design.

Trial Results

- Supplementation of 0.21% DL-Met increased individual larva dry matter weight by 6% whereas higher supplementation levels did not further improve larva weights (*Figure 1*).
- Although assuming a bioefficacy of 65% resulting in higher supplementation levels than DL-Met inclusions, MHA-FA supplementation did not affect individual larva weights (*Figure 1*).
- Overall final biomass (dry matter) was increased by 7% with DL-Met supplementation whilst biomass of MHA-FA fed black soldier fly larvae was 1 to 4% behind DL-Met fed larvae (*Figure 2*).
- Feed conversion ratio (on dry matter basis) was improved by 8% with DL-Met supplementation. MHA-FA was 1 to 5% less effective than DL-Met (*Figure 3*).

CONCLUSION

In this trial three graded levels of DL-Methionine (DL-Met) or liquid methionine hydroxy analogue (MHA-FA) were supplemented in 65:100 weight ratio in corresponding treatments to a non-supplemented basal diet. Even though a bioefficacy of 65% was assumed for MHA-FA a priori resulting in 54% higher inclusion levels, performance of black soldier fly larvae fed MHA-FA was behind that of DL-Met fed larvae. It is concluded that the bioefficacy of MHA-FA might be even lower than 65% in black soldier fly larvae. The results indicated that supplementing DL-Methionine to substrate improves productivity and feed utilization of black soldier fly larvae production.

FEEDBACK

"It was interesting to see that black soldier fly larvae responded to supplemented methionine sources while obviously DL-Met outperformed MHA-FA."



Dr. Andreas Lemme,
Global Senior Expert
Poultry, Evonik

Effects of DL-methionine and liquid methionine hydroxy analogue in black soldier fly larvae production

Trial conducted by ENORM Biofactory A/S, Denmark



Trial location:
ENORM Biofactory A/S,
Flemming, Denmark



Project team leaders:
Dr. Andreas Lemme,
Toke Munk Schou,
Nastasia Krog Noer

TABLE 1: Trial Design, Methods and Materials

Animals	Seed larvae/tray (16.8±0.66g dry matter (DM) (±standard error of the mean, SEM)), DM content ~37.5%; 6 trays/treatment
Design	Simultaneous dose response trial
Housing	800 mm x 600 mm x 15 mm trays
Diets	Based on brewery by-products, 18.3% crude protein (CP) in DM 1) Negative control: Basal, unsupplemented substrate (BS); 0.66% Met+Cys in DM 2) Treatment 2a,b,c: BS + 0.20, 0.40, or 0.60% DL-Met 3) Treatment 3a,b,c: BS + 0.31, 0.62, or 0.92% MHA-FA (154% of DL-Met, applied 65% bioefficacy)
Feeding	12.35 kg substrate/tray (2.93 kg DM); ad libitum for 20 days
Parameters	Biomass gain; mass balance calculations: amino acid & nitrogen retention, nitrogen losses (lost in form of ammonia as neither captured in biomass nor in frass)
Duration	20 days

FIGURE 1: Black soldier fly biomass gain on a dry matter basis (DM) in 20 days

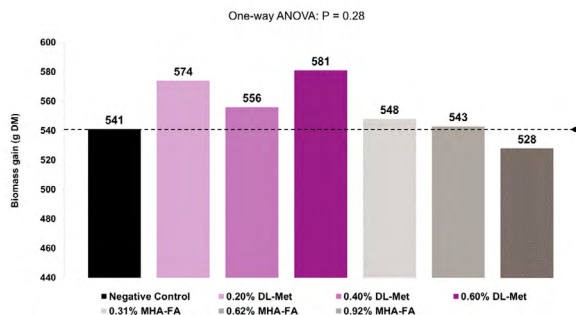


FIGURE 2: Amino acid retention in black soldier flies

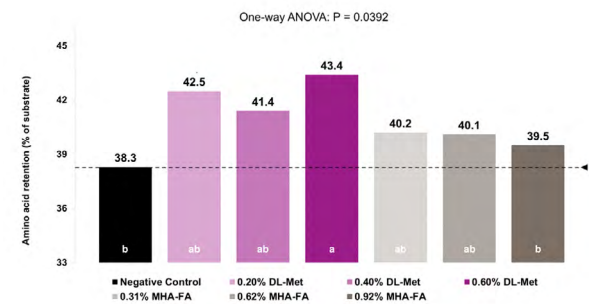


FIGURE 3: Nitrogen retention in black soldier flies

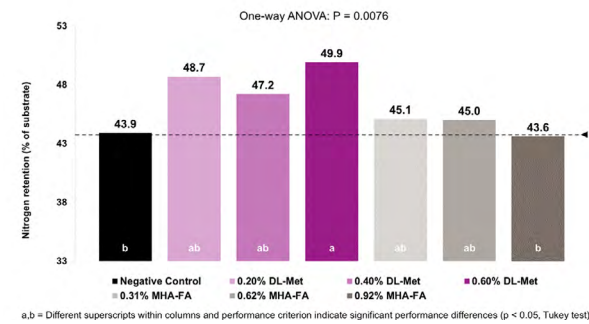


FIGURE 4: Nitrogen losses (ammonia) in black soldier flies

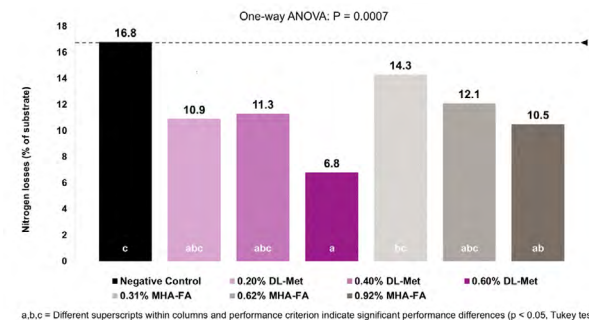
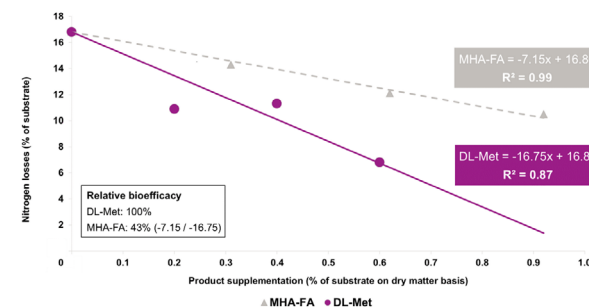


FIGURE 5: Slope-ratio analysis to determine the bioefficacy of MHA-FA relative to DL-Met based on nitrogen losses



Trial Objectives

The objective of this study was to evaluate the impact of incremental supplementation of either DL-Met or MHA-FA on performance and nutrient utilization of black soldier fly larvae.

Trial Results

- DL-methionine (DL-Met) supplementation increased biomass gain numerically by up to 7.4%, whereas supplementation of MHA-FA had no impact on biomass gain (*Figure 1*).
- Supplementation of 0.60% DL-Met significantly ($p < 0.05$) increased amino acid retention from substrate by 5 %-points, while this effect was less pronounced with MHA-FA supplementation (*Figure 2*).
- Nitrogen utilization in % of substrate was significantly improved with 0.60% DL-Met, but supplementation of MHA-FA had no effect (*Figure 3*).
- Nitrogen losses, which are basically ammonia losses, were significantly ($p < 0.05$; *Figure 4*) and linearly (*Figure 5*) reduced with graded product supplementation. MHA-FA was 43% as effective as DL-Met.

CONCLUSION

In this trial, supplementation of DL-methionine (DL-Met) improved black soldier fly larvae biomass gain and nitrogen retention whereas MHA-FA supplementation was ineffective. Nitrogen losses were significantly reduced by graded supplementation of DL-Met and MHA-FA. In fact, bioefficacy of MHA-FA relative to DL-Met was only 43%. DL-Met is more effective than MHA-FA as feed supplement to improve the black soldier fly larvae production system.

FEEDBACK

"While there is still much to learn about the optimization of black soldier fly larvae nutrition, it becomes clear with this trial that the 65% bioefficacy concept is successfully applicable for these animals as well."



Toke Munk Schou,
Head of R&D,
ENORM Biofactory



North, Central and South America

- 7 **USA** / Nitrogen retention in pigs
- 8 **USA** / Growth and carcass quality in pigs
- 9 **USA** / Broiler breeder flocks
- 10 **USA** / Effects of Met+Cys:Lys ratio and methionine sources on broiler performance
- 11 **Brazil** / Relative bioavailability for growth performance in male broilers
- 12 **Brazil** / Bioefficacy comparison of MHA-FA and DL-Met in broilers
- 13 **Peru** / Growth performance at different Met+Cys levels in male broilers

Effects of methionine sources on nitrogen retention in growing pigs

Trial conducted by Swine Research Center at the University of Illinois, USA
Published in: *Journal of Animal Science*, Volume 103, Issue Supplement_1, May 2025, Pages 99–100,
<https://doi.org/10.1093/jas/skaf102.107>

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
Swine Research Center,
University of Illinois at
Urbana-Champaign

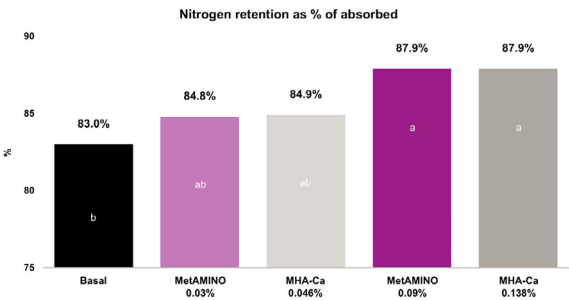


Project team leaders:
Prof. Dr. Hans Stein,
Dr. John Htoo,
Dr. Maria Mendoza

TABLE 1: Trial Design, Methods and Materials

Animals	Thirty barrows (initial body weight: 16.37 ±1.28 kg, PIC Genetics)
Design	Completely randomized block design with 6 replicants per treatment
Housing	Individually, in metabolism crates
Diets	Basal diet: A methionine-deficient mash diet based on corn, field peas, soybean meal, whey powder, and plasma protein was formulated with 0.23% standardized ileal digestible (SID) methionine (Met) and 0.55% SID methionine + cysteine Dietary treatments: Four additional diets were prepared by supplementing the basal diet with: 0.030% or 0.090% DL-methionine (MetAMINO®); 0.046% or 0.138% MHA-Ca
Feeding	Feed was provided at 3.2 times the energy requirement for maintenance, split into 2 equal daily meals (at 0800 and 1600 h); pigs had ad-libitum access to water
Parameters	Pig feed intake and body weight gain; dry matter of the fecal and diet samples; nitrogen content of fecal, urine and diets samples
Duration	7 days adaptation to the diets, and 4 days collection (urine and feces)

FIGURE 1: Effect of supplemental MetAMINO® (DL-Met) or MHA-Ca on nitrogen retention as % of absorbed



Bars with different letters are significantly different ($p < 0.05$)

TABLE 2: Effect of supplemental MetAMINO® or MHA-Ca on feed intake and final body weight of growing pigs

Item	Initial BW kg	Final BW kg	Feed intake g/d	N intake g/d
Basal	16.37	21.93 ^b	937 ^b	28.2
MetAMINO® 0.03%	16.38	23.28 ^a	986 ^a	29.3
MHA-Ca 0.046%	16.46	22.9 ^{ab}	972 ^{ab}	28.7
MetAMINO® 0.09%	16.31	23.09 ^{ab}	993 ^a	29.6
MHA-Ca 0.138%	16.36	23.3 ^a	966 ^{ab}	28.4
SEM ¹	0.58	0.71	24.29	0.72
Diet, P-values	0.999	0.215	0.172	0.279
Basal vs. others, P-values	0.890	0.036	0.040	0.223
MetAMINO® vs. MHA-Ca, P-values	0.909	0.913	0.409	0.258

¹ SEM = standard error of the mean
^{ab} Means with different superscript denote difference among treatments by alpha level of 0.05

TABLE 3: Effect of supplemental MetAMINO® or MHA-Ca on nitrogen absorption, retention and utilization

Item	ATTD ¹ of N %	N absorbed g/d	N retained g/d	PUN ² mg/dL
Basal	91.6	25.9	21.5 ^b	12.2 ^a
MetAMINO® 0.03%	90.6	26.5	22.5 ^{ab}	7.0 ^b
MHA-Ca 0.046%	90.9	26.1	22.2 ^{ab}	7.6 ^b
MetAMINO® 0.09%	90.0	26.6	23.4 ^a	5.8 ^b
MHA-Ca 0.138%	91.0	25.9	22.7 ^{ab}	5.8 ^b
SEM ³	0.68	0.69	0.71	0.89
Diet, P-values	0.509	0.690	0.191	<0.001
Basal vs. others, P-values	0.214	0.530	0.083	<0.001
MetAMINO® vs. MHA-Ca, P-values	0.316	0.432	0.503	0.740

¹ ATTD = apparent total tract digestibility
² PUN = plasma urea nitrogen
³ SEM = standard error of the mean
^{ab} Means with different superscript denote difference among treatments by alpha level of

Trial Objectives

To determine the nitrogen retention of pigs fed a reduced crude protein diet supplemented with 65 parts of DL-Met or 100 parts of MHA-Ca on a product basis.

Trial Results

- Pigs fed 65 parts MetAMINO® or 100 parts MHA on product basis did not differ in final body weight (BW), feed intake, and N intake (*Table 2*).
- Urine N excretion decreased as methionine sources increased in the diet, regardless of the source (data not shown).
- Nitrogen utilization, reflected by plasma urea nitrogen (PUN), improved linearly as methionine sources increased in the diet, regardless of the methionine source (*Table 3*).
- Nitrogen retained (g/d) tended to be greater for diets supplemented with methionine sources while the highest N retention (g/d) was achieved in pigs fed diet supplemented with 0.09 % MetAMINO® (*Table 3*).
- Nitrogen retention (% of absorbed) linearly increased regardless of the methionine source when used in a MetAMINO® to MHA-Ca ratio of 65 to 100 on product basis (*Figure 1*).

CONCLUSION

Supplementing a methionine-deficient and reduced crude protein diet with either 65 parts DL-methionine (DL-Met) or 100 parts MHA-Ca on a product-to-product basis resulted in similar nitrogen retention. No significant differences were observed when nitrogen retention was expressed as grams per day, percentage of intake, or percentage absorbed.

FEEDBACK

"Using nitrogen-balance method, we validated that nitrogen retention, a highly sensitive parameter, was not affected by methionine sources when used at a 65:100 (DL-methionine to MHA-product). This confirms that the efficacy of MHA relative to DLM is 65 %."



Prof. Dr. Hans Stein,
Professor, University of
Illinois, USA

Trial Objectives

The objective of the study was to evaluate the effect of dietary supplementation with 65 parts of DL-Met or L-Met replacing 100 parts of MHA-Ca on growth performance, carcass composition, and meat quality of finishing pigs.

Trial Results

- Pigs used in the study had optimal performance. Final body weight (BW) on day 104 was not different when the diet was supplemented with DL-Met, L-Met or MHA-Ca using an average bioefficacy of 65% for MHA relative to DL-Met or L-Met (*Figure 1*).
- Average daily gain and feed intake during phase 3, 4 or overall (phase 3 & 4) period were not different when the diet was adequately balanced by using DL-Met (or L-Met) to MHA-Ca ratio of 65:100 (*Figures 2 and 3*). Consequently, gain: feed was not affected.
- Carcass yield as well as loin eye area and back fat thickness of pigs at the end of the trial were not different when dietary methionine was supplemented at a DL-Met to MHA-Ca ratio of 65:100 on a product basis (*Table 2*).
- Meat quality and color scores were also not affected when using 65% bioefficacy for MHA relative to DL-Met or L-Met (*Table 3*).
- An economic analysis showed that there is an advantage of 1.00 US\$ per pig when pigs were fed the 65 part of MetAMINO® diet compared to pigs fed 100 parts MHA-Ca diet (*Table 4*).

CONCLUSION

Overall, daily feed intake, growth performance as well as carcass characteristics and meat quality of finishing pigs are not different when the diets are adequately balanced by using DL-methionine (DL-Met) or L-methionine (L-Met) to MHA-Ca ratio of 65:100 on a product basis. Results from this trial showed that balancing pig diets using DL-Met instead of MHA-Ca at a ratio of 65:100 on a product basis generates an extra income of 1.00 US\$ per pig.

FEEDBACK

"In a comprehensive performance and carcass evaluation trial, we validated that 100 parts of MHA-Ca can be replaced with 65 parts of MetAMINO® without affecting growth performance, carcass characteristics and meat quality of pigs."



Dr. John Htoo,
Global Senior Expert Swine,
Evonik

Effects of methionine sources on performance and productivity in commercial broiler breeder flocks

Trial conducted by North Carolina State University, USA

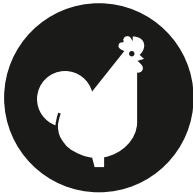
Published: Castro et al., 114th PSA Annual Meeting, 14th-17th July 2025, Raleigh, NC, USA, Abstract #337

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
North Carolina State
University Research Center,
USA

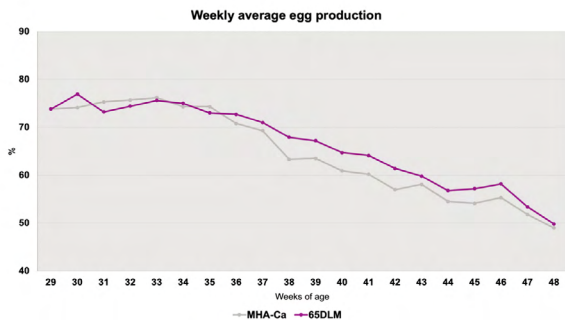


Project team leaders:
James Wen,
Victor D. Naranjo,
Dr. Andreas Lemme

TABLE 1: Trial Design, Methods and Materials

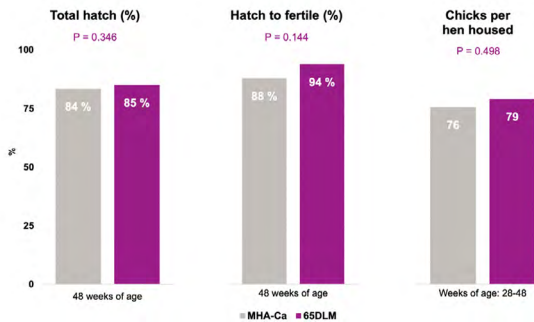
Animals	824 24-week-old fast feather broiler breeder hens (Cobb® 500) and 80 roosters (Cobb® Male)
Design	Completely randomized block design, 2 treatments, 8 replicates of 50-52 birds each
Housing	Floor pens containing nests. House management based on Cobb broiler breeder guidelines for lighting and temperature. Male to female ratio of 1:10
Diets	24-28 weeks of age: Common Breeder 1 diet formulated using MHA-FA (88% purity) – adaptation phase 28-48 weeks of age: 1) MHA-FA100: common Breeder 1 diet formulated using MHA-Ca (84% purity). 2) 65DLM: similar to diet 1 but with DL-methionine (MetAMINO®) at 65 parts of MHA-Ca levels (100:65 replacement)
Feeding	Feed was provided once a day (7 am) on a daily lb per bird basis. Amounts calculated based on the average body weight (BW), body weight gain (BWG), and weekly egg production of the entire flock to determine the daily caloric requirement at the beginning of each production week. Water was provided freely for the 9h-period following feeding.
Parameters	Performance (body weight, uniformity, egg production, egg mass), Egg quality (egg weight, shell strength, albumen quality, vitellin membrane strength), Reproduction (fertility and hatchability), Feathering
Duration	20 weeks

FIGURE 1: Egg production of broiler breeders from 29 to 48 weeks of age



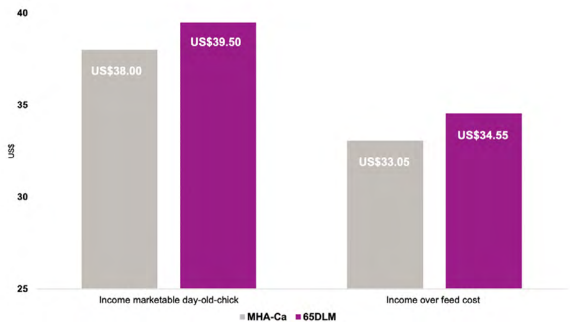
Egg production was similar between both treatments throughout the study ($P > 0.05$)

FIGURE 2: Total hatch %, hatch of fertile % and hatched chicks per hen housed



Average fertility (candling), total hatch, and hatch of fertile were similar between treatments ($P > 0.05$)

FIGURE 3: Economic benefits of replacing 100 parts of MHA-FA with 65 parts of DL-methionine



The income for marketable day-old-chick and income over feed cost were US\$1.50 higher in birds fed 65DLM than MHA-Ca

Trial Objectives

The objective of this study was to validate the 65% relative bioavailability value (RBV) of MHA-Ca in Cobb 500 broiler breeders raised from 28-48 weeks of age. The trial was conducted at the North Carolina State University Research Center, USA, and looked into performance parameters, as well as fertility and feathering coverage.

Trial Results

- No significant differences ($P > 0.05$) were seen between MHA-Ca and 65DLM for body weight (BW), average daily gain (ADG), flock coefficient of variation (CV), and mortality throughout the study.
- Regarding egg production and egg mass, no statistical differences were seen between the two treatments ($P > 0.05$, Fig. 1). However, a consistent numerical increase in both parameters was found when 65DLM was used from weeks 36 onwards. On average, the breeders fed 65DLM had 3.4%-points higher egg production and 2.1 g/hen/day more egg mass than the MHA-Ca group.
- The reproduction/fertility parameters were similar between the treatments ($P > 0.05$, Fig. 2). However, a numerical improvement of biological and economic relevance in the total hatch, hatch of fertile, and chicks per hen housed was seen when 65DLM was used. 65DLM-fed breeders had 1.6%-points higher total hatch, 6%-points higher hatch of fertile, and 3 extra chicks per hen housed compared to the MHA-Ca group.
- The severity of feathering loss in the back/rump area was significantly reduced with 65DLM ($P < 0.05$). The feathering coverage in the legs was significantly improved with MHA-Ca ($P < 0.05$).
- The income for marketable day-old-chick and income over feed cost were US\$1.50 higher in birds fed 65DLM than MHA-Ca (Fig. 3).

CONCLUSION

The trial showed that 100 units of MHA-Ca can be replaced with 65 units of DL-methionine (65DLM) in Cobb 500 broiler breeder hens from 28 to 48 weeks of age without affecting performance, reproduction, egg quality, and potentially reducing the severity of feather loss in the back/rump area. The economic analysis demonstrates a significant financial advantage in using DL-methionine compared to MHA-Ca in broiler breeder operations.

FEEDBACK

"This was the first experiment conducted on broiler breeders to evaluate the impact of substituting 100 parts of MHA with 65 parts of MetAMINO® in their feed. The results demonstrated no significant differences in breeder performance parameters between the two treatments."



James Wen,
Senior Technical Service
Manager, Evonik North
America

Effects of different Met+Cys:Lys ratio programs and methionine sources on growth performance during the first 42 days of age

Trial conducted at Poultry Research Partners in Georgia, USA

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

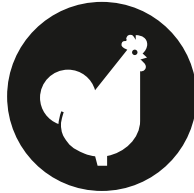
21

22

23



Trial location:
Poultry Research Partners
in Georgia, USA



Project team leaders:
Dr. Victor Naranjo,
Dr. Andreas Lemme

TABLE 1: Trial Design, Methods and Materials

Animals	3,072 one-day-old male Ross 708 broilers
Design	Completely randomized block design, 8 treatments, 12 replicates of 32 birds each
Housing	
Diets	Corn-soybean meal and animal byproduct-based diets
Feeding	Broilers were fed a 3-phase feeding program that lasted from d 0 to 14 (starter), d 15 to 28 (grower) and d 29 to 42 (finisher) on ad-libitum basis
Parameters	Body weight gain, feed intake, feed conversion ratio and processing yields
Duration	1 to 42 days of age

TABLE 2: Dietary treatments fed from day 0 to 42 of age

Met+Cys:Lys strategy	Starter (0 to 14 days)	Grower (14 to 28 days)	Finisher (28 to 42 days)
Negative control (without supplemental Met)	48	51	51
Customer's Met+Cys program¹	68	72	72
Intermediate Met+Cys ratios¹	72	75	75
Higher Met+Cys ratios¹	75	79	79
AMINOSpec only with DLM	72	74	76

¹ For each Met+Cys:Lys ratio program, diets were formulated with either MHA-FA (88%) or its corresponding replacement with 65 parts of DLM

FIGURE 1: Body weight of Ross 708 broilers on day 42

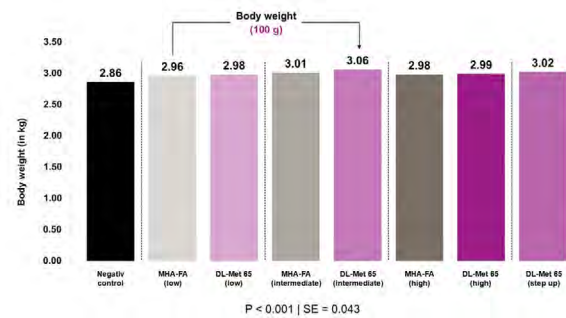
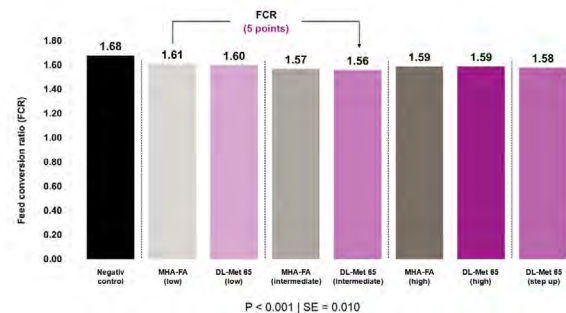


FIGURE 2: Overall feed conversion ratio of Ross 708 broilers from day 1 to 42 of age



Trial Objectives

The aim of this trial was to determine the effects of different SID Met+Cys to Lys ratio combinations and of replacing 100 units of liquid MHA-FA with 65 units of DL-Methionine on growth performance of broilers from 0-42 days of age.

Trial Results

- Broilers fed the negative control diet without any supplemental Methionine sources, had a significantly lower BW and greater FCR compared to the other treatments (*Figure 1 and 2*).
- Under the evaluated conditions, the different Met+Cys:Lys programs (*Table 2*) did not affect the final body weight (*Figure 1*) or the overall FCR (*Figure 2*).
- Overall, replacing 100 parts of liquid MHA-FA with 65 parts of DL-Met did not affect final BW or FCR at any of the 3 different Met+Cys:Lys ratio programs (*Figure 1 and 2*).
- The relative bioavailability of MHA-FA was validated to be equivalent to 65% DL-Met and that it can be applied at any Met+Cys:Lys ratio.

CONCLUSION

In this trial, different SID Met+Cys ratio programs were evaluated in male Ross 708 broilers from 0 to 42 days of age, comparing liquid MHA-FA with DL-Met at a 100:65 replacement ratio. The results showed that replacing 100 parts of MHA-FA with 65 parts of DL-Met did not affect growth performance, independent of the Met+Cys ratio program.

FEEDBACK

"The study confirmed that liquid MHA-FA can be replaced with 65 parts of DL-methionine independent of the Met+Cys:Lys program without affecting growth performance, while achieving significant savings with DL-Met."



Dr. Victor Naranjo,
Technical Director Evonik
Guatemala SA

Relative bioavailability value of DL-2-hydroxy-4-methylthio butanoic acid to DL-methionine for growth performance parameters of male broilers

Trial conducted by University of Vicosa, Brazil

Published in the 2024 Poultry Science Association (PSA) Annual Meeting, USA (Abstract #137 and #169) ➔

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

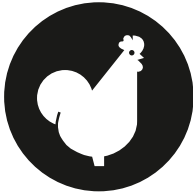
21

22

23



Trial location:
Broiler research farm at
Vicosa University, Brazil



Project team leaders:
G. Aguiar, M. Hannas,
J. D. Dorigam,
V. D. Naranjo, A. Lemme

TABLE 1: Trial Design, Methods and Materials

Animals	1,820 males Cobb 500 broilers
Design	Simultaneous dose response trial with liquid HMTBA and DL-Met to determine the relative bioavailability
Housing	Floor pens
Diets	Corn-soybean meal-based diets
Feeding	Negative control diet, without any supplemental Met and 6 increasing levels of supplemented methionine (0.04, 0.08, 0.12, 0.17, 0.25, and 0.33%) achieved with the inclusion of either DL-Met (99%) or HMTBA (88%) on equimolar basis. See Table 2 for details
Parameters	Body weight gain, feed intake and feed conversion ratio
Duration	14 – 28 days of age
Statistics	Simultaneous dose-response multi-exponential function

TABLE 2: Dietary treatments fed from day 14 to 28

Treatment	Source	Product addition %	Replicates	Birds
1	Negative control	0.000 (50)	7	140
2	DLM	0.040 (54)	7	140
3	DLM	0.080 (58)	7	140
4	DLM	0.120 (62)	7	140
5	DLM	0.170 (67)	7	140
6	DLM	0.250 (75)	7	140
7	DLM	0.330 (83)	7	140
8	HMTBA	0.045 (54)	7	140
9	HMTBA	0.091 (58)	7	140
10	HMTBA	0.136 (62)	7	140
11	HMTBA	0.193 (67)	7	140
12	HMTBA	0.284 (75)	7	140
13	HMTBA	0.375 (83)	7	140

FIGURE 1: Relative bioavailability value of HMTBA relative to DL-Met based on final body weight from day 14 to 28

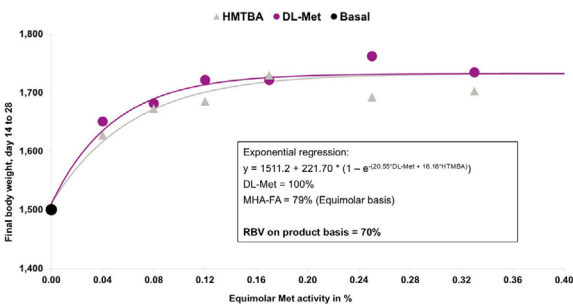
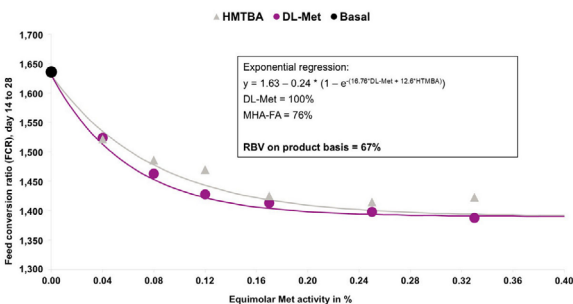


FIGURE 2: Relative bioavailability value of HMTBA relative to DL-Met based on feed conversion ratio from day 14 to 28



Trial Objectives

A study was conducted to estimate the relative bioavailability value (RBV) of DL-2-hydroxy-4-methylthio butanoic acid (HMTBA) to DL-methionine (DLM) for growth performance of male broiler chickens from 14 to 28 days of age.

Trial Results

- On equimolar basis, the calculated RBV were 79% for FBW (Final body weight, *Figure 1*) and 76% for FCR (Feed conversion ratio, *Figure 2*)
- On a product-to-product basis, the calculated RBV were 70% for FBW (*Figure 1*) and 67% for FCR (*Figure 2*)
- Based on these parameters, the average RBV of HMTBA to DLM for growth performance criteria (FBW and FCR) is 78% on equimolar basis or 68% on product-to-product basis for male grower chickens

CONCLUSION

Results from this trial demonstrated that the average relative bioavailability value (RBV) of HMTBA to DL-Met for growth performance criteria is on average 78% on equimolar basis or 68% on product-to-product basis for male grower chickens.

FEEDBACK

"Results from this trial demonstrated that the RBV of HMTBA was on average 78% on equimolar basis, which represents a 68% on product-to-product basis compared to DL-Met in the grower phase of broilers."



Dr. Melissa Hannas,
Prof. Monogastric Nutrition,
Vicosia University, Brazil

Comparison of applied bioefficacy of 65% and 80% for MHA-FA relative to DL-Met in broilers

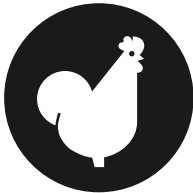
Trial conducted by the Federal University of Paraná, Brazil
Published in *animals* 2026, <https://doi.org/10.3390/ani16121811>

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
Federal University of Paraná,
Curitiba, Brazil

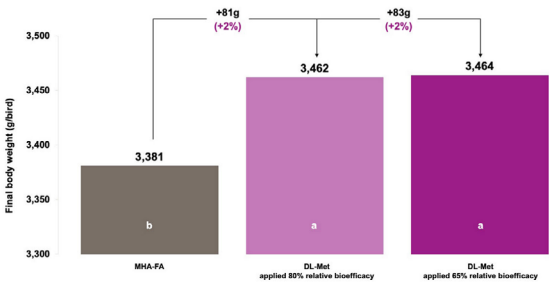


Project team leaders:
Patricia Tomazini,
Dr. Andreas Lemme,
Victor Naranjo,
Mariane Possamai,
Rafael Rancatti,
Alex Maiorka

TABLE 1: Trial Design, Methods and Materials

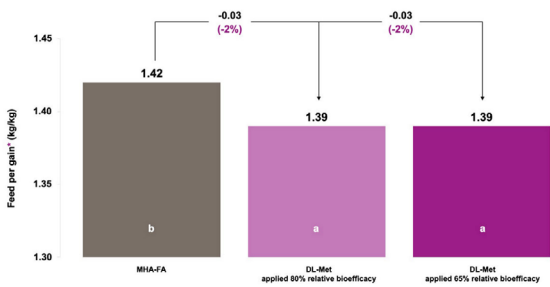
Animals	936 male Cobb 500 broilers (45.0 g/chick); 24 birds per floor pen, 39 pens
Design	Three dietary treatments in a randomized design
Housing	Floor pens, 1.85 m ² , fresh wood shavings on reused litter
Diets	Corn, soybean meal, meat and bone meal-based diets ▪ MHA-FA was supplemented to meet digestible Met+Cys specification with an applied bioefficacy of 80%. ▪ DL-Met replaced MHA-FA in an 80:100 weight ratio to simulate a commercial scenario. ▪ DL-Met replaced MHA-FA in a 65:100 weight ratio to challenge Evonik's recommendation of 65% bioefficacy of MHA-FA relative to DL-Met
Feeding	Pelleted feed; ad libitum; 5 experimental phases: 1-7-14-24-35-40 days
Parameters	Final body weight, feed per gain, breast meat yield based on 3 selected birds/pen
Duration	Days 1-40

FIGURE 1: Body weight of 40-day old male Cobb 500 broilers at the end of the trial



Superscripts a,b indicate significant treatment differences with $p < 0.05$

FIGURE 2: Overall feed conversion ratio of male Cobb 500 broilers at the end of the trial



Superscripts a,b indicate significant treatment differences with $p < 0.05$
* Not corrected for mortality

FIGURE 3: Breast meat weight relative to final body weight

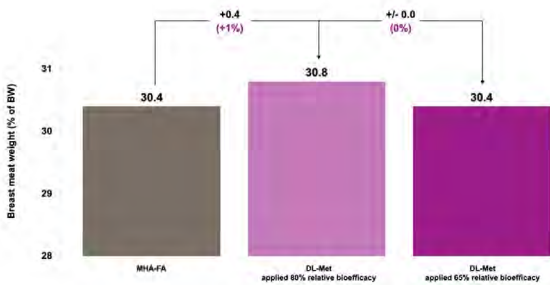
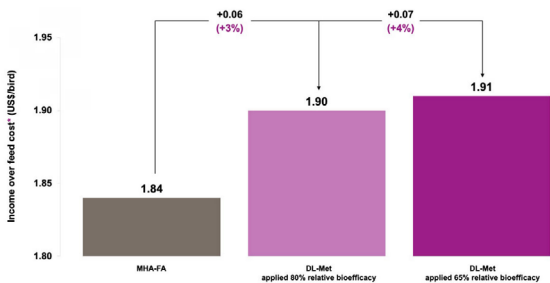


FIGURE 4: Income over feed cost per bird



* Based of feed prices Q4/2024, price per kg body weight 0.9 US\$/kg

Trial Objectives

The objective of this trial was to compare broiler performance and profitability when MHA-FA is replaced by DL-Met at a weight ratio of 100:65 but also of 100:80 with the latter sometimes applied in commercial feed production.

Trial Results

- Application of a bioefficacy of 80% for MHA-FA resulted in a significantly lower final body weight and a significantly higher feed conversion ratio compared to the DL-Met treatment (*Figures 1 and 2*). Breast meat yield was reduced by 0.4%-points (*Figure 3*).
- Replacing MHA-FA with DL-Met at a 100:65% weight ratio revealed significantly higher final body weight, significantly lower feed conversion ratio and similar breast meat yield (*Figures 1, 2, 3*).
- Calculation of income over feed cost based on Q4 2024 feed prices and price for delivered broilers (0.90 US\$/kg BW) showed up to 4% or 0.07 US\$/bird higher profitability when using DL-Met compared to MHA-FA (*Figure 4*)

CONCLUSION

In this trial, the effectiveness of MHA-FA supplementation was not only compared to DL-Met replacing MHA-FA at a 100:65 weight ratio but also a replacement at 100:80 weight ratio. The latter simulated a scenario which is sometimes found in commercial practice. Accordingly, both DL-Met treatments outperformed MHA-FA in terms of final body weight and feed conversion ratio. Breast meat yield was 0.4%-pts higher with DL-Met at 100:80 weight ratio indicating that application of a high bioefficacy for MHA-FA can result in performance drops. Interestingly, final body weight and FCR were significantly improved with DL-Met compared to MHA-FA when supplemented in the recommended 100:65% weight ratio. Use of DL-Met increased profitability in terms of income over feed cost by 4%.

FEEDBACK

"This trial was an eye-opener, demonstrating that assigning an overestimated relative bioefficacy to MHA-FA may compromise performance, while replacing MHA-FA with only 65% DL-Met achieved at least the same level of performance."



Prof. Alex Maiorka,
Professor of Animal Nutrition,
Federal University of Paraná

Effects of replacing liquid MHA-FA with 65% DL-Methionine on growth performance of male broilers

Trial conducted in collaboration with a Peruvian broiler integrator

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

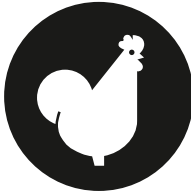
22

23



Trial location:

Broiler research farm of a Peruvian broiler producer



Project team leaders:

V. D. Naranjo,
J. Correa

TABLE 1: Trial Design, Methods and Materials

Animals	960 male Ross 308 broilers
Design	Completely randomized block design with 4 treatments and 8 replicates per treatment. Treatments included: 1) Reduced Met+Cys with MHA-FA 2) As treatment 1, but replacing MHA-FA with 65 parts DL-Met 3) Increased Met+Cys with MHA-FA 4) As treatment 3, but replacing MHA-FA with 65 parts DL-Met
Housing	Floor pens
Diets	Corn-soybean meal, full-fat soybean meal-and animal by products-based diets
Feeding	Broilers were fed a 5-phase feeding program that lasted from: d 0 to 12 (starter), 13 to 21(grower I), 22 to 28 (grower II), 29 to 36 (finisher I) and 37 to market (finisher II) on ad-libitum basis (see Table 1 for details)
Parameters	Body weight gain, feed intake and feed conversion ratio
Duration	38 days

TABLE 2: Product inclusions (kg/MT) of Met sources during all feeding phases from d0 to d38

Treatment	Feeding phases with duration				
	Starter (0 to 12)	Grower I (13 to 21)	Grower II (22 to 28)	Finisher I (29 to 36)	Finisher II (37 to market)
Reduced Met+Cys formulated with MHA-FA	3.79	3.74	3.74	3.38	3.29
As Diet 1, but with 65 parts DL-Met	2.46	2.42	2.43	2.20	2.14
Increased Met+Cys with MHA-FA	5.13	5.05	5.07	4.58	4.45
As Diet 3, but with 65 parts DL-Met	3.34	3.28	3.30	2.96	2.89
Product inclusions levels (kg/MT)					

TABLE 3: Growth performance of male broilers

Parameter	85% of Met+Cys		115% of Met+Cys	
	MHA-FA	65% DL-Met	MHA-FA	65% DL-Met
Final body weight (kg)	2.71	2.79	2.78	2.82
Cumulative feed intake (kg)	4.12	4.15	4.14	4.16
Feed conversion ratio (FCR)	1.52	1.49	1.49	1.48
Corrected FCR (2.70 kg)	1.54	1.50	1.50	1.49
European efficiency factor	465	480	486	495

TABLE 4: Economic benefits of replacing 100 parts of MHA-FA with 65 parts of DL-methionine

Switch from MHA-FA to MetAMINO**	MHA-FA	Met-AMINO**
MHA-FA demand in metric tons	1,260	
MetAMINO® ratio* to replace MHA-FA		65%
Equivalent MetAMINO® demand in metric tons		819
Price in \$/€/per kg **	2.40	3.00
Price ratio		80%
Costs in \$/€	3,024,000	2,457,000
Saving with MetAMINO® in \$/€		567,000
*65 units of MetAMINO® deliver comparable animal performance to 100 units of MHA-FA (source: MetAMINO® ATLAS, p.8; evonik.click/metamino)		
**FCA Europe price in € per kg from Calendar Week 8 in 2026 (source: Kemiex.com)		

Trial Objectives

The objective of the trial was to validate the recommended relative bioavailability of 65% at 2 different Met+Cys levels (below and above commercial requirement) by replacing 100 parts of liquid MHA-FA (88% BE) with 65 parts DL-Met on growth performance parameters of male broilers from 1 to 38 days of age.

Trial Results

- Overall, replacing 100 parts of liquid MHA-FA with 65 parts of DL-Met did not affect final BW, cumulative feed intake or FCR at either below or above the commercial Met+Cys levels in male broilers (*Table 3*)
- The European Production Efficiency Factor was greater for broilers fed DL-Met than their MHA-FA counterpart at both, the lower and greater Met+Cys levels (*Table 3*)
- The relative bioavailability of MHA-FA was validated to be equivalent to 65% DL-Met and that it can be applied at any Met+Cys level
- Replacing MHA-FA with DL-Met at a 65% ratio also offers significant potential for feed cost savings, with annual savings estimated at USD 567,000 (*Table 4*).

CONCLUSION

Results from the trial indicate that replacing 100 parts of MHA-FA with 65 parts of DL-Met did not affect growth performance parameters either below or above the commercial Met+Cys specification. An annual demand of 1,260 metric tons of MHA-FA could therefore be covered with only 819 metric tons of DL-Methionine, equivalent to a 65% ratio, resulting in annual savings of USD 567,000.

FEEDBACK

"This broiler trial conducted at the research facility of a Peruvian broiler integrator, confirmed that liquid MHA-FA can be replaced with 65 parts of DL-Met at any Met+Cys levels without affecting growth performance parameters while improving feeding costs, production efficiency and sustainability."



Dr. Victor Naranjo,
Technical Director Evonik
Guatemala SA



Asia-Pacific

- 14 **Oceania** / Performance responses of male broilers – PROXYMet™ vs. MHA-FA
- 15 **Oceania** / Performance responses of female broilers – PROXYMet™ vs. MHA-FA
- 16 **Thailand** / Bioefficacy of different methionine sources in male and female broilers
- 17 **China, Anhui** / Effects of PROXYMet™ replacing MHA-FA in white broilers
- 18 **China, Anhui** / Growth and slaughter parameters of Cherry Valley ducks
- 19 **China, Guangdong** / Growth performance and slaughter parameters of yellow broilers
- 20 **China, Hebei** / Effects of PROXYMet™ replacing MHA-FA in Peking ducks
- 21 **China, Shandong** / Growth performance of white broilers
- 22 **China, Shandong** / Equal growth with PROXYMet™ in broilers
- 23 **China, Shandong** / Broiler performance test with PROXYMet™

Effects of PROXYMet™ replacing MHA-FA in male broiler diets

Trial conducted by a broiler integrator in Oceania

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

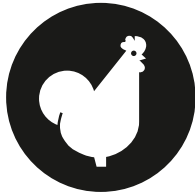
21

22

23



Trial location:
Oceania



Project team leaders:
Amy Liu,
Sheila Heidi M. Ramos,
Pradeep Krishnan

TABLE 1: Trial Design, Methods and Materials

Animals	320 Ross 308 male broilers
Design	Completely randomized design: 2 treatments with 8 replicates per treatment, 20 birds each
Housing	Housing is based on a pen-trial shed
Diets	Corn, soybean meal and sunflower based diet, supplemented with either: 1) MHA-FA as the methionine source; or 2) PROXYMet™: Similar to diet 1 but MHA-FA was replaced by PROXYMet™ (65% DL-Met, 35% limestone) in a 1:1 weight ratio. The feeding period (day 0-35) included 3 feeding phases: Starter (day 0-10), grower I (day 11-21), grower II (day 21-28), and finisher (day 29-35)
Feeding	The alignment between measured and expected concentrations of PROXYMet™ and MHA-FA throughout all feeding phases substantiates the precision and consistency of feed manufacturing in the analyzed trial diets.
Parameters	Average daily feed consumption, average daily gain (ADG), and feed conversion ratio (FCR)
Duration	35 days

FIGURE 1: Body weight of male broilers during the 35-day feeding period

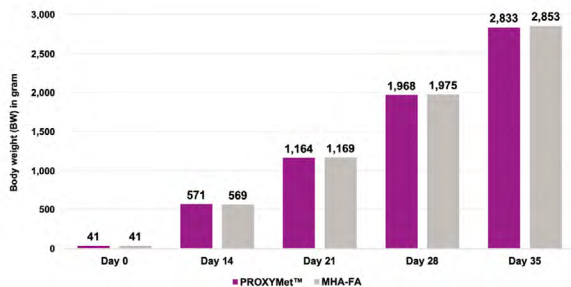


FIGURE 2: Cumulative feed consumption during the 35-day feeding period

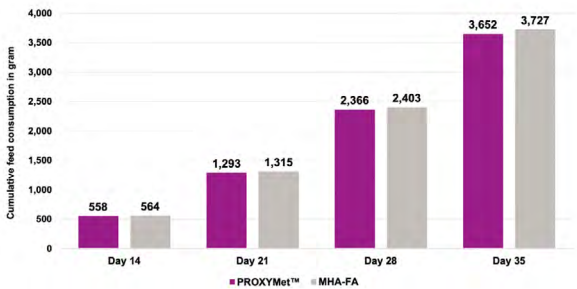
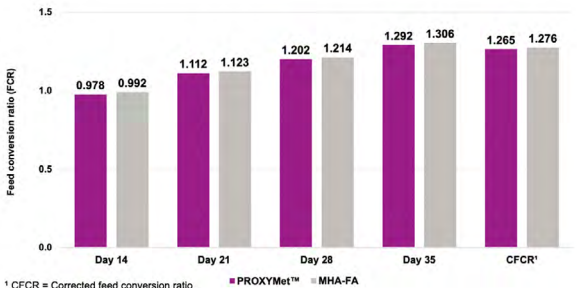


FIGURE 3: Feed conversion ratio during the 35-day feeding period



¹ CFCR = Corrected feed conversion ratio

TABLE 2: Dietary treatments fed from day 14 to 28

Item	Price USD / kg	Dosage kg / t	Met cost USD / t	Cost saving USD / t feed
MHF-FA	2.006	3.000	6.018	–
PROXYMet™	1.534	3.000	4.602	1.416

Trial Objectives

The objective of this study was to evaluate whether 650 g of DL-methionine supplied via PROXYMet™ could replace 1 kg of MHA-FA in diets for all-male broiler chickens while maintaining similar growth performance.

Trial Results

- The findings of this study indicate that the inclusion of 650 grams of DL-methionine supplied through PROXYMet™ can effectively substitute for 1 kilogram of MHA-FA in diets for all-male broiler chickens while sustaining comparable growth performance, as reflected by similar body weight (BW, *Figure 1*), feed consumption (*Figure 2*), and feed conversion ratio (FCR, *Figure 3*).
- 650 grams of DL-methionine supplied through PROXYMet™ is equivalent to 1,000 grams of MHA-FA.
- Replacement of MHA-FA with PROXYMet™ resulted in a feed cost reduction of 1.42 USD/t (*Table 2*).

CONCLUSION

This study conducted at a customer's trial facility in Oceania showed that 1 kilogram of MHA-FA can be replaced by 650 grams of DL-methionine in male Ross 308 broilers. This has strong cost saving potential when applied in commercial production conditions.

FEEDBACK

"The results of this experimental trial clearly show that 650 grams of DL-methionine achieve the same performance in male broilers as 1 kilogram of MHA-FA. This may have significant economic impact for commercial production."



Amy Liu,
Business Director,
Evonik Australia

Effects of PROXYMet™ replacing MHA-FA in female broiler diets

Trial conducted by a broiler integrator in Oceania

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

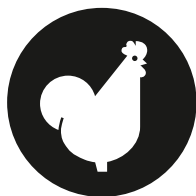
21

22

23



Trial location:
Oceania



Project team leaders:
Amy Liu,
Sheila Heidi M. Ramos,
Pradeep Krishnan

TABLE 1: Trial Design, Methods and Materials

Animals	320 Ross 308 female broilers
Design	Completely randomized design: 2 treatments with 8 replicates per treatment, 20 birds each
Housing	All experimental procedures were performed at an integrator's dedicated trial facility, which is designed to support optimum broiler growth and performance under conditions representative of commercial production practices.
Diets	Corn, soybean meal and sunflower meal-based diet, supplemented with either: 1) MHA-FA as the methionine source; or 2) PROXYMet™: Similar to diet 1 but MHA-FA was replaced by PROXYMet™ (65% DL-Met, 35% limestone) in a 1:1 weight ratio. The feeding period (day 0-34) included 3 feeding phases: Starter (day 0-10), grower I (day 11-21), grower II (day 21-28), and finisher (day 29-34)
Feeding	Verification of the expected PROXYMet™ and MHA-FA supplementation levels across all feeding phases provides evidence of accurate and consistent feed manufacturing in the analyzed trial samples.
Parameters	Average daily feed consumption, average daily gain (ADG), feed conversion ratio (FCR) and corrected FCR (CFCR) for 2.65 kg body weight and mortality
Duration	34 days

FIGURE 1: Body weight of female broilers during the 34-day feeding period

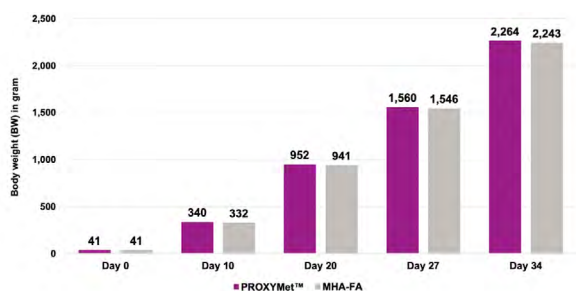


FIGURE 2: Phase-wise feed consumption during the 34-day feeding period

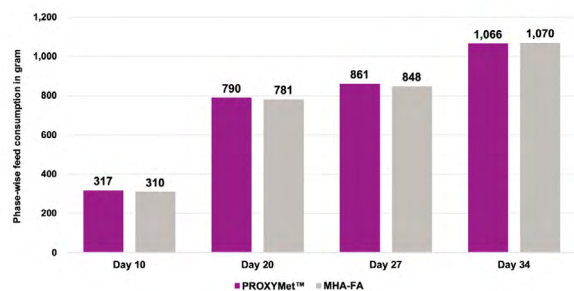
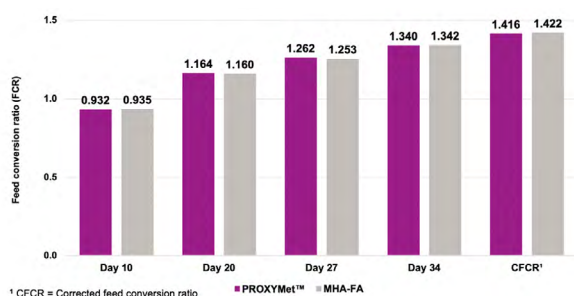


FIGURE 3: Feed conversion ratio during the 34-day feeding period



¹ CFCR = Corrected feed conversion ratio

TABLE 2: Costs of the different methionine sources per ton of feed

Item	Price USD / kg	Dosage kg / t	Met cost USD / t	Cost saving USD / t feed
MHF-FA	2.006	2.890	5.797	–
PROXYMet™	1.534	2.890	4.734	1.064

Trial Objectives

Building on findings from a prior all-male broiler study, this trial aimed to determine whether 650 grams of DL-methionine supplied via PROXYMet™ could effectively replace 1 kilogram of MHA-FA in all-female broiler feeds without affecting performance outcomes.

Trial Results

- Body weight gain (BWG), feed intake (FI), and feed conversion ratio (FCR) did not differ significantly among treatments at any feeding phase (*Figures 1, 2, 3*). However, birds receiving the PROXYMet™ treatment showed a numerical advantage of 22 grams in final body weight (*Figure 1*).
- 650 grams of DL-methionine in PROXYMet™ is a suitable replacement for 1 kilogram of MHA-FA in all-female broiler diets.
- Replacement of MHA-FA with PROXYMet™ resulted in a feed cost reduction of 1.06 USD/t (*Table 2*).

CONCLUSION

In this study conducted at a customer's trial facility in Oceania, PROXYMet™ matched MHA-FA performance and even delivered a 22 grams numerical weight gain advantage in female Ross 308 broilers. At 650 grams DL-methionine per kg product, PROXYMet™ stands as a reliable 1:1 MHA-FA substitute ready for commercial-scale adoption.

FEEDBACK

"The findings confirm that replacing 1 kilogram of MHA-FA with 650 grams of DL methionine provided through PROXYMet™ supports comparable performance in all female broilers, consistent with results from a previous trial."



Sheila Heidi M. Ramos,
Senior Technical Service
Manager, Evonik

Comparing the biological efficiency of dry DL-Methionine and Liquid HMTBa in male and female broiler chickens

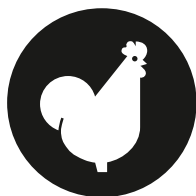
A Joint Research Trial conducted by Thailand's Kasetsart University (Kamphaeng Saen Campus), a local broiler integrator, and Evonik

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
Animal Research Centre,
Department of Animal
Science, Faculty of
Agriculture Kasetsart
University, Kamphaeng Saen
Campus, Nakhon Pathom,
Thailand



Project team leaders:
Dr. Yuwares Ruangpanit
Kasetsart University
(Kamphaeng Saen Campus)

TABLE 1: Trial I design: Biological efficiency in male broilers

Animals	1,080 Ross 308 male broiler chicks
Design	Treatment 1: Standard diet formulated based on the nutritional matrix of HMTBa. Treatment 2: Test diet supplemented with DL-methionine replacing HMTBa on a 65% basis. Treatment 3: Diet formulated at 90% of the standard nutrient specifications based on the HMTBa nutritional matrix Treatment 4: Diet formulated at 90% of the standard nutrient specifications supplemented with DL-methionine replacing HMTBa on a 65% equivalency basis
Diets	Experimental diets were formulated to meet the nutrient requirements of Ross 308 broilers in accordance with the Aviagen Ross 308 Broiler Nutrition Specifications (2022)
Feeding	Male broilers were fed in 4 phases: • Starter 1 (d 0-14): Crumble • Starter 2 (d 15-21): Pellet • Grower (d 22-33): Pellet • Finisher (d 34-40): Pellet
Parameters	Body weight gain, Feed intake, Feed conversion ratio, Mortality rate, Culling rate, Feed conversion ratio (mortality-corrected)
Duration	40 days

TABLE 2: Trial II design: Biological efficiency in female broilers

Animals	1,152 Ross 308 female broiler chicks
Design	Treatment 5: Standard diet formulated based on the nutritional matrix of HMTBa. Treatment 6: Test diet supplemented with DL-methionine replacing HMTBa on a 65% basis. Treatment 7: Diet formulated at 90% of the standard nutrient specifications based on the HMTBa nutritional matrix Treatment 8: Diet formulated at 90% of the standard nutrient specifications supplemented with DL-methionine replacing HMTBa on a 65% equivalency basis
Diets	Experimental diets were formulated to meet the nutrient requirements of Ross 308 broilers in accordance with the Aviagen Ross 308 Broiler Nutrition Specifications (2022)
Feeding	Female broilers were fed in 4 phases: • Starter 1 (d 0-14): Crumble • Starter 2 (d 15-21): Pellet • Grower (d 22-33): Pellet • Finisher (d 34-42): Pellet
Parameters	Body weight gain, Feed intake, Feed conversion ratio, Mortality rate, Culling rate, Feed conversion ratio (mortality-corrected)
Duration	40 days

TABLE 3: Effect of biological efficiency of dry DL-Methionine and Liquid HMTBa on the growth performance of male broilers at 40 days of age

Parameter	Treat-ment 1 HMTBa 100	Treat-ment 2 DLM 65	Treat-ment 3 90% HMTBa 100	Treat-ment 4 90% DLM 65	P-value
Initial weight	44.35	44.31	44.36	44.33	0.9935
Final weight (g)	3,404.27 ^b	3,488.13 ^a	3,390.85 ^b	3,426.35 ^{ab}	0.0102
Weight gain (g/b)	3,359.92 ^b	3,443.82 ^a	3,346.49 ^b	3,382.01 ^{ab}	0.0103
Feed intake (g/b)	5,396.32	5,380.26	5,302.55	5,344.62	0.5768
Feed conversion ratio	1.606	1.562	1.585	1.580	0.3088
Mortality (%)	1.481	0.741	1.852	1.111	0.8986
Production index based on mortality (%)	522.05	554.04	525.09	536.02	0.1392

^{ac} Means within the same row with different superscripts differ significantly (P < 0.05)

TABLE 4: Effect of biological efficiency of dry DL-Methionine and Liquid HMTBa on the growth performance of female broilers at 42 days of age

Parameter	Treat-ment 5 HMTBa 100	Treat-ment 6 DLM 65	Treat-ment 7 90% HMTBa 100	Treat-ment 8 90% DLM 65	P-value
Initial weight	43.74	43.73	43.70	43.72	0.9969
Final weight (g)	2,952.92	3,006.52	2,954.94	2,974.33	0.3805
Weight gain (g/b)	2,909.18	2,962.79	2,911.24	2,930.62	0.3811
Feed intake (g/b)	5,585.84	5,561.20	5,635.19	5,643.38	0.7885
Feed conversion ratio	1.920 ^{ab}	1.877 ^b	1.936 ^a	1.926 ^{ab}	0.0309
Mortality (%)	0.000	0.694	1.389	1.042	0.1680
Production index based on mortality (%)	366.17 ^{ab}	378.72 ^a	358.42 ^b	363.93 ^{ab}	0.0118

^{ac} Means within the same row with different superscripts differ significantly (P < 0.05)

TABLE 5: Economic benefits of replacing 100 parts of MHA-FA with 65 parts of DL-methionine

Switch from MHA-FA to MetAMINO**	MHA-FA	MetAMINO**
MHA-FA demand in metric tons	1,200	
MetAMINO* ratio* to replace MHA-FA		65%
Equivalent MetAMINO* demand in metric tons		780
Price in \$/€ per kg **	2.00	2.50
Price ratio		80%
Costs in \$/€	2,400,000	1,950,000
Saving with MetAMINO* in \$/€		450,000

65 units of MetAMINO deliver comparable animal performance to 100 units of MHA-FA (source: MetAMINO* ATLAS, p.8; evonik.click/metamino)

**FCA Europe price in € per kg from Calendar Week 8 in 2026 (source: Kemixx.com)

Trial Objectives

The collaborative study compares the efficacy of 65 parts of DL-Methionine (99%) and 100 parts HMTBa on the performance of commercial male and female broiler. The inclusion of both genders was a specific request from the local broiler integrator to re-confirm whether the 65% concept is equally effective in both.

Trial Results

Trial I: Animal performance in male broilers

- During the starter period (0–21 days of age) and grower period (22–33 days of age), dietary treatments significantly affected final body weight, weight gain, feed conversion ratio (FCR), Birds fed Treatment 2 exhibited the highest final body weight and weight gain ($P < 0.05$). Feed conversion ratio was significantly improved in Treatment 2 compared with the other treatments (Table 3; $P < 0.05$).
- During the finisher period (34–40 days of age), dietary treatments significantly affected final body weight (Table 3; $P < 0.05$). Birds receiving Treatment 2 had greater final body weight than Treatments 1 and 3, whereas Treatment 4 showed intermediate values and did not differ from the other treatments.
- Over the entire experimental period (0–40 days of age), overall body weight gain was significantly

affected by dietary treatments ($P < 0.05$). Birds fed Treatment 2 achieved greater body weight gain.

Trial II: Animal performance in female broilers

- During the starter period (0–21 days of age) and grower period (22–33 days of age), dietary treatments significantly affected final body weight, weight gain, feed conversion ratio (FCR), Birds fed Treatment 6 exhibited the highest final body weight and weight gain ($P < 0.05$). Feed conversion ratio was significantly improved in Treatment 6 compared with the other treatments (Table 4; $P < 0.05$).
- Over the entire experimental period (0–42 days of age), dietary treatments significantly affected overall FCR and production index based on mortality (PI [M]) (Table 4; $P < 0.05$).
- Birds fed Treatment 6 exhibited improved feed efficiency compared with Treatment 7, while Treatments 5 and 8 showed intermediate values and did not differ from either Treatment 6 or Treatment 7.

Economic savings

- The local broiler integrator currently uses 1,200 MT of HMTBa per year.
- Switching to DL-Methionine would result in annual savings of €450,000, equivalent to an 18.75% reduction in methionine cost (Table 5).

CONCLUSION

The efficiency of the two methionine sources was investigated in two studies, one in male broilers and one in female broilers, to assess whether the 65% concept is applicable regardless of gender. Diets containing dry DL-methionine at 65% equivalency relative to liquid HMTBa maintained growth performance and feed efficiency comparable to or superior to those obtained with other dietary treatments, while offering significant cost savings.

FEEDBACK

"The consistent outcome of both broiler trials at this facility provides strong evidence that 65% bioefficacy ratio of MetAMINO® can be reliably applied in commercial broiler production, delivering performance benefits alongside significant cost savings."



Dr. Pradeep Krishnan Rajalekshmy,
Regional Technical Director,
Evonik Methionine Sea PTE LTD

Trial Objectives

The objective of this trial was to determine the effect of PROXYMet™ (65% DL-methionine) replacing 100% MHA-FA on the performance of white broilers.

Trial Results

- There were no statistically significant differences between the PROXYMet™ group and MHA-FA group in white broilers in terms of final body weight (BW), feed conversion ratio (FCR), survival rate, and European Performance Efficiency Factor (EPEF, *Figures 1, 2, 3, 4*)
- Adding PROXYMet™ replacing an equal quantity of MHA-FA in white broiler feed can save about 10, 9, 8.8 RMB/t cost in the three feeding phases (*Table 2*), respectively.

CONCLUSION

The trial showed that PROXYMet™ (65% DL-methionine, DLM) can replace an equal quantity of MHA-FA in white broilers, with no difference in growth performance parameters. It confirmed the nutritional value of 65% for MHA-FA compared to DLM. Using PROXYMet™ to replace equal MHA-FA in white broiler feed can save cost for meat production.

FEEDBACK

"As shown in this trial, PROXYMet™ (65% DL-methionine) can replace 100% MHA-FA in white broilers and reduce diet cost. Our customer was convinced by the outcome of this trial and accepted that the nutritional value of MHA-FA is 65% compared to DL-methionine."



Daniel Gao,
Business Manager,
Evonik China

Trial Objectives

The objective of two consecutive trials was to challenge the recommended 65% bioefficacy for MHA-FA relative to DL-methionine on performance of meat-type Cherry Valley ducks.

Trial Results

- Compared with the MHA-FA treatment, the 65% DL-Met treatment (65% DL-Met replacing 100% MHA-FA) showed no significant differences in growth performance (e.g. body weight, body weight gain, feed conversion ratio) in both trials (*Figures 1 and 2*).
- Compared with the MHA-FA treatment, the 65% DL-Met treatment showed no significant differences in slaughter parameters (including breast muscle rate, leg muscle rate, and feather yield) in trial 1 (*Figure 3*).
- The feed cost of the 65% DL-Met treatment was reduced by 7 RMB/t in trial 1 and 5 RMB/t in trial 2, respectively, compared with the MHA-FA treatment.
- According to the customer, the cost per ton of duck meat production was reduced by 62 RMB/t in trial 1 and by 25 RMB/t in trial 2 for the 65% DL-Met treatment compared with the MHA-FA treatment.

CONCLUSION

65% DL-methionine (DL-Met) replacing 100% MHA showed no significant differences in growth performance and slaughter parameters of Cherry Valley ducks in two consecutive feeding trials. However, the feed cost of 65% DL-Met treatment was reduced by 5-7 RMB/t. Accordingly, the production cost for meat was lowered between 25 and 62 RMB/t. The nutritional value of 65% for MHA-FA compared to DL-Met was confirmed for meat-type ducks in these trials.

FEEDBACK

"65% DL-methionine can replace 100% MHA-FA in ducks and reduce diet cost. The customer was convinced by the outcome of these scientific studies and replaced all MHA-FA by DL-Met in feed."



Daniel Gao,
Business Manager,
Evonik China

Trial Objectives

The objective of this trial was to determine the effect of 65% DL-methionine (DLM) replacing 100% MHA-FA on growth performance and slaughter parameters of yellow broilers.

Trial Results

- Compared with the MHA-FA treatment, the 65% DLM treatment (65% DL-methionine replacing 100% MHA-FA) showed no differences in yellow broilers' body weight (BW, *Figure 1*), average daily gain (ADG, *Figure 2*), feed conversion ratio (FCR, *Figure 3*), as well as in slaughter parameters (*Figure 4*) of broilers.
- Adding 65% DLM to replace 100% MHA-FA in yellow broiler feed can save between 3 and 5.2 RMB cost per ton feed in the three feeding phases (*Table 2*).

CONCLUSION

65% DL-methionine (DLM) replacing 100% MHA-FA showed no differences on growth performance and slaughter parameters of yellow broilers. This trial confirms the nutritional value of 65% for MHA-FA compared to DLM. However, replacing 100% MHA-FA by 65% DLM in yellow broiler can save 3 to 5.2 RMB per ton feed.

FEEDBACK

"This trial conducted at a customer's farm showed that 65% DL-methionine can replace 100% MHA-FA in yellow broilers and reduce diet cost."



Lisa Qiao,
Business Manager,
Evonik China

Effect of PROXYMet™ replacing MHA-FA on performance of Peking ducks

Trial conducted 2024 by a customer in Hebei province, China

TRIAL

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

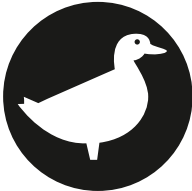
21

22

23



Trial location:
Hebei, China

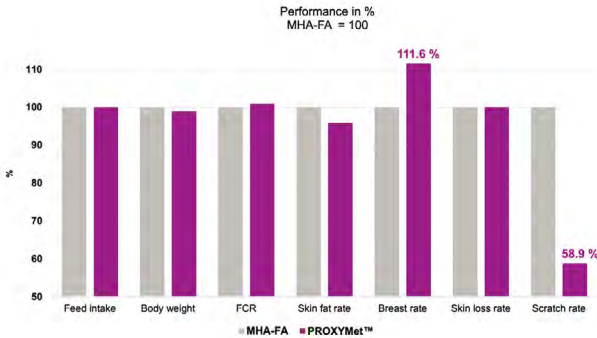


Project team leaders:
Alisa Lv, Dr. Tom Han

TABLE 1: Trial Design, Methods and Materials

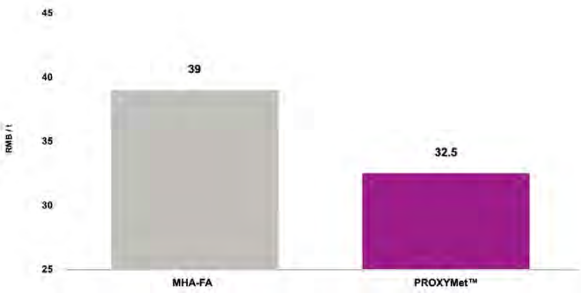
Animals	7,600 15-day-old Peking ducks
Design	Two groups of 3,800 animals each
Housing	Ducks were reared in their commercial farm with cage system
Diets	Corn-mix-meals-based commercial finisher duck feed Control group: commercial feed with MHA-FA (2.5 kg per ton) Treatment group: MHA-FA was replaced by PROXYMet™ (MetAMINO® diluted to 65% with limestone) in equal amounts The dosage of MHA-FA or PROXYMet™ was equal in the corresponding diets with 2.5 kg per ton
Feeding	Both groups received the corresponding feed and were managed under the customer's standard operating procedures
Parameters	- Final body weight (kg) - Feed intake (kg) - Feed conversion ratio (FCR) - Skin fat rate - Breast rate - Skin loss rate - Scratch rate
Duration	20 days (15-35d)

FIGURE 1: Performance parameters compared to MHA-FA



Parameter	MHA-FA (%)	PROXYMet™ (%)
Feed intake	100	100
Body weight	100	100
FCR	100	100
Skin fat rate	100	96
Breast rate	100	111.6
Skin loss rate	100	100
Scratch rate	100	58.9

FIGURE 2: Methionine source supplement costs in feed



Methionine Source	Cost (USD / t)
MHA-FA	39
PROXYMet™	32.5

52

Trial Objectives

The objectives of this study were:

1. to validate that PROXYMet™ can directly replace MHA-FA in commercial meat duck feeds without compromising animal performance
2. to provide strong evidence for duck feed customers to switch from MHA-FA to DL-methionine (DLM)

Trial Results

- Ducks in MHA-FA or PROXYMet™ groups reached a similar final body weight (2.62 vs 2.64 kg).
- No differences were found in feed intake, FCR, skin fat rate, and skin loss rate.
- Ducks in PROXYMet™ group showed higher breast rate and less scratch rate.
- Feed costs per ton were reduced by 6.5 RMB when using PROXYMet™ instead of MHA-FA (Figure 2).

CONCLUSION

The trial showed that MHA-FA can be directly replaced by the same weight of PROXYMet™ without compromising growth and slaughter performance in Peking ducks. This trial confirmed the nutritional value of 65% for MHA-FA compared to DL-methionine (DLM) in Peking ducks under commercial conditions. Feed costs per ton were reduced by 6.5 RMB when using PROXYMet™ instead of MHA-FA.

FEEDBACK

“Replacing 100 % MHA-FA with 65% DLM on a customer’s farm led to the same performance in Peking ducks and reduced feed cost.”



Alisa Lv,
Business Manager,
Evonik China

Trial Objectives

The objective of this study was to verify that the biological efficacy of MHA-FA is only 65% of solid DL-methionine, providing experimental evidence for the rational selection of methionine sources and reduction of feed costs.

Trial Results

- Compared to the MHA-FA group, broilers in the 65% DLM group showed a significantly higher body weight ($P=0.013$), better average daily gain (ADG) ($P=0.012$), and a lower feed conversion ratio (FCR) ($P=0.019$) during the starter phase (1-12 days, *Table 2*).
- During the grower phase (13-21 days; *Table 3*) and the finisher phase (22 – 40 days; *Table 4*) performance in terms of body weight, daily gain, feed intake, and feed conversion ratio did not differ between the MHA-FA treatment and the 65% DLM treatment.
- Overall, the growth performance during the entire period (1-40 days) was the same in the 65% DLM group compared to 100% MHA-FA (*Table 5*) confirming a relative bioefficacy of 65% for MHA-FA relative to DLM.
- The replacement of MHA-FA by only 65% dose with DLM reduced feed cost by 2.46 RMB/t (*Table 6*).

CONCLUSION

The trial showed that 65 parts of DL-methionine (DLM) can replace 100 parts of MHA-FA without compromising the growth performance of broilers with even better effects during their early phase and the potential to reduce feed costs. This proves that the bioefficacy of MHA-FA is only 65% on weight-basis compared to DLM.

FEEDBACK

“As the trial revealed, replacing 100 parts of MHA-FA with 65 parts of MetAMINO® in broilers is feasible and shows advantages in the early development phase. Overall, DLM promotes growth and feed utilization more effectively.”



Bill Chu,
Business Manager,
Evonik China

Effects of 65 parts of DLM replacing 100 parts of MHA-FA in broiler diets

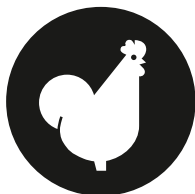
Trial conducted 2025 by Buen in Shandong province, China

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
Linyi, Shandong province,
China



Project team leaders:
Joe Wang, Dr. Tom Han

TABLE 1: Trial Design, Methods and Materials

Animals	1,360 Arber Acres broilers
Design	Completely randomized design of 4 treatments with 20 replicates per treatment and 17 birds each
Housing	Broilers were fed in a cage system under Buen's commercial trial farm conditions
Diets	Basal diet: corn-soybean meal-based commercial broiler feed. The feeding period (1-35 days) included 2 feeding phases: starter (1-20 days); grower (21-35days). Materials: MHA-FA (liquid MHA, 88% content); PROXYMet™ (MetAMINO® diluted to 65% content with limestone) 1) MHA-FA treatment (Control group): Standard commercial diet containing MHA-FA 2) PROXYMet™ treatment: MHA-FA was replaced with an equivalent amount of PROXYMet™; all other ingredients were the same as in the control formulation 3) 80% MHA-FA treatment: MHA-FA dosing was reduced by 20% compared to the control group, making it 80% of the original MHA-FA level 4) 80% PROXYMet™ treatment: The reduced MHA-FA in treatment 3 was replaced by an equivalent amount of PROXYMet™
Feeding	All broilers were raised according to Buen's standard operation procedures (SOP) under commercial conditions
Parameters	Body weight (BW), average daily feed intake (ADFI), feed conversion ratio (FCR)
Duration	35 days

FIGURE 1: Body weight (BW) of broilers on day 20 and 35 in different treatments

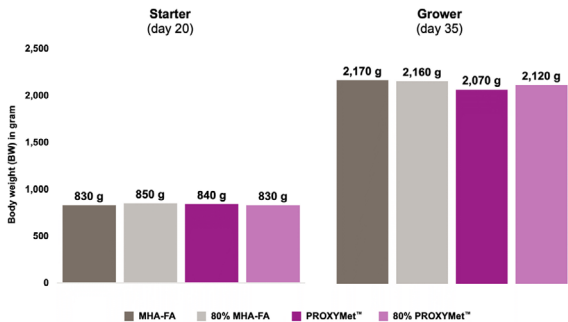


FIGURE 2: Average daily feed intake (ADFI) of broilers in starter and grower phases

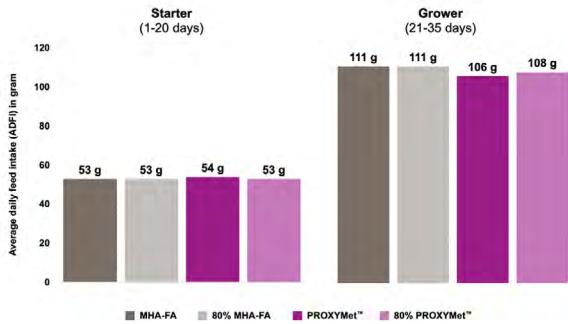


FIGURE 3: Feed conversion ratio (FCR) of broilers on day 20 and 35

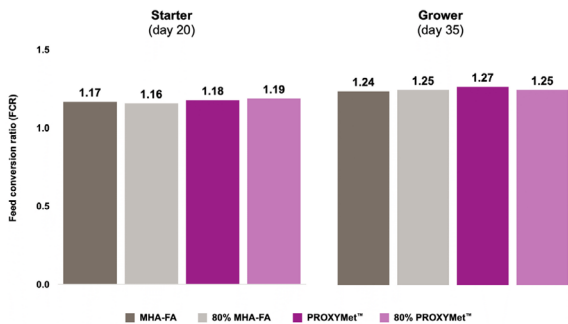


TABLE 2: Cost savings per ton feed

Item	Price RMB/kg	Dosage kg/t	Met cost RMB/t	Cost saving RMB/t feed
MHF-FA	15.0	3.54, 3.85	53.10, 57.75	–
PROXYMet™	13.0	3.54, 3.85	46.02, 50.05	7.08, 7.7

Trial Objectives

The objective of this study was to determine the effects of replacing 100 parts of MHA-FA with 65 parts of DL-methionine on broiler performance under commercial conditions

Trial Results

- Birds receiving feed added with PROXYMet™ showed no differences in body weight (*Figure 1*), average daily feed intake (*Figure 2*), and FCR (*Figure 3*) compared to those which received an equal quantity of MHA-FA.
- A 20% reduction of product supplementation did not impair broiler performance suggesting room for a reduction of dietary Met+Cys specifications in general (*Figures 1, 2, 3*).
- Replacing MHA-FA with PROXYMet™ saved about 7 to 7.7 RMB per ton of broiler feed (*Table 2*).

CONCLUSION

The trial showed that PROXYMet™ (65% DL-methionine, DLM) can replace an equal quantity of MHA-FA in Arber Acres broilers without compromising growth performance, while reducing feed costs. This trial conducted under commercial conditions confirmed the nutritional value of 65% for MHA-FA compared to DLM in broilers.

FEEDBACK

"The customer was convinced by the outcome of this trial and began to replace MHA-FA by MetAMINO® (DL-methionine) in parts of their broiler feed."



Joe Wang,
Business Manager,
Evonik China

Effects of 65 parts of DL-methionine replacing 100 parts of MHA-FA on growth performance in broiler diets

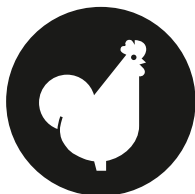
Trial conducted 2024 by New Hope Liuhe in Shandong province, China

TRIAL

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23



Trial location:
Pingdu, Shandong province,
China

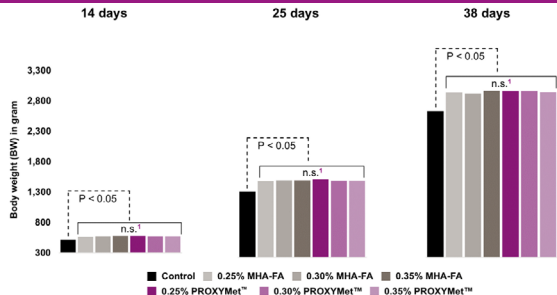


Project team leaders:
Dr. Lorin Zhang,
Dr. Tom Han

TABLE 1: Trial Design, Methods and Materials

Animals	1,848 one-day-old ROSS 308 male broilers
Design	Completely randomized design of 7 treatments (T1-T7) with 6 replicates per treatment, 33 birds each; using a 2 x 3 + 1 factorial arrangement with 2 sources of methionine (MHA-FA and PROXYMet™) and 3 levels of supplementation
Housing	3-layer large cage rearing system
Diets	Corn-soybean meal-based commercial broiler feed diets The feeding period (1-38 days) included 3 feeding phases: starter (1-14 days), grower (15-25 days), and finisher (26-38 days). Treatment T1: Negative control, deficient in methionine and cysteine (av. 34.6% below recommendation) Treatments T2-T3-T4: Supplemented with 0.25%, 0.30% and 0.35% MHA-FA, respectively Treatments T5-T6-T7: Supplemented with 0.25%, 0.30% and 0.35% PROXYMet™ (65% DL-Met, 35% limestone)
Feeding	Broilers were fed in a cage system under NHL's trial farm conditions
Parameters	Growth performance: Final body weight (FBW, g), average daily gain (ADG, g), average daily feed intake (ADFI, g), feed conversion ratio (FCR), survival rate (%) Slaughter performance: Carcass (%), breast (%), leg (%), wing (%), abdominal fat (%)
Duration	38 days

FIGURE 1: Effect of dietary treatments on broiler body weight (BW) from 0-38 days of age



¹ n.s.: nonsignificant

TABLE 2: Effect of MHA-FA and PROXYMet™ on final growth performance in broilers

Item		Final body weight	Average daily gain	Average daily feed intake	Feed conversion ratio	Survival
Met source	MHA-FA	2,962	76.7	104	1.35	98.1
	PROXYMet™	2,975	77.1	103	1.34	97.6
Level	0.25 %	2,968	76.9	103	1.35	97.9
	0.30 %	2,962	76.7	104	1.35	98.1
	0.35 %	2,974	77	103	1.34	97.6
SEM ¹		106	2.8	3	0.02	3.3
P-value	Met	0.67	0.67	0.89	0.21	0.68
	Level	0.95	0.96	0.9	0.35	0.94
	M x L	0.64	0.65	0.73	0.67	0.71

¹ SEM = standard error of the mean

TABLE 3: Effect of MHA-FA and PROXYMet™ on slaughter performance in broilers

Item		Carcass	Breast	Leg	Wing	Abdominal fat
Met source	MHA-FA	72.7	28.9	33.6	10.1	1.37
	PROXYMet™	73.9	30.4	32.4	9.9	1.44
Level	0.25 %	73.1	29.4	32.4	10.20	1.33
	0.30 %	73.6	29.6	32.4	9.83	1.49
	0.35 %	73.4	30.1	32.4	10.00	1.38
SEM ¹		2.2	1.8	1.2	0.42	0.33
P-value	Met	0.07	0.01	<0.01	0.04	0.45
	Level	0.76	0.54	0.50	0.03	0.37
	M x L	0.28	0.35	0.30	0.20	0.49

¹ SEM = standard error of the mean

TABLE 4: Cost savings per ton feed

Item	Price RMB / kg	Dosage kg / t	Met cost RMB / t	Cost saving RMB / t feed
MHF-FA	15.0	2.5, 3.0, 3.5	37.5, 45.0, 52.5	–
PROXYMet™	13.0	2.5, 3.0, 3.5	32.5, 39.0, 45.5	5.0, 6.0, 7.0

Trial Objectives

The objective of this study was to compare the effects of different levels of MHA-FA and DL-methionine (DLM) on the growth performance and carcass traits of broilers to further validate the 65% bioefficacy of MHA-FA. The findings aim to provide scientific evidence for the choice of methionine sources in the feed industry.

Trial Results

- The results of the trial showed that the control group had the lowest body weight ($P < 0.05$) during the 1-14, 15-25, 26-38 d period (*Figure 1*).
- Between the two methionine sources, the final body weight numerically favored the PROXYMet™ groups over the MHA-FA groups, although no statistical difference was found ($P > 0.05$; *Figure 1*).
- Overall, the results indicated no difference in growth performance between MHA-FA and PROXYMet™ (*Table 2*).
- Compared to MHA-FA, PROXYMet™ tended to improve the total eviscerated yield ($P = 0.07$) and significantly increased breast muscle yield ($P < 0.05$; *Table 3*).
- There were no significant interactions between methionine sources and inclusion levels ($P > 0.05$; *Tables 2 and 3*).
- Statistically, the inclusion level of either product had impact neither on final body weight, feed intake and feed conversion ratio (*Table 2*) nor on carcass yield and breast meat yield (*Table 3*) suggesting that lowest inclusion level was sufficient for optimizing performance.
- Compared to MHA-FA, using PROXYMet™ to replace could save 5, 6 or 7 RMB per ton feed at the dosing level of 2.5, 3.0 or 3.5 kg, respectively (*Table 4*).

CONCLUSION

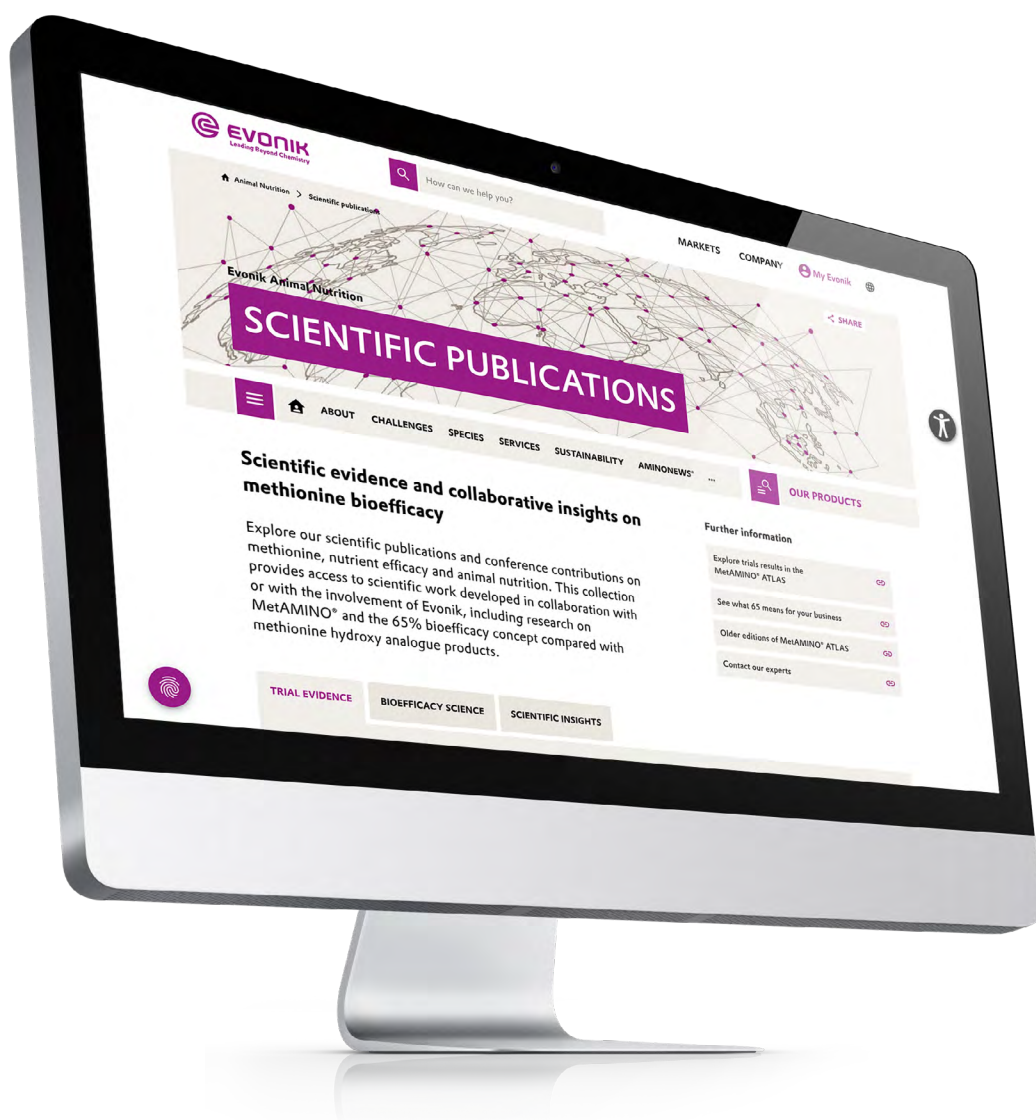
In this trial under trial farm conditions, PROXYMet™ and MHA-FA showed the same growth performance in ROSS 308 male broilers. Regarding slaughter performance, PROXYMet™ even achieved better results than MHA-FA. This trial confirmed the bioefficacy of 65% for MHA-FA compared to DL-methionine in broilers, regardless of the supplementation level, and the potential to reduce feed costs with DL-methionine.

FEEDBACK

"The customer was convinced by the results and decided to switch from MHA-FA to MetAMINO® (DL-methionine, DLM) for parts of his feeds."



Dr. Lorin Zhang,
Senior Business Manager,
Evonik China



Section 2

Articles & Abstracts





.....
Explore the complete collection online
The digital MetAMINO® ATLAS provides full access to all scientific publications, abstracts and expert insights referenced in this edition.
<https://evonik.click/metamino-atlas>
.....

Trial related articles & abstracts

- 1

Metabolic and nutritional response of Nile tilapia juveniles to dietary methionine sources; British Journal of Nutrition. 2022;127(2):202-213; Masagounder et al.
- 2

Growth and metabolic response of juvenile Nile tilapia demonstrate DL-Methionine is superior to MHA-Ca; Fish Farming Technology: International Aqua Feed, October 2021; Masagounder et al.
- 3

Higher nutritional value of DL-methionine confirmed in growing broilers; 24th European Symposium on Poultry Nutrition, 2025, #PS3-251; A. Lemme, J. Tyl, H. Kozeluhova, M. Naatjes
- 4

Responses of slow growing broilers to methionine supplementation and methionine sources; Evonik – Facts & Figures 15217, 2025; Dr. Andreas Lemme
- 5

Methionine supplementation affected performance of black soldier fly larvae (*Hermetia illucens*) and microbial activity; Bornimer Agrartechnische Berichte (111), ISSN 0947-7314 (InsectsPlus 2025, 12th-14th May, Cloppenburg, Germany), Page 71; Dr. Andreas Lemme and Patrick Klüber
- 6

Nitrogen retention was not different in pigs fed diets supplemented with 65 parts of DL-Methionine or 100 parts of MHA-Ca; Journal of Animal Science, Volume 103, Issue Supplement_1, May 2025, Pages 99-100; Jessica P. Acosta , S. Maria S. Mendoza , John K. Htoo , Hans H. Stein
- 7

Effects of supplemental methionine sources in finishing pig diets on growth performance, carcass characteristics, cutting yields, and meat quality; Translational Animal Science, Volume 8, 2024, txae088; Hannah M. Remole, John K. Htoo, S. M. Mendoza, Casey L. Bradley, Ryan N. Dilger, Anna C. Dilger, Bailey N. Harsh
- 8

Effects of methionine sources on performance and productivity in broiler breeders; Poultry Science Association Annual Meeting Abstracts (114th PSA abstract # 337 page 154), presented July 14-17, 2025 Raleigh, North Carolina; Fernanda Castro, Corey Wishon, Dannica Wall, Adam Fahrenholz, Victor Naranjo, Lynn Worley-Davis, Allison Pullin
- 9

Relative bioavailability value of DL-2hydroxy-4-methylthio butanoic acid to DL-methionine for growth performance parameters of male broiler from 14 to 28 days of age and 28 to 42 days of age; Poultry Science Association Annual Meeting Abstracts (113th PSA abstract #137 and #169), July 15-18, 2024 Louisville, Kentucky, US; G. Aguiar, G. Braga, L. Fonseca, M. Nascimento, D. Cardoso, A. Lourenco, N. Furlani, M. Farias, G. Viana, A. Lemme, J. Dorigam, V. Naranjo, M. Hannas
- 10

Effects of DL-methionine or methionine hydroxy analogue-free acid supplementation on growth performance and carcass yield of broilers fed reduced energy diets with guanidinoacetic acid supplementation; animals, 2026; Patrícia Tomazini Medeiros, Dr. Andreas Lemme, Victor Naranjo, Mariane Possamai, Rafael Rancatti, Alex Maiorka

Comparing the relative bioefficacy of MHA products with DL-methionine, related articles & abstracts

- 1 Meta-Analyses of Methionine Source Concept Validation Trials in Broilers; animals, 2024; Dr. Andreas Lemme, Zeyang Li, Julianio Dorigam
- 2 Effects of increased dietary supplementation with DL-methionine or with DL-methionine hydroxyl analogue on the intestinal morphology, and intestinal permeability- and immunity-associated gene expression, in growing pigs; Canadian Journal of Animal Science 105:1-8; Emmanuel O. Oladejo, Md. Shamimul Hasan, Susan C. Sotak, John K. Htoo, Peixin Fan, James Brett, Jean M. Feugang, and Shengfa F. Liao
- 3 Bioavailability of calcium salt of hydroxy analogue of methionine relative to DL-methionine to support growth performance of 11 to 20 kg pigs; Journal of Animal Science, 2024 May 4;102(Suppl 2):115–6; B. Jayaraman, J. Morales, M. Rodriguez and J. K. Htoo
- 4 Effects of methionine supplement sources and crude protein on Ross 708 male broiler performance and carcass yield; Journal of Applied Poultry Research, 2024; D.R. Boontarue, F.L.S. Castro, C.M. Poholsky, B.S. Liebross, J.W. Boney
- 5 Amino acid requirements of neonate larvae of the black soldier fly, *Hermetia illucens*; Journal of insects and food and feed, 2026; C. Sandroch, J. Wohlfahrt, T. Stadlander, F. Leiber, F. Schindler, M. Hardick, A. Lemme, C. Lambertz
- 6 Understanding methionine bioefficacy: Implications for animal performance and feed costs; Milling and Grain August 2026; Dr. Andreas Lemme
- 7 Multitissue transcriptomics demonstrates the systemic physiology of methionine deficiency in broiler chickens; Animal Volume 18, Issue 5, 2024; Klünemann et al.
- 8 Methionine sources differently affect production of reactive oxygen species, mitochondrial bioenergetics, and growth of murine and quail myoblasts in vitro; current issues in molecular biology, 2023; Katja Stange, Toni Schumacher, Claudia Miersch, Rose Whelan, Martina Klünemann, Monika Röntgen
- 9 Effect of DL-methionine and MHA on the performance and gut health of aflatoxin-challenged broilers; Poultry Science Association Annual Meeting Abstracts (114th PSA abstract #300); C. Gayard, C. Fudge, C. Chongxiao, R. Shanmugasundaram, T. Applegate
- 10 Supplementation of DL-methionine at 65% of MHA-FA supports similar performance in broilers irrespective of dietary crude protein and methionine + cysteine levels, Poultry Science Association Annual Meeting Abstracts, 2024 (113th PSA abstract #170), Zeyang Li, Julianio Dorigam, Dr. Andreas Lemme, Gabriel Viana

Latest research of DL-methionine, related articles & abstracts

- 1 Preventive–curative functional amino acid–supplemented diet improves health, growth performance, and resilience of growing pigs under an immune challenge; Journal of Animal Science 104, 2026; França et al.
- 2 Estimating standardized ileal digestible methionine requirements for gilts during gestation using whole-body nitrogen retention and describing plasma creatine, glutathione, and taurine concentrations; Journal of Animal Science 103, 2025; Alfonso et al.
- 3 Transport and expression of transporters for 3-O-methyl-D-glucose and L-methionine along the intestine of broiler chickens receiving different methionine supplements; Poultry Science, 2025; Riedel et al.
- 4 Rethinking amino acid nutrition of black soldier fly larvae (*Hermetia illucens*) based on insights from an amino acid reduction trial; insects, 2024; Dr. Andreas Lemme, Patrick Klüber
- 5 Betaine cannot replace methionine; Expert Note, July 2026; Dr. Andreas Lemme

Unlocking the full potential of MetAMINO®:

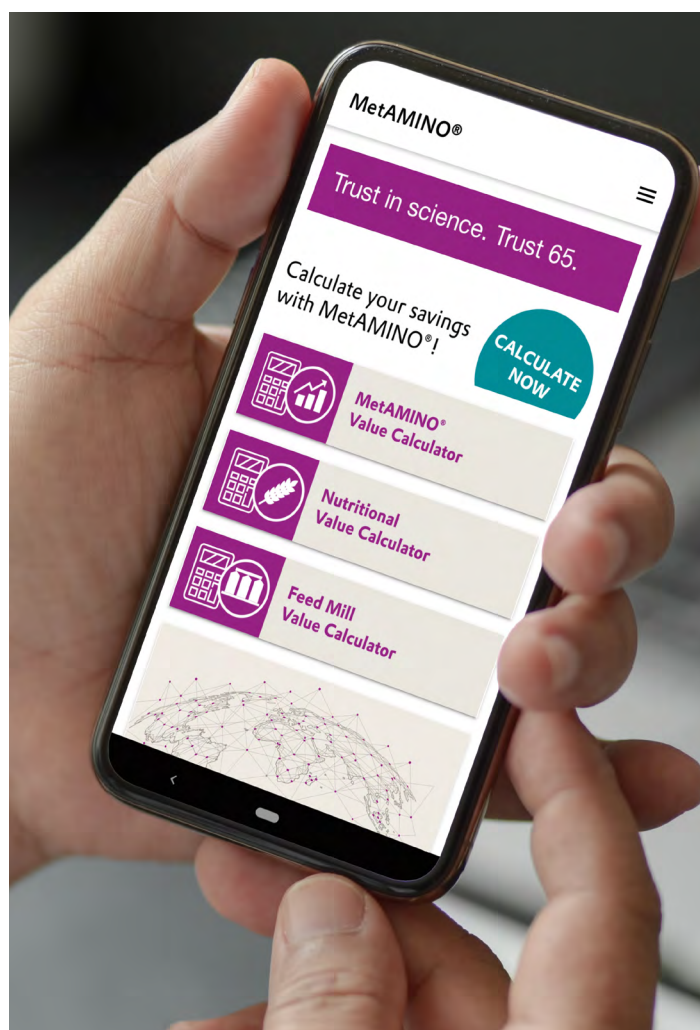
Related articles & insights from AMINO Services

- 1 An advanced approach for replacing methionine hydroxy analogue with DL-methionine suggests considerable feed cost savings beyond product price-related savings; AMINO*News*, July 2026; Dr. Andreas Lemme, Han
- 2 Key to precisely balanced diets – How to implement precision nutrition; Dr. Markus Wiltafsky-Martin, Director Service Commercialization, Evonik
- 3 AMINONIR: Near-infrared spectroscopy (NIR) analytical service – the next level; Dr. Markus Wiltafsky-Martin, Director Service Commercialization, Evonik
- 4 Incorporating liquid MHA-FA into feed can result in longer mixing times compared to dry DL-methionine; Christian Rabe, Head of Feed Technology, Evonik

From bioefficacy evidence to economic application

MetAMINO® Calculator

- Calculate your methionine savings in
 - purchasing
 - feed formulation
 - feed milling
- Make data-driven decisions



From evidence to application

.....

The MetAMINO® ATLAS brings together trial evidence and scientific publications that demonstrate the nutritional value of DL-methionine. Turning this evidence into measurable value also requires practical tools, reliable data and implementation expertise. The following extended abstracts show how Evonik's AMINO Services help nutritionists and feed producers apply scientific insights in daily practice, from feed-cost optimisation and precision nutrition to raw-material analytics and feed-mill operations.

.....

An advanced approach for replacing methionine hydroxy analogue with DL-Methionine suggests considerable feed cost savings beyond product price-related savings

AMINONews® | July 2026

Dr. Andreas Lemme and Tom Han

Based on many simultaneous dose-response studies, Evonik's recommendation for the nutritional value of methionine hydroxy analogue (**MHA**) relative to that of DL-methionine (**DL-Met**) is 65 % (Lemme et al., 2020). This recommendation is supported by a 2020 publication that not only provides a meta-analysis of recent dose-response trials but also validates the methodology used. This validation reinforces the recommendation that 1 kg of supplemental MHA can effectively be replaced by 650 g DL-Met without compromising animal performance under any production conditions. In fact, simultaneous dose-response trials have been conducted for over 40 years and Evonik's 65 % bioefficacy recommendation was first established in the 1990s (Jansman et al., 2003; Lemme et al., 2007, 2012). Numerous feeding trials have been conducted since then to challenge this recommendation. A recent meta-analysis of such 65:100 challenge trials clearly demonstrates that broiler performance remains unaffected when 65 % DL-Met is used in place of 100 % MHA (Lemme et al., 2024).

Moreover, the meta-analysis revealed that the 65 % bioefficacy concept works consistently with any dietary Met+Cys setting (below, at, above requirement), with any MHA product (free acid, calcium salt), with any source of data (grey, peer-reviewed literature), with any diet type (corn, wheat, corn+wheat based) or with any broiler strain (e.g., Ross 308, Cobb 500). The firm conclusion drawn from all these data is that MHA supplementation can always be replaced with 65 % as much DL-Met without compromising animal performance. This substitution also enables cost savings provided the price ratio of DL-Met to MHA does not exceed 65 %.

However, replacing MHA with DL-Met offers an additional opportunity to optimize diet composition, enabling significant feed cost savings. It should be emphasized that this concept starts with a theoretical potential. A detailed analysis of the diet composition is essential to determine the extent to which this potential can be practically realized.

HOW MHA REPLACEMENT IS RELATED TO THE IDEAL PROTEIN CONCEPT

The term "advanced MHA replacement" aligns with the ideal protein (**IP**) concept. This concept emphasizes that animals require essential amino acids (**EAA**) in specific ratios to effectively meet their needs for both growth and for maintenance. While the IP concept is based on

dietary digestible amino acids, Lys is usually the reference amino acid meaning all other digestible EAA are expressed relative to digestible Lys. A well established and accepted amino acid profile for broilers is provided with AMINOSpec® Chick 3.2 (Table 1).



.....
Read the full articles in the digital MetAMINO® ATLAS

The digital MetAMINO® ATLAS provides full access to the expert articles featured in this section, together with the complete trial content and supporting scientific resources.

<https://evonik.click/metamino-atlas>

Table 1 Ideal amino acid profile for broilers fed a 5-phase feeding program suggested by AMINOSpec® Chick 3.2

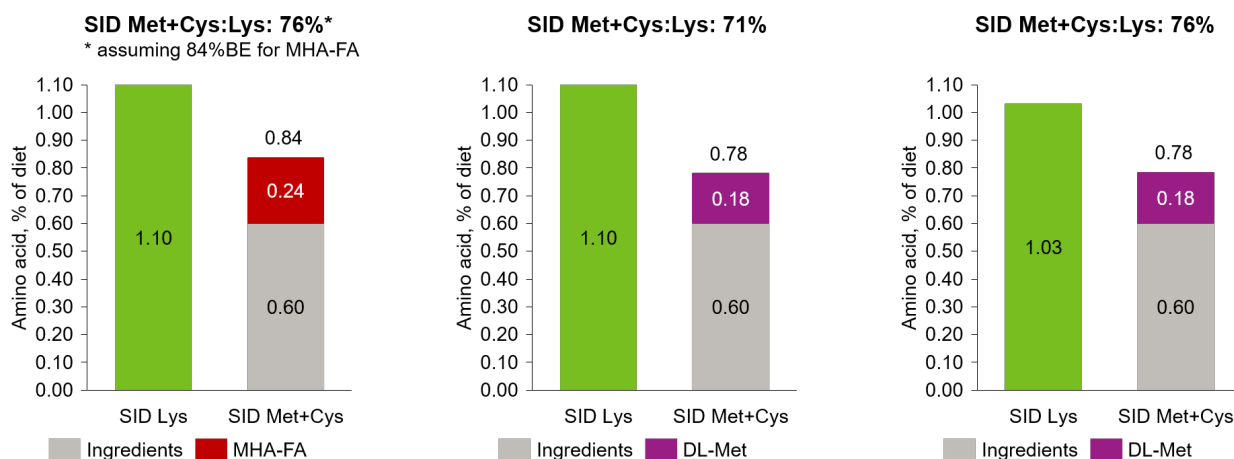
Evonik ideal protein profile (SID AA: SID Lys, %)

	Lys	Met	Met+Cys	Thr	Trp	Arg	Ile	Leu	Val	His	Phe+Tyr	Gly equiv.
0–12 days	100	40	72	63	16	103	68	107	79	33	116	121
13–24 days	100	41	74	64	16	104	69	107	80	33	116	118
25–35 days	100	42	76	65	16	105	71	107	80	33	116	115
36–48 days	100	43	77	66	17	107	72	107	81	33	116	112
49–54 days	100	43	79	67	17	108	73	107	81	33	116	110

As shown in Table 1, the suggested ratios of EAA to standardized ileal digestible (SID) Lys change with age. Accordingly, for example, the SID Met+Cys:Lys ratio increases from 72 % in starter feed to 79 % in finisher feed. This can be explained by changing proportions of SID Met+Cys requirements for growth and for

maintenance purposes. It should also be noted that ratios for semi-essential Gly_{equivalents} (SID Gly + 0.714 * SID Ser) to Lys are defined but they shrink as birds are getting older because of increasing capacity for de-novo synthesis of Gly and Ser.

Figure 1 The overestimation of the nutritional value of MHA supplementation also means an overestimation of dietary SID Met+Cys and SID Met+Cys:Lys ratio and allows for adjustment of the entire essential amino acid profile when replacing MHA with DL-Met in a 100:65 weight ratio in a 25-35 day broiler feed.



In the context of MHA replacement with DL-Met, the SID Met+Cys:Lys ratio is of particular relevance. The nutritional value of MHA is often overestimated, which leads to an overestimation of the overall dietary SID Met+Cys levels and, consequently, the SID Met+Cys:Lys ratio.

The scenario displayed in the left graph of Figure 1 illustrates the nutritional goal of a nutritionist who uses MHA while applying a bioefficacy of 84 % for MHA to meet SID Met+Cys recommendations. The targeted amino acid levels are 1.100 % SID Lys and 0.836 % SID Met+Cys achieving an SID Met+Cys:Lys ratio of 76 %. In this scenario, the ingredients contribute 0.60 % SID Met+Cys leaving a gap of 0.236 % SID Met+Cys that needs to be covered using supplemental MHA. Assuming a bioefficacy of 84 % for MHA, the nutritionist assumes that each kg of MHA provides 840 g SID Met+Cys. Consequently, 0.281 % MHA is supplemented to bridge the gap ($0.236 / 0.84 = 0.281$).

Based on the concept of 65 % bioefficacy for MHA, 0.281 % MHA can be replaced by 0.183 % DL-Met without compromising animal performance. The middle graph in Figure 1 shows that the addition of 0.183 % DL-Met to the SID Met+Cys from ingredients results in a total of 0.783 % SID Met+Cys instead of the originally

targeted 0.836 %. Consequently, the SID Met+Cys:Lys ratio decreases to 71 %, indicating that this ratio was overestimated when using MHA. The magnitude of this overestimation, however, depends on the assumed bioefficacy for MHA and the extent of the SID Met+Cys gap that needs to be filled by supplemental MHA.

The Nutritional Value Calculator available at www.metamino.com can help nutritionists identify the magnitude of SID Met+Cys overestimation. The AMINOSpec® Chick 3.2 recommendation for 25–35-day-old broilers specifies a SID Met+Cys:Lys ratio of 76 %. According to the middle graph of Figure 1, the SID Met+Cys:Lys ratio is lower than 76 % but approximately 71 % when using DL-Met. This indicates a relative oversupply of SID Lys along with an excess of all EAA. Consequently, the SID Lys specification can be reduced to a level that aligns with the recommended SID Met+Cys:Lys ratio of 76 %.

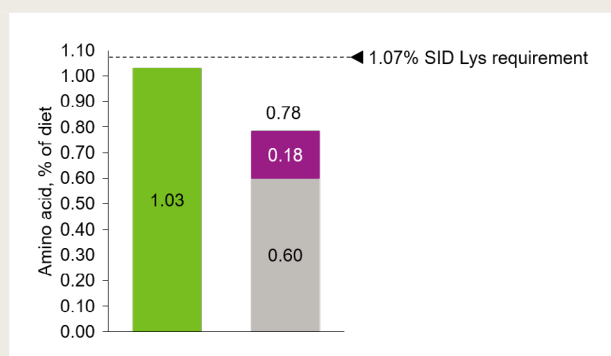
In the example shown in the right graph of Figure 1, SID Lys can be reduced from 1.10 % to 1.03 %, which is about 6 % lower. This adjustment is not limited to SID Lys specifications, but all other EAA can be reduced to meet the IP profile. In a feed formulation this would most likely result in substantial diet cost reductions.

THE DIFFERENCE BETWEEN A THEORETICAL POTENTIAL AND A REALISTIC SAVING SCENARIO

Indeed, the scenario described in Figure 1 suggests an opportunity to adjust the dietary amino acid profile. However, whether such adjustment can be implemented without affecting the performance of the animals depends on whether the specified amino acid levels and ratios meet or exceed the requirements of the broilers.

Under practical conditions, the ideal SID Met+Cys:Lys ratio may slightly differ from the actual recommendation. What would happen if the SID Met+Cys requirement is overestimated or exceeded in the broiler feed as assumed in the scenarios displayed in Figure 1? What if the optimal SID Met+Cys:Lys ratio is not 76 % but only 73 %? Such a discrepancy may occur due to several factors, including, for example, optimal production conditions that reduce the maintenance Met+Cys requirement of broilers or Met+Cys matrix values for feed ingredients that differ from analysed values. Of course, broiler performance will not be negatively affected when DL-Met is used to replace MHA-FA provided the 65 %-bioefficacy concept is applied (Figure 1, middle graph). However, if the adjustment of SID Lys and all EAA still assumes an optimal SID Met+Cys:Lys ratio of 76 %, the resulting SID Lys level of 1.03 % is 0.04 % lower than the optimal level of 1.07 % SID Lys. Consequently, 1.03 % SID Lys along with all EAA would become limiting amino acids, certainly impairing broiler performance.

Figure 2 An overestimation of the SID Met+Cys requirement may result in lower-than-required SID Lys in the case of full EAA adjustments after replacing MHA-FA with DL-Met in a 100:65 weight ratio



Moreover, assuming an SID Met+Cys:Lys of 76 % suggests a potential of 0.07 % SID-Lys reduction to 1.03 %. However, compared to 1.10 % SID Lys, the theoretical potential of 0.07 % SID Lys reduction can only be realized by 42 % (1.07 % vs 1.03 %).

These findings highlight the importance of exercising caution when adjusting SID Lys and EAA levels during the replacement of MHA-FA with DL-Met. Despite this, there remains a significant potential for reducing SID Lys and EAA levels, which could lead to notable feed cost savings—on top of the cost benefits of using DL-Met instead of MHA-FA.

WHAT COULD BE A REALISTIC ADJUSTMENT OF SID LYS AND EAA COMBINED WITH AN MHA REPLACEMENT BY DL-MET?

To address this question a broiler feeding trial was conducted at the Poultry Testing Station, Ustasice, Czech Republic (Table 2). Standard starter (1-8d), grower 1 (9-16d), grower 2 (17-24d), and finisher diets (25-35d) were formulated according to AMINOSpec® Chick 3.2 recommendations.

- In treatment 1, liquid MHA-FA was used for balancing SID Met+Cys and a bioefficacy of 88 % was assumed for MHA-FA.
- MHA-FA was replaced with DL-Met in a 100:65 weight ratio in Treatment 2. The SID Met+Cys:Lys ratios of starter, grower 1, grower 2, and finisher diets were 64, 65, 67, and 68 %, which were considerably lower than the targeted 72, 73, 74, and 76 % in Treatment 1.
- In Treatments 3 to 5, SID Lys and all EAA were gradually adjusted. Accordingly, the adjustments represented 25, 50, and 75 % of the entire theoretical potential for the individual feeding phases. Reducing the SID Lys and EAA levels but maintaining the SID Met+Cys specification at the same time led to gradually increased SID Met+Cys:Lys ratios from 70 (Trt 2), 71 (Trt 3), 72 (Trt 4), and 74 % in Treatment 5.
- In a further set of treatments (6 to 10), the diets were formulated using the same specification as those of treatments 1 to 5, except for methionine source supplementation. The supplementation of MHA-FA and DL-Met was halved in order to ensure a marginal SID Met+Cys supply. Accordingly, SID Met+Cys:Lys ratios in starter, grower 1, grower 2 and finisher diets of Treatment 7 were 54, 55, 56, and 59 % and increased to 58, 59, 60, and 62 % in Treatment 10.

Table 2 Experimental design of a broiler feeding trial in which liquid MHA-FA was replaced with DL-Met with different degrees of SID Lys adjustments.

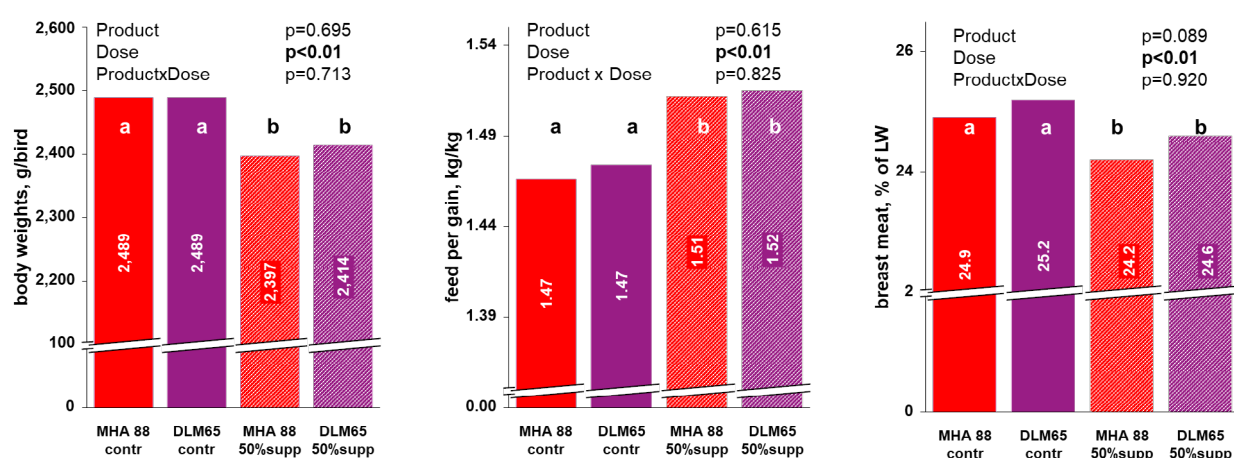
Treatment		Product ¹	Dose of Product	SID Lys adjustment potential % of potential	SID Lys			
Part 1	Part 2				% of diet			
					S	G 1	G 2	F
1		MHA-FA	To achieve recommended SID Met+Cys 2	0	1.34	1.29	1.22	1.15
2	2	DL-Met	65 % as much as Trt 1	0	1.34	1.29	1.22	1.15
	3	DL-Met	65 % as much as Trt 1	25%	1.31	1.26	1.19	1.12
	4	DL-Met	65 % as much as Trt 1	50%	1.27	1.22	1.16	1.10
	5	DL-Met	65 % as much as Trt 1	75%	1.24	1.19	1.13	1.07
6		MHA-FA	50 % as much as Trt 1	0	1.34	1.29	1.22	1.15
7	7	DL-Met	50 % as much as Trt 2	0	1.34	1.29	1.22	1.15
	8	DL-Met	50 % as much as Trt 2	25%	1.31	1.26	1.19	1.12
	9	DL-Met	50 % as much as Trt 2	50%	1.27	1.22	1.16	1.10
	10	DL-Met	50 % as much as Trt 2	75%	1.24	1.19	1.13	1.07

¹DL-Met: MetAMINO®; MHA-FA: liquid methionine hydroxy analogue free acid, in feed formulations MHA-FA was considered with 88 % bioefficacy relative to DL-Met

Experimental feed formulations were adjusted to reflect amino acid and proximate analyses (AMINONIR®) of corn, wheat, soybean meal, and rapeseed meal. All experimental diets were analysed for amino acids, MHA-FA, free DL-Methionine and proximates content (AMINOLab®, AMINONIR®). Analytical results confirmed calculated values. Diets were mixed and pelleted at the feed mill of the Poultry Testing Station.

A total of 8,400 mixed-sex day old Ross 308 broiler chicks with an average weight of 47.3 ± 0.86 g/chick (mean $\pm$ SD) were equally assigned to 60 floor pens with 140 birds each. Wood shavings were used for bedding in the pens of 8.15 sqm (17.2 birds/sqm). The barn was fully climate controlled, and the temperature program was set according to the Ross broiler manual. Water and feed were supplied ad libitum.

Figure 3 Final body weight (left), feed conversion corrected for mortality (middle) and breast meat yield (right) of broilers fed diets supplemented with liquid MHA-FA (MHA 88) or DL-methionine (DLM65) in a 100:65 weight (Treatments 1, 2, 6 and 7) ratio either to meet AMINOSpec® Chick 3.2 specifications or with 50 % reduced product dose.



^{a,b} Means within performance parameter with no common superscript differ significantly ($P < 0.05$) related to analysis of variance (ANOVA).

Feed consumption and body weights were determined after each feeding phase. Feed conversion ratio (FCR) was corrected for mortality. At the end of the experiment, 4 male and 4 female broilers were selected for carcass evaluation from each pen. Carcass, breast meat, and thigh weights, as well as abdominal fat weights, were determined and related to live weight. Data were analysed by two-way ANOVA with interactions. For this purpose, data were split into Part 1 (Treatments 1, 2, 5, and 6) and Part 2 (Treatments 2, 3, 4, 5, 7, 8, 9, and 10) (see Table 2). Treatment differences were considered significant with $P < 0.05$ (Tukey).

Results shown in Figure 3 confirm earlier findings that replacing MHA-FA with DL-Met in a 100:65 weight ratio allowed for the same growth, feed conversion ratio and meat yield (Lemme et al., 2024). Even at marginal SID Met+Cys levels (50 % product supplementation), no performance difference between the MHA-FA and DL-Met treatments were observed validating the statement that the 65 % bioefficacy concept is successfully

applicable under nutritionally sensitive test conditions. The absence of statistical interactions ($P > 0.05$) substantiates the independency of the 65 % bioefficacy concept from dietary Met+Cys supply.

Adjustments of SID Lys and EAA had an impact on broiler performance (Table 3). Statistically, an adjustment of SID Lys and EAA by up to 50 % did not negatively impact broiler performance in any respect.

In contrast, 75 % adjustments resulted in lower final body weights, a higher feed conversion ratio, and a reduced breast meat yield ($P < 0.05$). Although these effects were more pronounced at higher product supplementation levels (interaction: $P < 0.05$), it indicates that the amino acid supply limited broiler performance in Treatments 5 and 10. It is concluded that it is not advisable to reduce SID Lys and EAA by more than 75 % of the theoretical potential for diets used in this trial. It can be speculated whether dietary SID Met+Cys in the control diets exceeded the actual requirement, or whether other SID EAA were below the

requirement levels. This imbalance may have led to an overestimation of the potential for dietary adjustments. Notably, the final body weights across all treatments exceeded the breeder performance objectives (Aviagen, 2021; 7.5 to 14 % above). In conclusion, it will be challenging to identify the potential for SID Lys and EAA adjustments alongside a MHA replacement under commercial conditions. It is therefore not recommended to apply the full theoretical potential immediately, but rather to approach it step-wise.

Interestingly, broiler performance at 50 % reduced DL-Met supplementation (Treatments 6-10) did not differ significantly from that at 100 % DL-Met supplementation (Treatments 1-5), as shown in Table 3 although statistical analysis conducted for Treatments

1, 2, 6, and 7 (Figure 3) showed significant effects. In any case, the performance reduction was not strongly pronounced, and it can be speculated whether the SID Met+Cys requirement for growth was low because of excellent production conditions.

Even though only 50 % of the theoretical potential for adjusting dietary SID Lys and EAA along with the replacement of MHA-FA with DL-Met in a 100:65 weight ratio allowed for similar performance compared to the MHA control, feed cost savings of up to €9.31/t was achieved (Table 3). These savings were almost €7.00 higher compared to simple product replacements (Treatments 2 and 7), assuming a DL-Met price of €2.50/kg and an MHA-FA price of €2.00/kg.

Table 3 Final body weight (BW), feed conversion ratio (FCR), carcass yield, abdominal fat, and breast meat yield (BMV) of broilers fed experimental diets differing in both the dosage level of DL-Methionine and the degree of dietary adjustment of EAA levels to increase SID Met+Cys:Lys ratios

Trt	Product	Product dose % of optimal	SID Lys adjust- ment %	Average diet cost €/t	Diff. to MHA-FA treatment ¹	BW Day 35 g/bird	FCR Overall kg/kg	Carcass yield % of LW	Abd. Fat % of LW	BMV all % of LW
2	DL-Met	100	0	349.24	-2.34	2489	1.474 ^a	72.3	0.98	25.2 ^a
3	DL-Met	100	25	345.63	-5.94	2427	1.499 ^{ab}	72.5	1.06	25.1 ^a
4	DL-Met	100	50	342.26	-9.31	2468	1.485 ^a	71.9	0.97	24.8 ^a
5	DL-Met	100	75	338.84	-12.73	2347	1.557 ^b	72.1	1.11	23.5 ^b
7	DL-Met	50	0	345.94	-1.17	2414	1.515 ^{ab}	71.9	0.99	24.6 ^a
8	DL-Met	50	25	342.19	-4.92	2438	1.495 ^a	71.8	0.97	24.6 ^{ab}
9	DL-Met	50	50	338.71	-8.40	2420	1.503 ^{ab}	71.6	1.06	24.2 ^{ab}
10	DL-Met	50	75	335.18	-11.92	2385	1.510 ^{ab}	71.5	1.08	24.2 ^{ab}
Pooled SEM						23.8	0.0135	0.38	0.053	0.27
		100				2433	1.504	72.2	1.03	24.6
		50				2414	1.506	71.7	1.02	24.4
			0			2452 ^a	1.495 ^{ab}	72.1	0.99	24.9 ^a
			25%			2433 ^{ab}	1.497 ^a	72.1	1.01	24.8 ^a
			50%			2444 ^a	1.494 ^{ab}	71.8	1.01	24.5 ^{ab}
			75%			2366 ^b	1.533 ^b	71.8	1.09	23.8 ^b
ANOVA with interactions, p-levels										
Product dose						0.307	0.815	0.063	0.924	0.227
Adjustment of EAA						0.004	0.016	0.296	0.068	<0.01
Interaction						0.085	0.010	0.932	0.863	0.029

¹ average diet cost of Treatments 1 and 2 were €351.57/t and €347.10/t, respectively

a-c Means within a column with no common superscript differ significantly (P < 0.05) related to analysis of variance (ANOVA).

TRIALS UNDER REAL COMMERCIAL CONDITIONS REVEALED PROMISING OUTCOMES

The concept of combining an MHA replacement with an adjustment of SID Lys and EAA has been applied in three consecutive broiler feeding trials in China. These trials were conducted in commercial barns equipped with cage systems, a common practice in China's broiler production. The first trial included 2 x 4 houses with about 31,400 broilers each, the second 2 x 3 houses with 30,800 broilers each, and the third trial included 2 houses with 31,500 broilers each. While the broiler fattening is done in a 5-phase feeding program, MHA-FA was only used in the final 3 phases. Therefore,

the experimental concept was tested from 19 to 42 days. It is worth mentioning that the Chinese broiler nutrition concept differs from the rest of the world, insofar as diets are nutritionally very dense in the later phases. Accordingly, both metabolizable energy and levels of essential amino acids are high. For example, metabolizable energy levels of 3,200 up to 3,500 kcal/kg are common practice in these grower and finisher phases, accompanied by crude protein contents of 24–25 %.

Table 4 Key feed specifications for adjustments of SID Lys¹ along with MHA-FA replacement with DL-Met in a 100:65 weight ratio applied in 3 consecutive broiler trials in China

	Trial 1		Trial 2		Trial 3	
	Standard with MHA-FA	Trial with DL-Met	Standard with MHA-FA	Trial with DL-Met	Standard with MHA-FA	Trial with DL-Met
Phase 3						
SID Lys	1.25 %	1.22 %	1.31 %	1.25 %	1.34 %	1.29 %
% of potential		26 %		70 %		59 %
SID Met+Cys²	0.91 %	0.92 %	0.92 %	0.94 %	0.96 %	0.97 %
Ratio²	73 %	75 %	70 %	75 %	72 %	75 %
Diet price		-40.5 RMB/t		-38.6 RMB/t		-57.4 RMB/t
Phase 4						
SID Lys	1.24 %	1.21 %	1.29 %	1.25 %	1.29 %	1.27 %
% of potential		62 %		62 %		46 %
SID Met+Cys²	0.91 %	0.92 %	0.91 %	0.95 %	0.95 %	0.97 %
Ratio²	73 %	76 %	71 %	76 %	74 %	76 %
Diet price		-48.1 RMB/t		-48.3 RMB/t		-41.1 RMB/t
Phase 5						
SID Lys	1.27 %	1.22 %	1.29 %	1.24 %	1.28 %	1.23 %
% of potential		26 %		39 %		59 %
SID Met+Cys²	0.92 %	0.94 %	0.92 %	0.96 %	0.92 %	0.95 %
Ratio²	72 %	77 %	72 %	77 %	72 %	77 %
Diet price		-47.7 RMB/t		-49.7 RMB/t		-42.0 RMB/t

¹ Not only was SID Lys adjusted, but the other essential amino acids were adjusted to AMINOSpec® Chick 3.2 recommendations

² SID Met+Cys and SID Met+Cys:Lys ratios for the standard diets were recalculated, assuming 65 % bioefficacy for MHA-FA, while the nutritionist originally applied 78 % bioefficacy.

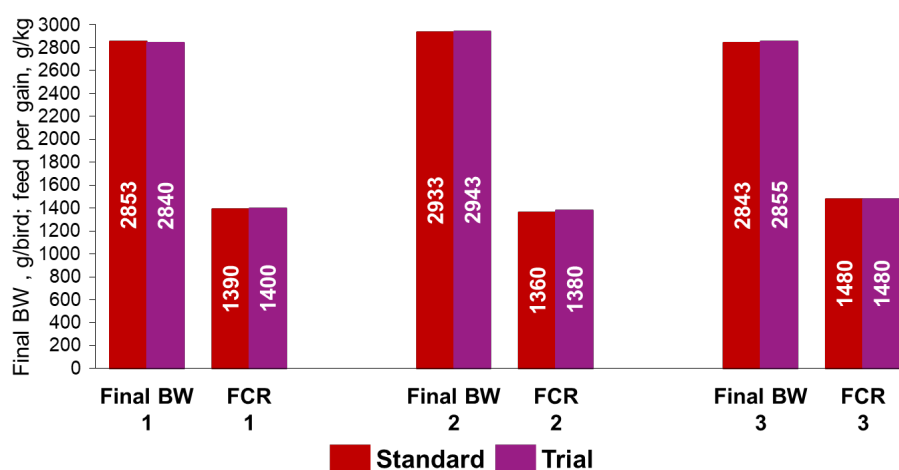
Following the concept discussed above, adjusted specifications levels for SID Lys were reduced by between 0.02 and 0.06 % (Table 4). Referring to the theoretical adjustment potential, the trial diets realized between 26 and 70 % to this adjustment. This rather wide range is explained by the fact that at the same time the recommended AMINOSpec® Chick 3.2 amino acid profile was targeted in trial diets and which differed from the amino acid profile used in the commercial feeds. For

example, the SID Val and SID Ile levels were increased between 0.01 and 0.03 % and affected the degree of adjustment with respect to diet cost. The price ratio between MHA-FA and DL-Met was 72 % and, therefore 11 % (Trial 1) and 6 percentage points lower (Trials 2, 3) than the applied technical bioefficacy of 83 and 78 %, respectively. All adjustments together allowed for feed cost reductions between RMB 38.6–57.4/t equivalent to about €5.0–7.5/t (Table 4).

Feed sample analyses reflected variations for single amino acids which are of no surprise in commercial feed production operations with high throughput. However,

in general the analyses confirmed the concept of methionine product replacement and EAA adjustments.

Figure 4 Average final body weights and feed conversion ratios of three commercial feeding trials with broilers grown in cage systems.



The results of the three consecutive trials using a total of about 500,000 broilers confirmed that this concept of adjustment of EAA along with the replacement of MHA with DL-Met does not compromise performance (Figure 4), but allows for substantial feed cost savings,

as indicated in Table 4. The outcome also suggests that amino acid nutrition needs to be handled holistically, particularly in the context of MHA replacement, because the success of adjustments depend on optimal dietary levels of each EAA.

CONCLUSION

In broiler feed, MHA can be replaced with DL-Met in a 100:65 weight ratio without compromising performance. This concept has been successfully established for decades (Lemme et al., 2024) and enables further dietary amino acid adjustments. Such adjustments can lead to substantial feed cost savings beyond the savings achievable through product exchange alone. However, feeding trials indicate that such amino acid adjustments need to be implemented with caution as the full theoretical potential may not always be realized. Several reasons contribute to this limitation. For instance, the actual SID Met+Cys requirement may differ from

that assumed for the diet formulation. Additionally, safety margins added to the SID Met+Cys matrix values of the macro ingredients or specifications for other EAA (or nutrients in general) may interact. Basically, the nutritional principle that the performance level will be determined by the first limiting factor remains critical. Nevertheless, two trials have demonstrated that even minor adjustments of EAA specifications, along with MHA replacement, can yield attractive feed cost savings. These findings highlight the potential benefits of optimizing amino acid levels alongside product substitution in broiler diets.

REFERENCES

- Jansman, A.J.M., Kan, C.A., Wiebenga, J., 2003, Comparison of the biological efficacy of DL-methionine and hydroxy-4-methylthiobutanoic acid (HMB) in pigs and poultry, CVB documentation report nr. 29, Centraal Veevoederbureau, Lelystad, The Netherlands, pp56.
- Lemme, A., Li, Z., Dorigam, J., 2024, Meta-analyses of methionine source concept validation trial in broilers, animals 14, 1771, doi.org/10.3390/ani14121771
- Lemme, A., Naranjo, V., de Paula Dorigam, J.C., 2020, Utilization of methionine sources for growth and Met+Cys deposition in broilers, animals 10, 2240, doi:10.3390/ani10122240
- Lemme, A., Helmbrecht, A., Mack, S., 2012, Commercial methionine sources in poultry, AMINONews® Review, Evonik Industries, pp36.
- Lemme, A., Petri, A., Redshaw, M., 2007, What's new about commercial methionine sources in poultry, AMINONews™, Degussa, pp36.

Key to precisely balanced diets: How to implement precision nutrition

AMINONews® | October 2026

Dr. Markus Wiltafsky-Martin | Director Service Commercialization, Evonik

Precision nutrition aims to align the supply of energy, amino acids and other nutrients as closely as possible with the requirements of the animal. Achieving this objective requires a connected process rather than an isolated formulation step. Nutritional targets must reflect the species, production phase and performance objective; ingredient values must represent the raw materials actually being used; and the formulated diet must be translated accurately into the finished feed. This article describes a practical implementation pathway covering nutritional recommendations, raw-material evaluation, laboratory and near-infrared analysis, feed formulation, accurate dosing and final-feed quality control. It explains how AMINOSpec®, AMINODat®, AMINOLab®, AMINONIR®, AMINOBatch® and AMINOSys® contribute complementary information and controls throughout this process. When purchasing, nutrition, production and quality-control teams work with consistent data and clearly defined targets, unnecessary safety margins can be reduced, nutrient utilisation can be improved and production results can become more predictable. Precision nutrition thereby turns scientific knowledge into coordinated decisions across the feed-production chain.

AMINONIR®: Near-infrared spectroscopy analytical service – The next level

AMINONews® | October 2026

Dr. Markus Wiltafsky-Martin | Director Service Commercialization, Evonik

Feed formulation is only as accurate as the raw-material information on which it is based. Nutrient composition can vary between origins, suppliers, harvests and individual production batches, while conventional indicators such as crude protein may not fully reveal differences in amino acid or energy content. Formulating primarily with average values can therefore affect ingredient valuation, increase the need for safety margins and create a gap between the calculated and actual nutrient supply. This article explains how AMINONIR® combines rapid near-infrared analysis with validated calibrations, controlled reference analytics and continuously updated global datasets. Examples involving key feed ingredients illustrate how analytical information can reveal nutritionally and economically relevant variability that may otherwise remain undetected. The resulting data support raw-material quality control, more representative matrix values and earlier identification of materials that differ from the expected specification. By providing nutrient profiles within minutes, AMINONIR® helps purchasing, formulation and quality teams respond more quickly to variability and make better-informed decisions before a raw material enters feed production.

Incorporating liquid MHA-FA into feed can result in longer mixing times compared to dry DL-methionine

AMINONews® | October 2026

Christian Rabe | Head of Feed Technology, Evonik

Feed manufacturing efficiency depends not only on nutritional formulation but also on the physical form and processing requirements of feed ingredients and additives. This article examines how liquid additives can influence mixing homogeneity, batch cycle time and overall feed-mill throughput. Sufficient distribution of dry ingredients must be achieved before liquids are introduced, as liquid application can inhibit the further distribution of dry particles. Liquid additives are typically sprayed during the active mixing process and require an additional wet-mixing phase. Where several liquids are added sequentially, each additional liquid may therefore extend the total cycle time. Using liquid MHA-FA and dry DL-methionine as an example, the article illustrates how replacing an additional liquid with a dry alternative can shorten the mixing cycle, increase batches per hour and improve mixer utilisation when mixing capacity is a production bottleneck.



.....
Read the full articles in the digital MetAMINO® ATLAS

The digital MetAMINO® ATLAS provides full access to the expert articles featured in this section, together with the complete trial content and supporting scientific resources.

<https://evonik.click/metamino-atlas>
.....

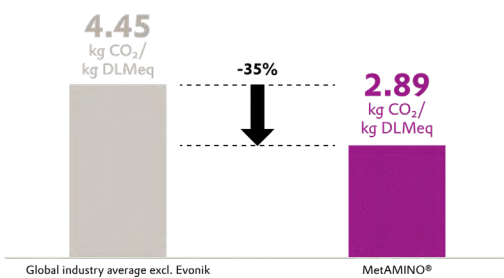
From product footprint to nutritional impact

The environmental contribution of MetAMINO® can be evaluated from two complementary perspectives. The product carbon footprint (PCF) quantifies greenhouse gas emissions associated with the production of MetAMINO®. Its nutritional handprint describes how amino acid-balanced feeding strategies can influence environmental impacts beyond the product itself. Together, these perspectives connect production efficiency with the broader sustainability potential of precision amino acid nutrition.

The cradle-to-gate carbon footprint of MetAMINO®

The PCF of MetAMINO® quantifies the greenhouse gas emissions associated with raw materials, upstream supply chains, energy generation and manufacturing processes. The assessment follows a cradle-to-gate approach and therefore

covers production-related emissions up to the point at which MetAMINO® leaves the factory. The methodology and results for MetAMINO® have been independently verified and certified by TÜV Nord.



What drives the result?

- Production technology and process efficiency
- Energy inputs and renewable electricity
- Raw-material inputs and supply pathways
- Backward integration of production processes
- Continuous operational improvements

From product mass to nutritional function

The carbon footprint comparison is expressed per kilogram of DL-methionine equivalent, providing a functionally equivalent basis for comparing different methionine sources. This approach accounts for differences in the product quantities required to achieve the same nutritional effect. The comparative assessment therefore considers bioefficacy

alongside production technology, energy use and raw-material inputs. The carbon footprint advantage of MetAMINO® is thus not driven by bioefficacy alone, but by the combined contribution of nutritional efficiency and production excellence.

Scientific interpretation

The Product Carbon Footprint provides a transparent basis for evaluating production-related greenhouse gas emissions and supporting value-chain carbon accounting. It does not

represent emissions directly released by the product during feed production, animal metabolism or downstream use.

From footprint to handprint

While the environmental impact of producing a feed additive represents one component of a sustainability assessment, the nutritional handprint captures the broader sustainability benefits enabled by feed additives via their nutritional application. In this assessment, these benefits arise from amino acid-balanced low protein diets across the animal-production value chain. Precision amino acid nutrition can make it possible to reduce dietary crude protein while maintaining an adequate supply of essential amino acids, improving nitrogen utilisation and reducing reliance on protein-rich raw materials.

Environmental impact of amino acid-balanced low crude protein diets

Reducing dietary crude protein while maintaining a balanced supply of essential amino acids is a recognised strategy for improving nitrogen efficiency in animal production. Lower crude protein levels can reduce the need for protein-rich raw materials and decrease the amount of nitrogen supplied in excess of animal requirements.

To quantify the environmental implications, Evonik compared conventional market diets with amino acid-balanced low crude protein diets for broilers, laying hens and pigs.

The assessment covered production systems across six regions and considered regional differences in raw-material availability and dietary protein levels. Environmental impacts were evaluated using a life-cycle assessment approach **from cradle to farm**, according to ISO 14040 and ISO 14044.

Species evaluated

- Broilers
- Laying hens
- Pigs

Assessment scope

- Six production regions
- Cradle-to-farm gate boundary
- Regional diet scenarios

Environmental indicators

- Greenhouse gas emissions
- Land use
- Terrestrial eutrophication
- Acidification
- Blue water consumption

Results across the assessed scenarios

Compared with the conventional market diets, amino acid-balanced low crude protein diets delivered measurable improvements across several environmental impact categories. The magnitude and distribution of the reductions differed by species, region and impact category.

The existing species-specific results should therefore remain visible rather than being condensed into a single universal reduction claim.

Scientific interpretation

The results demonstrate the environmental potential of precision amino acid nutrition under the conditions evaluated in the comparative lifecycle assessment. They should not be interpreted as fixed reduction values applicable to all production systems. The achievable effect depends on the initial crude protein content, the degree of protein reduction,

	GHG emissions reduction	Land use impact reduction	Eutrophication potential reduction
 Broilers	up to -11%	up to -10%	up to -18%
 Layers	up to -28%	up to -14%	up to -17%
 Pigs	up to -12%	up to -7%	up to -30%

Results shown reflect the global scenarios evaluated in the assessment. The assessment for each species considers regional variations in available raw materials and dietary protein levels.

the amino acid supplementation strategy, locally available raw materials, regional agricultural and energy systems, and the species and production phase. When these factors are considered appropriately, amino acid-balanced low crude protein diets can reduce environmental impacts while maintaining the same animal performance.

Product footprint

Quantifies cradle-to-gate greenhouse gas emissions associated with producing MetAMINO® and enables comparison on a functionally equivalent basis.

Nutritional handprint

Represents the environmental benefits enabled by amino acid-balanced feed strategies across feed production and animal production systems.

EVONIK OPERATIONS GMBH
Animal Nutrition Business Line

evonik.click/animalnutrition

**Learn more about
MetAMINO®**

evonik.click/MetAMINO



This information and any recommendations, technical or otherwise, are presented in good faith and believed to be correct as of the date prepared. Recipients of this information and recommendations must make their own determination as to its suitability for their purposes. In no event shall Evonik assume liability for damages or losses of any kind or nature that result from the use of or reliance upon this information and recommendations. EVONIK EXPRESSLY DISCLAIMS ANY REPRESENTATIONS AND WARRANTIES OF ANY KIND, WHETHER EXPRESS OR IMPLIED, AS TO THE ACCURACY, COMPLETENESS, NON-INFRINGEMENT, MERCHANTABILITY AND / OR FITNESS FOR A PARTICULAR PURPOSE (EVEN IF EVONIK IS AWARE OF SUCH PURPOSE) WITH RESPECT TO ANY INFORMATION AND RECOMMENDATIONS PROVIDED. Reference to any trade names used by other companies is neither a recommendation nor an endorsement of the corresponding product, and does not imply that similar products could not be used. Evonik reserves the right to make any changes to the information and / or recommendations at any time, without prior or subsequent notice.

202610