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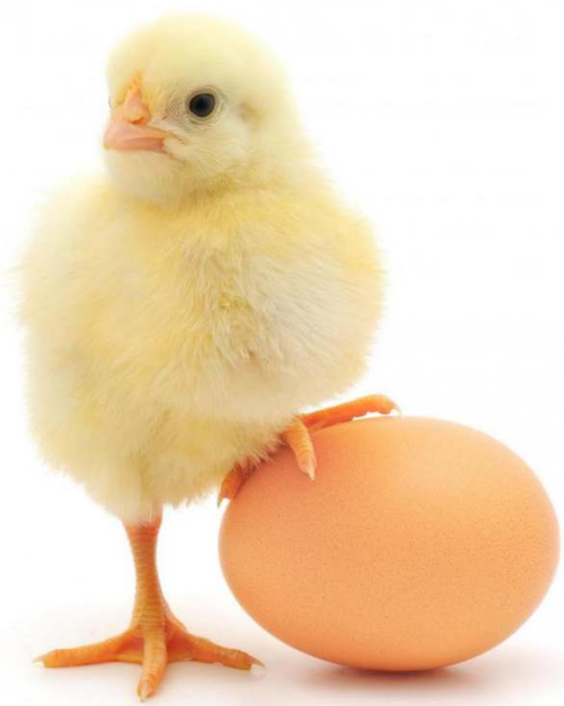

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Relative Effectiveness of Methionine Sources in Turkeys – Scientific and New Commercial Data

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Introduction

Knowing the relative nutritive value of liquid MHA-FA compared to DL-methionine (DL-Met) is an important precondition to cost-effective purchasing, feed formulation and animal production. Over the last few years there has been new and intriguing research published, mainly with broiler chickens, about the nutritional effectiveness of liquid MHA-FA relative to DL-methionine and the reasons for the difference (Esteve-Garcia and Austic, 1993; Huyghebaert, 1993; Rostagno and Barbosa, 1995; Schutte and De Jong, 1996; Thomas *et al.*, 1991; Van Weerden *et al.*, 1992; Wallis *et al.*, 1999; Lemme *et al.*, 2002; Hoehler *et al.*, 2003). Consequently, a relative bioefficacy of 65% of liquid MHA-FA relative to DL-methionine on a weight basis (1 kg liquid MHA-FA to 0.65 kg of DL-Met) has found increasing acceptance among broiler nutritionists around the world.

In contrast, scientific data in turkeys are rather scarce. In this paper, scientific and commercial data on relative effectiveness of methionine sources in turkeys will be presented and discussed. The first part of the data originated with Dr. Larry Potter and co-workers at Virginia Tech, Blacksburg, Virginia in the 1980s and remained unpublished at that time (copies in Degussa Corporation files). The second part is a study conducted at the Akey Nutrition and Research Center in Lewisburg, Ohio in 2002 and the third part consists of four "commercial comparison" trials with DL-Met versus liquid MHA-FA in Minnesota and South Dakota from 2001 to 2003.

Bioefficacy of different nutrient sources: Prices of methionine sources change over time, but the amount of liquid MHA-FA needed for replacing DL-methionine is constant and independent from the level of animal performance and environmental conditions. Fig. 1 illustrates the principle that any experiment about the effectiveness of different sources of the same nutrient should addressed (Littell *et al.*, 1997). Only this method provides a consistent and reliable estimate of the relative effectiveness of different sources of the same nutrient. This result is independent of the targeted level of animal performance.

Why are data in turkeys rather limited?: The literature compilation of Lemme (2002) on the comparison of methionine sources consists of a total of 125 data sets for different animal species and performance criteria, out of which 85 are from broiler chicks and only 24 are from turkeys. The reason for this discrepancy mainly results from the much greater importance of the worldwide broiler production. Out of a global poultry meat production of 70 million tons per year, about 60 million tons (86%) is represented by broiler meat and only about 5 million tons (7%) is represented by turkey meat (Executive Guide to World Poultry Trends, 2002).

Based on the 24 data sets for weight gain and feed conversion in turkeys mentioned above, an average bioefficacy of 71% (weight/weight) can be calculated for liquid MHA-FA relative to DL-Met. All of these trials were conducted more than 15 years ago from 1981 to 1987. Compared with dose-response data in broiler chicks, efficacy results in turkeys have been highly variable. For example, bioefficacy figures for liquid MHA-FA in three experiments carried out in the same facilities and published by Noll *et al.* (1984) for weight gain and feed conversion varied from 48 to 98%. A relative bioefficacy of liquid MHA-FA of 98% relative to DL-Met (weight/weight) corresponds to a bioefficacy of 111% on an equimolar basis. In contrast, none of the broiler data sets summarized by Lemme (2002) showed such high values. This phenomenon of a high variation of turkey live performance data is also known from other nutritional experiments and can be mainly attributed to:

1. smaller animal numbers,
2. a higher genetic variability of turkeys versus broilers,
3. a higher sensitivity of turkeys to environmental and management conditions.

The latter reason is especially important for the existing data on bioefficacy experiments in turkeys because all of these experiments were carried out with young animals in the starter and early grower phases.

Comparing methionine sources in turkeys by Potter and co-workers (1981-1987): Four trials were conducted at the Virginia Polytechnic Institute in Blacksburg, Virginia by Dr. Larry Potter and co-workers from 1981 to 1987 (unpublished data; available from Degussa Corporation). Weight gain and feed conversion were chosen as performance criteria in order to determine the biological efficacy of liquid MHA-FA relative to DL-Met in turkeys.

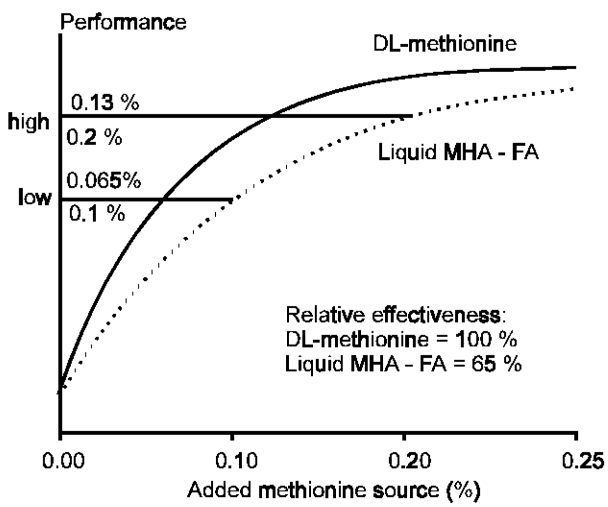

Fig 1: 1 kg of liquid MHA-FA can be replaced with 0.65 kg of DL-methionine, independent of the targeted performance level (see also Lemme *et al.*, 2002).

A total of 1,632 commercial Large White turkeys, provided with a common diet for their first week of life, were used in two out of the four similar experiments which are presented here. At 7 days of age, the birds were assigned to the different dietary treatments in 96 pens. Each pen contained nine males or females, except in Experiment 1 in which seven females were placed per pen. Both experiments concluded at 6 weeks of age. Eleven graded and corresponding levels of either DL-Met (0.0152 to 0.5051%) or liquid MHA-FA (0.0170% to 0.5682%) were added to a basal corn-soy diet, resulting in 23 experimental diets. The basal diet did not contain any supplemental methionine.

The turkeys clearly responded to the supplemented products, demonstrating that the basal diet was indeed deficient in Met and Met+Cys and the supplemented methionine sources did cover the sensitive range of turkey performance (Fig. 2 and 3). Non-linear regression analysis was used to evaluate the effectiveness of liquid MHA-FA relative to DL-Met. The relative effectiveness of liquid MHA-FA compared to DL-Met for response in weight gain was 59 and 56%, respectively, in these experiments. For feed conversion ratio, the relative effectiveness of liquid MHA-FA was determined to be 80 and 55%, respectively.

A summary of all four trials is presented in Table 1, showing that bioefficacy of liquid MHA-FA was 64% on average for supporting weight gain and 66% on average for feed conversion ratio response. These results agree very well with broiler data and demonstrate that the biological effectiveness of liquid MHA-FA is indeed 65% of that of DL-Met in market turkeys as well as in broiler chickens.

Table 1: Relative effectiveness of liquid MHA-FA relative to DL-methionine for live performance in turkeys 1 to 6 weeks of age in four different experiments (Potter and co-workers, 1981-1987).

Unpublished Data Source (Authors)	Relative effectiveness (%) Weight gain	Feed conversion
Schmidt & Potter	75	63
Schmidt & Potter	64*	67
Potter *et al.*	59*	80
Potter *et al.*	56*	55*
Overall average	64	66

* Significantly lower than 88% ($p<0.05$).

Turkey trial at Akey Nutrition and Research Center, Akey Inc., Lewisburg, Ohio (2002): In 2002, a dose-response experiment was performed with graded levels of either DL-Met or liquid MHA-FA in starting turkeys (Table 2). For experimental feed formulation purposes, the ratio between both products at each of the three corresponding inclusion levels was 65% based on the assumption that 100 units of liquid MHA-FA can be replaced by 65 units DL-Met and give similar live performance results.

Table 2: Experimental design

Treatment	Methionine source	Addition of methionine source (% of product)	Addition of methionine equivalents (%)*
I	-	-	-
II	DL-Met	0.100	0.099
III	DL-Met	0.200	0.198
IV	DL-Met	0.300	0.297
V	Liquid MHA-FA	0.154	0.136
VI	Liquid MHA-FA	0.308	0.271
VII	Liquid MHA-FA	0.462	0.407

*Based on a DL-Met and DL-MHA-FA content of 99% and 88% in the commercial products, respectively.

A total of 315 male day-old BUTA Big 6 turkey poults were distributed to 63 battery cages containing five birds each. Nine cages were assigned to each of 7 treatments in a complete block design. Treatments corresponded to seven experimental diets, comprised of one basal diet which was deficient in Met+Cys and six diets with three graded levels of either DL-Met or liquid MHA-FA.

The experimental diets consisted mainly of corn, soybean meal and fish meal and were fed from day 1 to 21 (Table 3). A single master batch was formulated to be deficient in Met (0.43%) and Met+Cys (0.81%) but to meet or to exceed the protein, other essential amino acids, energy, vitamin and mineral requirements of starting turkeys. The test substances were added to

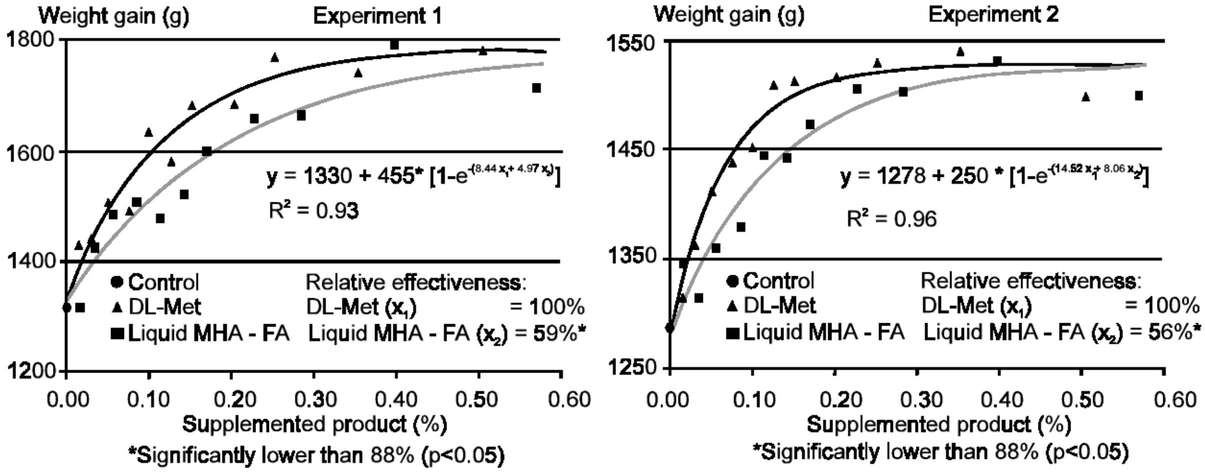

Fig. 2: Effectiveness of liquid MHA-FA as compared to DL-methionine for supporting weight gain in turkeys (1 to 6 weeks of age, Potter *et al.*, 1987)

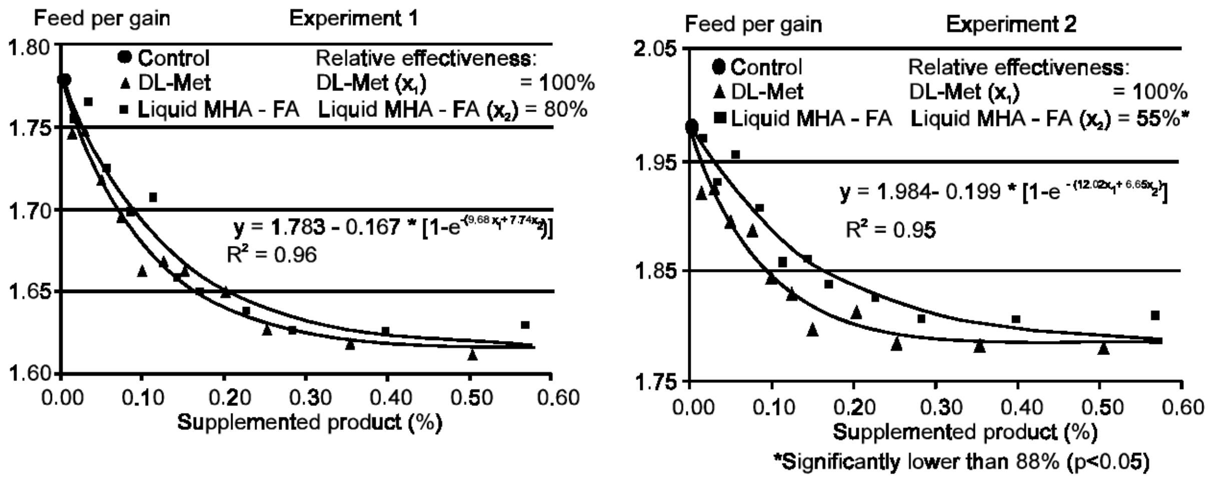

Figure 3: Effectiveness of liquid MHA-FA as compared to DL-methionine for feed conversion ratio response in turkeys (1 to 6 weeks of age, Potter *et al.*, 1987)

Table 3: Ingredients as well as calculated energy and nutrient content of the basal diet

Ingredients (%)		Energy and nutrients (%)	
Corn	52.09	ME (Kcal/kg)	2947
Corn starch	0.46	ME (MJ/kg)	12.3
Soybean meal (48%)	35.75		
Fish meal	5.00	Crude protein	25.2
Soybean oil	1.00	Lys	1.78
Dicalcium phosphate	2.35	Met	0.43
Calcium carbonate	1.49	Met+Cys	0.81
Biolys® 60	0.76		
L-Threonine	0.27	Calcium	1.40
Vitamins, Salt, Enzymes	0.83	Available Phosphorus	0.70

aliquots of the basal diet at the expense of corn starch. Analyses verified accurate feed production and DL-Met or liquid MHA-FA supplementation. Feed in mash form and water were offered *ad libitum*. Light intensity, temperature and ventilation rate were typical of settings used under commercial conditions. Mortality was recorded, but only two birds died during the experiment. Performance data were evaluated by analysis of

Table 4: Effect of graded levels of DL-Met and liquid MHA-FA on weight gain and feed conversion in male BUTA Big 6 turkey poults (1-21 days of age)

Treatment	Methionine source	Addition of methionine source (% of product)	Weight gain* Mean ± SD	Feed per gain* Mean ± SD
I	-	-	481 ± 33 [a]	1.547 ± 0.042 [b]
II	DL-Met	0.100	520 ± 21 [ab]	1.490 ± 0.057 [ab]
III	DL-Met	0.200	550 ± 32 [bc]	1.458 ± 0.033 [a]
IV	DL-Met	0.300	567 ± 29 [c]	1.462 ± 0.075 [ab]
V	Liquid MHA-FA	0.154	525 ± 31 [abc]	1.496 ± 0.071 [ab]
VI	Liquid MHA-FA	0.308	550 ± 12 [bc]	1.476 ± 0.034 [ab]
VII	Liquid MHA-FA	0.462	564 ± 21 [bc]	1.469 ± 0.035 [ab]

* Mean ± SD: means ± standard deviation. ** Different superscripts within column indicate significant differences, $p<0.05$.

Table 5: Feed composition in the trial "Lismore No. I"'(MN, USA, 2001) for turkeys fed either DL-methionine (65 units) or liquid MHA-FA (100 parts) supplemented diets from start to finish (values given are lbs. per US ton of feed, one US ton contains 2000 lbs. or 907.2 kg)

Weeks:	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-finish
Crude Protein (%):	24.6	23.3	23.4	21.0	19.8	18.7	17.9	17.2
Ingredients (lbs/ton)								
Corn	639	674	601	949	808	866	910	1450
Soybean meal (44%)	750	700	600	465	415	375	350	325
Wheat screening	300	300	500	300	500	500	500	-
Fat	80	120	100	100	100	100	100	100
Vitamins, minerals & others	216	191	178	167.5	157	143	128	117
Biolys® 60	8	7	13	9	13	11	9	7
L-threonine	2	2	1	2.5	1	-	-	-
Liquid MHA-FA or	5	6	7	7	6	5	3	1
DL-methionine	3.25	3.90	4.55	4.55	3.90	3.25	1.95	0.65
DL-methionine / MHA-FA	65%	65%	65%	65%	65%	65%	65%	65%

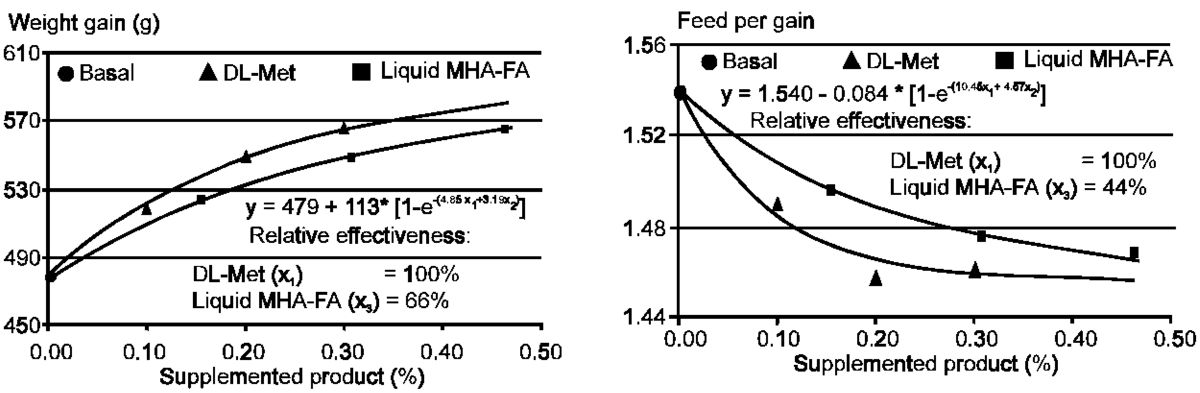

Fig. 4: Weight gain and feed conversion of male turkeys 1 to 21 days of age fed incremental levels of DL-methionine or liquid MHA-FA.

variance including comparison of means and simultaneous exponential regression in order to estimate the relative effectiveness of liquid MHA-FA compared to DL-Met.

The significant performance response verified that the basal diet was deficient in Met+Cys (Table 4 and Fig. 4). Weight gain achieved at the highest inclusion levels was 85 g higher than that achieved with the basal diet and feed conversion ratio could be improved by about 8 points on average. Comparing performance data of the corresponding treatments (Treatments II versus V, III versus VI, IV versus VII) no statistical difference could be

Table 6: Design and combined results of the four "commercial comparison" trials in Minnesota and South Dakota, 2001-2003

	Lismore Colony No. I		Claremont Colony No. I		Lismore Colony No. II[1]		Claremont Colony No. II[1]	
Trial completed	12/2001		5/2002		7/2002		1/2003	
Turkeys	Nicholas toms		Nicholas toms		Nicholas toms		Nicholas toms	
Methionine Source	DL-Met	MHA-FA	DL-Met	MHA-FA	DL-Met	MHA-FA	DL-Met	MHA-FA
Ratio DL-Met/MHA-FA	65	100	65	100	65	100	65	100
No. of birds	7994	7497	6301	5585	7824	7147	6251	6307
Age at processing	20 weeks 4 days	20 weeks 5 days	20 weeks 2 days	20 weeks 2 days	20 weeks 5 days	20 weeks 6 days	20 weeks 4 days	20 weeks 4 days
Total condemnation[2]	0.8 %	1.0 %	2.3 %	2.4 %	1.6 %	2.2 %	1.4 %	1.4 %
Final weight (kg, mean)	19.1	19.4[3]	17.6	17.5	18.3	18.3[3]	18.9	18.5

[1]Dietary methionine specifications in trials No. II were 10% lower than in trials No. I. [2] Whole birds and parts combined. [3]Turkeys fed liquid MHA-FA supplemented feeds were one day older, i.e. expected to be about 0.2 kg heavier than the DL-Met birds.

observed. With respect to weight gain, corresponding treatments showed very similar performance confirming that 100 units of liquid MHA-FA can be replaced by 65 units of DL-Met without affecting performance. Regarding feed conversion, there were no differences between corresponding treatments in terms of statistical significance, but DL-Met fed turkeys demonstrated numerical advantages at each supplemental level.

As shown in Fig. 4, the response data for both performance criteria followed a non-linear trend and thus data were analyzed by simultaneous exponential regression. According to regression analysis, liquid MHA-FA was only 66 and 44% as effective as DL-Met regarding weight gain and feed conversion, respectively. This result is in line with the data by Potter *et al.* (1981 to 1987), discussed previously, as well as with the outcome of a comprehensive list of experimental results showing an average effectiveness of 65% for liquid MHA-FA compared to DL-Met in broilers (Lemme, 2002).

Commercial comparisons confirming effectiveness under practical conditions: The 65% bioefficacy figure can be confirmed under field conditions by a quite simple approach: both DL-Met and liquid MHA-FA can be added to two batches of a practical diet, the dosage of DL-Met being 65 % of that of the supplemented MHA-FA. The expected result is that there should be no differences in response and performance (taking into account normal variations in animal performance). This "commercial comparison" can be conducted with any diet, under a variety of possible external conditions and with any animal species. Table 6 shows four recent examples of such commercial comparisons of DL-Met versus liquid MHA-FA in turkeys. The trials were conducted from 2001 to 2003, usually in two identical barns side-by-side (paired houses), with substantial numbers of animals over the entire grow-out period. Diets were supplemented with either 65 parts of DL-Met or with 100 parts of liquid MHA-FA (see Table 5, with the example "Lismore No. I"). In these trials, the turkeys received a common starter feed up to 3 or 4 weeks of age. The two different treatments, DL-Met vs. liquid MHA-FA (dietary weight/weight ratio at 65/100), were applied from week 4 or 5 up to processing. However, under the commercial circumstances at the time, it was not possible to monitor feed consumption. Feed formulas and feeding regimen were according to local conditions in this geographical area.

Final body weights and processing data demonstrated that applying a relative effectiveness of 65% for liquid MHA-FA relative to DL-Met caused no differences in animal performance.

The trials "Lismore No. I" and "Claremont No. I" were conducted with the common nutrient specifications of the feeds in the different age periods. In contrast, the trials "Lismore No. II" and "Claremont No. II" were conducted subsequently to the first trials with a 10% reduction of the dietary methionine specifications. This was done to increase the sensitivity of the test. The consistency of the results demonstrates the high reliability of the bioeffectiveness figure of 65% for liquid MHA-FA relative to DL-Met in turkeys. Results confirm that the amount of liquid MHA-FA needed for replacing DL-Met is constant and independent from dietary levels (or safety margins) and environmental conditions.

Under conditions current at the time, using DL-Met at 65 % of liquid MHA-FA in turkeys resulted in substantial cost savings for these Minnesota and South Dakota turkey producers.

Conclusions: Scientific information on relative effectiveness of methionine sources in turkeys is scarce. Numerous scientific experiments in the past with broiler chicks have established that, based on relative bioefficacy, the weight of DL-met needed is 65% of the weight of liquid MHA-FA (0.65 kg DL-met to 1 kg liquid MHA-FA). New scientific and unpublished data in turkeys agree with broiler data for liquid MHA-FA relative to DL-methionine. The 65% bioefficacy figure can be confirmed by "commercial comparison" (paired house) trials under practical conditions and examples of several recent commercial turkey trials were presented.

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