BENSON HILL®

Collaborative Study in Broilers and Turkeys

Benson Hill's Ultra-High Protein, Low Oligosaccharide Soybean Meal

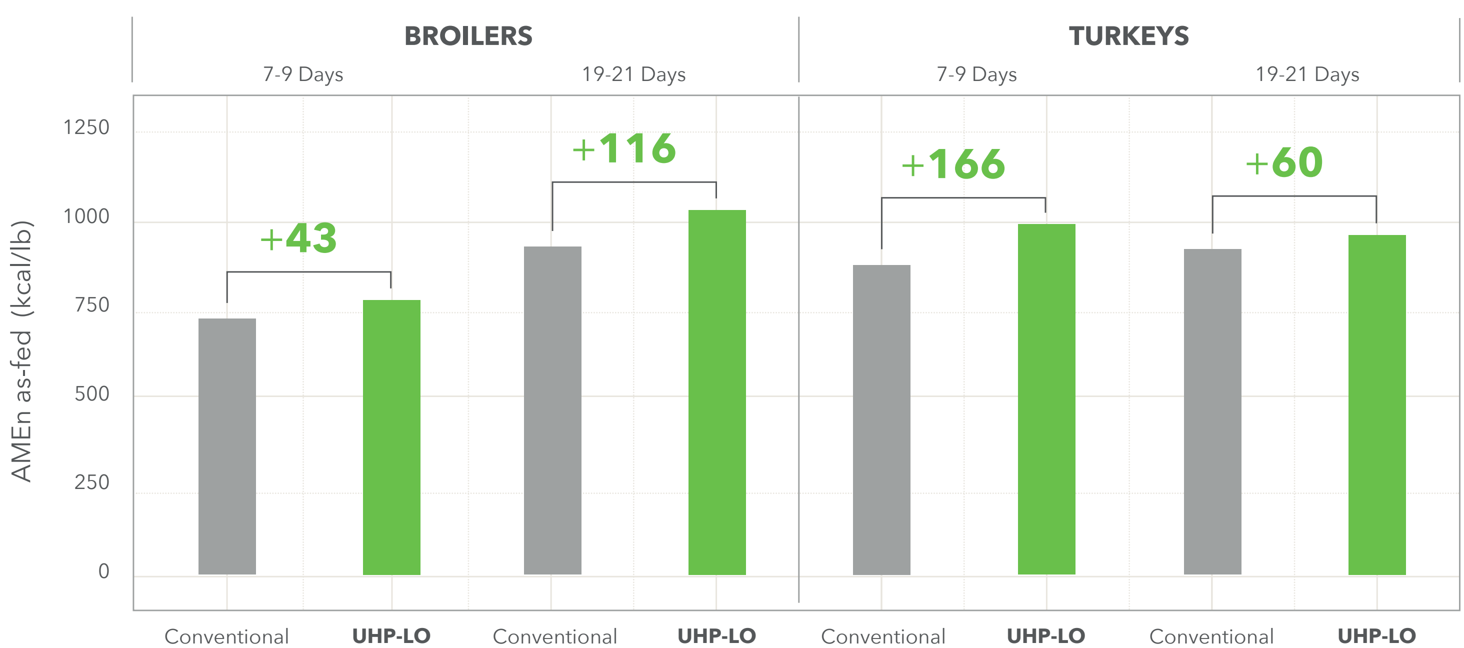
Delivers **1.5x more metabolizable energy** than previous estimates

UNIVERSITY OF ARKANSAS

A NEW STUDY IN BROILERS AND TURKEYS SHOWS THAT BENSON HILL ULTRA-HIGH PROTEIN, LOW OLIGOSACCHARIDE (UHP-LO) SOYBEAN MEAL HAS A 1.5X GREATER METABOLIZABLE ENERGY BENEFIT THAN PREVIOUSLY ESTIMATED.

Benson Hill ultra-high protein, low oligosaccharide (UHP-LO) soybean meal (SBM) has significantly higher protein and metabolizable energy compared to commodity SBM, creating the potential for lower feed costs, improved animal performance, and increased carcass weights when included in poultry rations. An academic study in 2012 estimated that UHP-LO SBM has an extra 80 kcals/lb metabolizable energy in broiler chickens compared to conventional soybean meal[1] and subsequent commercial feeding trials have validated this energy credit, in some cases even suggesting that UHP-LO SBM has higher energy levels[2].

New research conducted by Dr. Benjamin Parsons and Dr. Danielle Graham at the University of Arkansas found that, UHP-LO SBM delivers up to 1.5x more energy than previously estimated, suggesting that UHP-LO SBM can create even more value for producers through feed cost savings and animal performance. Results show that relative to conventional SBM, UHP-LO SBM has up to an extra 116 kcals/lb (256 kcals/kg) metabolizable energy in broilers, and up to an extra 166 kcals/lb (367 kcals/kg) metabolizable energy in turkeys. The following report prepared by Dr. Ben Parsons and Dr. Danielle Graham details these new study results.



UNIVERSITY OF ARKANSAS

DR. BENJAMIN PARSONS

Assistant Professor

Research primarily focused on evaluation of nutrient availability in feedstuffs by determining digestibility, retention, and bioavailability

Ph.D. in Poultry Science from the University of Arkansas, 2023

M.S. in Animal Sciences from the University of Illinois Urbana/Champaign, 2021

B.S. in Animal Sciences from the University of Illinois Urbana/Champaign, 2019

DR. DANIELLE GRAHAM

Assistant Professor

Research primarily focused on avian intestinal health.

Ph.D. in Poultry Science from the University of Arkansas, 2021

M.S. in Poultry Science from the University of Arkansas, 2018

B.S. in Animal Sciences from the University of Arkansas, 2015

1. Perryman and Dozier, 2012, Poultry Science, Oct;91(10):2556-63 doi: 10.3382/ps.2012-02379
2. Commercial trial overviews, https://bensonhill.com/industries/better-feed/poultry-feed/, resource downloads

Benjamin W. Parsons / Danielle Graham

Department of Poultry Science
University of Arkansas
Ph: 217-552-9303
E-mail: bp032@uark.edu ; bmahaffe@uark.edu

Evaluation of metabolizable energy in high protein-reduced oligosaccharide soybean meal

The objective of this study was to determine the metabolizable energy content in ultra-high protein-reduced oligosaccharide soybean meal (**UHPLO-SBM**) compared with conventional soybean meal (**C-SBM**). Two bioassays were conducted: 1) ad libitum-fed broiler chicken assay, and 2) ad libitum-fed turkey poult assay.

Conclusions

1. There was a clear increase in amino acids and reduction in the fiber fractions in the UHPLO-SBM compared with the C-SBM. This is valuable for poultry nutritionists, as poultry have limited fermentation capacity, oligosaccharides reduce nutrient availability in the diet, and amino acids are one of the most expensive nutrients in the diet.

2. UHPLO-SBM was found to have a greater ME value compared with C-SBM in both ad libitum-fed broiler chickens and turkeys. Overall, there was good agreement between the broiler and turkey bioassays, albeit higher ME values for the test ingredients were observed in young turkeys compared with young broiler chickens. The ME values for the test ingredients at 21 days-of-age, however, were similar between broilers and turkeys with AME_n values for C-SBM ranging from 2244 to 2390 kcal/kg and UHPLO-SBM ranging from 2500-2523 kcal/kg.

3. The relative difference in ME values between the C-SBM and UHPLO-SBM ranged from 95 to 367 kcal/kg across age and species, with an average of 212 kcal/kg.

4. The greatest difference between the 2 test ingredients was reported in young turkeys, which may be more susceptible to health challenges compared with broiler chickens. This is an area worth investigating further to evaluate both nutrient availability of other nutrients in UHPLO-SBM (i.e. amino acids and phosphorus) and assessing potential improvements in growth performance in practical diets from UHPLO-SBM due to effects that utilization of this soybean meal may have on the nutrient availability of other components of the diet and gastrointestinal health.

MATERIALS AND METHODS

Experimental design and procedures

For this study, one sample of solvent-extracted UHPLO-SBM was supplied by Benson Hill. A sample of solvent extracted dehulled C-SBM was obtained from the feed mill at the University of Illinois.

Apparent metabolizable energy content (**AME** and **AME_n**) was determined using ad libitum-fed broiler chickens in Experiment 1. Male Cobb 500 broiler chickens were obtained from a commercial hatchery. Birds were raised on a nutritionally-complete corn-soybean meal-based starter diet until 5 days-of-age. On day 5, birds were fasted overnight. On day 6, individual birds were weighed, allotted to equalize body weight among treatments, and were provided 1 of 3 experimental diets ad libitum from 6 to 9 days-of-age. On day 7, pans were scraped, clean collection papers were placed, and excreta were collected for 48 h. On day 9, excreta were collected from each pen and BW gain and feed intake were recorded. After excreta were collected and BW and feed intake were recorded, birds were placed back on a nutritionally-complete corn-soybean meal-based starter diet until 17 days-of-age. On day 17, birds were fasted overnight. On day 18, individual birds were weighed, re-allotted to equalize body weight among treatments, and were placed back on 1 of the 3 experimental diets ad libitum from 18 to 21 days-of-age. On day 19, pans were scraped, clean collection papers were placed, and excreta were collected for 48 h. On day 21, excreta were collected from each pen and body weight gain and feed intake were recorded. The AME and AME_n of test ingredients were calculated by difference using the basal substitution method as described below.

$$ME\ of\ test\ ingredient = ME_R - \frac{ME_R - ME_T}{I}$$

$$ME_R = ME\ of\ reference\ diet\ (diet\ 1)$$

$$ME_T = ME\ of\ test\ diet\ (diets\ 2\ or\ 3)$$

$$I = inclusion\ rate\ of\ test\ ingredient$$

The AME and AME_n content of soybean meal was also determined in Experiment 2, this time using ad libitum-fed turkey poults. Female Nicholas Select poults were obtained from a commercial hatchery. Procedures for poults in Experiment 2 were the same as Experiment 1. Birds were raised on a nutritionally-complete corn-soybean meal-based starter diet until 5 days-of-age. On day 5, birds were fasted overnight. On day 6, individual birds were weighed, allotted to equalize body weight among treatments, and were provided 1 of 3 experimental diets ad libitum from 6 to 9 days-of-age. On day 7, pans were scraped, clean collection papers were placed, and excreta were collected for 48 h. On day 9, excreta were collected from each pen and BW gain and feed intake were recorded. After excreta were collected and BW and feed intake were recorded, birds were placed back on a nutritionally-complete corn-soybean meal-based starter diet until 17 days-of-age.

On day 17, birds were fasted overnight. On day 18, individual birds were weighed, re-allotted to equalize body weight among treatments, and were placed back on 1 of the 3 experimental diets ad libitum from 18 to 21 days-of-age. On day 19, pans were scraped, clean collection papers were placed, and excreta were collected for 48 h. On day 21, excreta were collected from each pen and BW gain and feed intake were recorded. The AME and AME_n of test ingredients were calculated by difference using the basal substitution method described above.

In Experiments 1 and 2, dietary treatments were corn-soybean meal-based diets. A common basal diet was formulated to meet the nutritional recommendations for Cobb broiler chickens or Nicholas Select turkey poults, which served as diet 1. Diets 2 and 3 were the same as diet 1, except 30% of the basal diet was replaced by the test ingredient. Titanium dioxide was included as an indigestible marker in all diets. The composition of the dietary treatments is shown in Table 1.

Statical Analyses

Data from Experiments 1 and 2 were analyzed using a 2-way ANOVA with main effects being diet and age. Differences among treatment means were assessed using Fisher's LSD. The significance value for all analyses was $P < 0.05$.

RESULTS AND DISCUSSION

Nutrient composition

The nutrient composition of C-SBM and UHPLO-SBM on an as-fed basis is shown in Table 2. The CP content in UHPLO-SBM was higher than C-SBM by approximately 6 percentage units. The UHPLO-SBM contained a lower crude fat content of 0.7% compared with 2.8% in conventional SBM. The higher crude fat level in C-SBM indicates that some gums and soap stocks were likely added back to the soybean meal at the crushing plant from which the meal was obtained. The difference in crude fat content between samples is likely responsible for the similar gross energy values between the meals. The UHPLO-SBM was found to contain less fiber compared with C-SBM, as observed with the lower NDF, ADF, raffinose, stachyose, and verbascose, and galactose. The oligosaccharide in particular, both raffinose and stachyose, were reduced by approximately 80%, while still maintaining similar or higher levels of sucrose. The mineral profile was generally similar between SBM. The TUI / mg in UHPLO-SBM was deemed acceptable as a general target ranged for meals is below or within the 5 to 8 range TUI / mg. The KOH protein solubility for UHPLO-SBM was lower than the target of 80% or above which may suggest some over heating of the meal; however, this would not have an effect on the energy value of the meal as this was likely only a slight overheating based on the KOH protein solubility %.

Experiment 1: Ad libitum-fed broiler chickens

There was an age × diet interaction for growth performance. The BW gain of birds was lower for test diets with SBM (diets 2 and 3) compared with diet 1 from 6-9 day-of-age, but highest for birds fed UHPLO-SBM from 18-21 days-of-age (Table 3). Feed efficiency followed similar trends, albeit, feed efficiency was greater for birds fed UHPLO-SBM compared with C-SBM are both ages. It should be noted, however, that diets were not balanced (SBM added in place of 30% of the test diet) and only fed for 3 days, thus, this trial was not designed to assess difference in growth performance when feeding UHPLO-SBM. The ME values for the test ingredients in broiler chickens are shown in Table 4. There was no age × diet interaction for the ME values of test ingredients. For both AME and AME_n values, UHPLO-SBM had a higher ME value compared with C-SBM on both an as-fed and dry matter basis. For example, the AME values of UHPLO-SBM were 156 and 345 kcal/kg higher compared with C-SBM at 9 and 21 days-of-age, respectively. Similar differences were observed for AME_n values, where UHPLO-SBM had AME_n values on an as-fed basis that were 95 and 256 kcal/kg higher at 9 and 21 days-of-ag, respectively. Overall, HLPO soybean was found to contain an AME_n value for 2500 kcal/kg in 21 day-old broiler chickens. This is the value that would be used by formulating nutritionist, but it is also useful to provide relative comparisons. Further, AME_n values corrected to 0 nitrogen retention, as done herein, are the standard for formulating nutritionists. There is some discussion about moving away from a 0 nitrogen retention correction in the future as it penalizes high protein ingredients, but formulating based on these AME_n corrected to 0 nitrogen retention is still the standard practice.

Experiment 2: Ad libitum-fed turkey poults

There was an age × diet interaction for feed intake, where feed intake of the diet with C-SBM was similar to UHPLO-SBM from 6-9 days-of-age but greater than UHPLO-SBM from 18-21 days-of-age (Table 5). There was no difference ($P > 0.05$) in BW gain and feed efficiency between diets 2 and 3 at either age, although BW gain and feed efficiency were numerically greater in the UHPLO-SBM diet compared with C-SBM from 6-9 days-of-age. As mentioned above, the growth performance in this study is not indicative of use in practical diets, but it is monitored for recording and publishing purposes. The ME values for the test ingredients in turkeys are shown in Table 6. There was no age × diet interaction for the ME values of test ingredients ($P > 0.05$); however, the ME values of UHPLO-SBM were numerically greater compared with C-SBM at 9 days-of-age compared with 21 days-of-age, as indicated by *P*-values between 0.05 and 0.10 for the interaction of main effects. For both AME and AME_n values, UHPLO-SBM had a higher ME value compared with C-SBM on both an as-fed and dry matter basis. For example, the AME values of UHPLO-SBM were 397 and 95 kcal/kg higher compared with C-SBM at 9 and 21 days-of-age, respectively. Similar differences were observed for AME_n values, where UHPLO-SBM had AME_n values on an as-fed basis that were 367 and 133 kcal/kg greater at 9 and 21 days-of-age, respectively. Overall, HLPO soybean was found to contain an AME_n value for 2523 kcal/kg in 21 day-old turkey poults.

Table 1. Ingredient composition of basal diets in broiler and turkey studies[1]

Ingredient, %	Experiment 1 (broiler)	Experiment 2 (turkey)
Corn	61.3	39.3
SBM	33.0	48.4
Soybean Oil	1.6	5.7
Limestone	0.92	1.50
Dical	1.5	3.10
NaCl	0.2	0.22
L-Lys HCl	0.18	0.32
DL Met	0.29	0.36
L-Thr	0.09	0.10
NaHCO3	0.17	0.10
Broiler Vitamin/Mineral Mix[2]	0.15	-
Turkey Vitamin/Mineral Mix[3]	-	0.26
Choline Chloride	0.10	0.10
TiO_2	0.50	0.50
HyD	-	0.05
Santaquin	-	0.02

[1]Conventional and high protein-low oligosaccharide soybean meal were added at the expense of 30% of the basal diets above for treatments 2 and 3, respectively.

[2]Provided per kg of diet: vitamin A, 6,173 IU; vitamin D3, 4,409 ICU; vitamin E, 44 IU; vitamin B12, 0.01 mg; menadione, 1.20 mg; riboflavin, 5.29 mg; d-panthothenic acid, 7.94 mg; thiamine, 1.23 mg; niacin, 30.86 mg; pyridoxine, 2.20 mg; folic acid, 0.71 mg; biotin, 0.07 mg; manganese, 100 mg; zinc, 100 mg; iron, 15 mg; selenium, 0.25 mg; copper, 15 mg; iodine, 1.2 mg.

[3]Provided per kg of diet: vitamin A, 6,173 IU; vitamin D3, 4,409 ICU; vitamin E, 44 IU; vitamin B12, 0.01 mg; menadione, 1.20 mg; riboflavin, 5.29 mg; d-panthothenic acid, 7.94 mg; thiamine, 1.23 mg; niacin, 30.86 mg; pyridoxine, 2.20 mg; folic acid, 0.71 mg; biotin, 0.07 mg; copper, 19mg; iron 4.50 mg; iodine, 2.46 mg; selenium, 0.37 mg; zinc, 165 mg.

Table 2. Nutrient composition of test soybean meals[1]

Item, % as-fed	Conventional SBM	UHPLO SBM
DM	93.1	93.0
CP	46.7	53.2
Crude fat	2.8	0.7
NDF	40.1	32.7
ADF	7.7	6.8
Sucrose	5.98	8.20
Raffinose	0.75	0.16
Stachyose	3.24	0.63
Verbascose	0.10	0.00
Ribose	0.05	0.05
Fucose	0.06	0.00
Arabinose	1.10	0.36
Xylose	0.44	0.75
Mannose	0.32	0.00
Glucose	2.29	0.20
Galactose	3.25	0.20
Ca	0.30	0.30
P	0.64	0.74
Na	0.005	0.004
Ash	5.86	6.29
KOH protein solubility[2]	-	71.8
TUI / mg[3]	-	4.31
Gross energy, kcal/kg	4412	4457

[1]Abbreviations: SBM = soybean meal; UHPLO = high protein-low oligosaccharide; NDF = neutral detergent fiber; ADF = acid detergent fiber; TUI = trypsin units inhibited.
[2]Measured using the newly standardized procedure by Ruiz et al. at Dairyland Laboratories. Values of 80% or above indicates samples are not overprocessed.
[3]Measured at Eurofins using the new AOCS procedure (Liu et al., 2021); target values are 5-8 TUI / mg, lower values are fine but higher values indicate under-processing.

Table 3. Growth performance of broiler chickens from 6 to 9 and 18 to 21 d-of-age and metabolizable energy of experimental diets at 9 and 21 d-of-age in Experiment 1[1]

Item	Age (days)	Dietary treatment 1	2	3	SEM	P-values Age	Diet	Age×Diet
Feed intake (g/chicken)	6-9	121[a]	109[b]	106[b]	2.7	<0.001	0.023	0.010
	18-21	307	303	309				
BW gain (g/chicken)	6-9	97[a]	80[b]	84[b]	4.9	<0.001	0.009	<0.001
	18-21	147[b]	158[b]	184[a]				
Gain:feed (g/kg)	6-9	802[a]	733[b]	791[a]	15.3	<0.001	<0.001	<0.001
	18-21	479[b]	519[b]	596[a]				
AME[2] (kcal/kg as-fed)	9	2884[a]	2582[b]	2629[b]	25.1	<0.001	<0.001	<0.001
	21	2844[a]	2747[b]	2851[a]				
AME_n[3] (kcal/kg as-fed)	9	2716[a]	2398[b]	2427[b]	23.0	<0.001	<0.001	<0.001
	21	2682[a]	2551[b]	2628[ab]				

[a-b]Values within a row with no common superscript differ (*P* < 0.05). Values are means of 8 pens of 6 broiler chickens (6-9 d-of-age) or 5 broiler chickens (18-21 d-of-age).

[1]Dietary treatments: 1 – basal diet; 2 – As 1 + 30% conventional soybean meal; 3 – As 1 + 30% high protein-low oligosaccharide soybean meal.

[2]AME = Apparent metabolizable energy.

[3]AME_n = nitrogen-corrected AME; values were corrected to 0 nitrogen retention.

Table 4. Metabolizable energy of feedstuffs at 9 and 21 d-of-age in broiler chickens in Experiment 1[1,2]

Item	Age (days)	Dietary treatment: Conv. SBM	Dietary treatment: UHPLO SBM	SEM	P-values: Age	P-values: Diet	P-values: Age×Diet
AME (kcal/kg as-fed)	9	1879	2035	64.7	<0.001	0.002	0.203
	21	2451[b]	2796[a]				
AME_n (kcal/kg as-fed)	9	1657	1752	57.1	<0.001	0.011	0.220
	21	2244[b]	2500[a]				
AME (kcal/kg DM)	9	2018	2188	69.5	<0.001	0.002	0.201
	21	2635[b]	3006[a]				
AME_n (kcal/kg DM)	9	1779	1884	61.3	<0.001	0.010	0.218
	21	2410[b]	2688[a]				

[a-b]Values within a row with no common superscript differ ($P < 0.05$). Values are means of 8 pens of 6 broiler chickens (6 d-of-age) or 5 broiler chickens (21 d-of-age).

[1]AME = Apparent metabolizable energy.

[2]AME_n = nitrogen-corrected AME; values were corrected to 0 nitrogen retention.

Table 5. Growth performance of turkey poults from 6 to 9 and 18 to 21 d-of-age and metabolizable energy of experimental diets at 9 and 21 d-of-age in Experiment 2[1]

Item	Age (days)	Dietary treatment 1	2	3	SEM	P-values Age	Diet	Age×Diet
Feed intake (g/poult)	6-9	75[a]	70[b]	70[b]	2.6	<0.001	0.002	0.048
	18-21	156[a]	152[a]	140[b]				
BW gain (g/poult)	6-9	59[a]	51[b]	54[b]	4.0	<0.001	0.520	0.369
	18-21	105	107	101				
Gain:feed (g/kg)	6-9	785	728	763	20.9	0.005	0.699	0.177
	18-21	690	716	714				
AME[2] (kcal/kg as-fed)	9	2790[a]	2635[b]	2754[a]	23.3	<0.001	<0.001	0.172
	21	2864	2783	2812				
AME_n[3] (kcal/kg as-fed)	9	2565[a]	2407[b]	2517[a]	20.0	<0.001	<0.001	0.197
	21	2669[a]	2578[b]	2618[ab]				

[a-b]Values within a row with no common superscript differ ($P < 0.05$). Values are means of 8 pens of 8 poults.
[1]Dietary treatments: 1 – basal diet; 2 – As 1 + 30% conventional soybean meal; 3 – As 1 + 30% high protein-low oligosaccharide soybean meal.
[2]AME = Apparent metabolizable energy.
[3]AME_n = nitrogen-corrected AME; values were corrected to 0 nitrogen retention.

Table 6. Metabolizable energy of feedstuffs at 9 and 21 d-of-age in turkey poults in Experiment 2

Item	Age (days)	Dietary treatment: Conv. SBM	Dietary treatment: UHPLO SBM	SEM	P-values: Age	P-values: Diet	P-values: Age×Diet
AME (kcal/kg as-fed)	9	2273[b]	2670[a]	73.9	0.042	0.005	0.069
	21	2595	2690				
AME_n (kcal/kg as-fed)	9	2037[b]	2404[a]	61.7	0.002	<0.001	0.091
	21	2390	2523				
AME (kcal/kg DM)	9	2441[b]	2871[a]	79.4	0.042	0.005	0.069
	21	2787	2893				
AME_n (kcal/kg DM)	9	2188[b]	2586[a]	66.3	0.002	<0.001	0.091
	21	2567	2714				

[a-b]Values within a row with no common superscript differ ($P < 0.05$). Values are means of 8 pens of 8 poults.

[1]AME = Apparent metabolizable energy.

[2]AME_n = nitrogen-corrected AME; values were corrected to 0 nitrogen retention.

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About Benson Hill

Benson Hill is a seed innovation company that unlocks nature's genetic diversity in soy quality traits through a combination of proprietary genetics, its AI-driven CropOS® technology platform, and its Crop Accelerator. Benson Hill collaborates with strategic partners to create value throughout the agribusiness supply chain to meet the demand for better feed, food and fuel. More information can be found at bensonhill.com or on X, formerly known as Twitter at @bensonhillinc.

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