Effect of heat treatment on Soybean Meal & DDGS quality

Rapid Evaluation of Digestibility from Evonik Degussa - AMINORED®

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EVONIK INDUSTRIES

Agenda

- Measurement of under- and over-processed Soybean products
- New fast method to determine heat damage based on NIR
- Effect of heat damage on amino acid digestibility
- Determination of digestibility in relation to heat damage via AMINORED®
- Heat damage affect value of the raw material
- Conclusions

Traditional Methods to Monitor SBM Quality

- Urease assay (UA) – pH method
- KOH protein solubility test
- Protein dispersibility index (PDI)
- Trypsin Inhibitor Assay (TIA)

Bird performance still varies although quality of SBM are within specs

Beans	A	D
Crush	A	D
CP, %	46.8	46.7
Fibre, %	3.5	3.4
ether ext. %	1.4	1.8
ash, %	7.1	7.7
AME, kcal/kg	2431	2459
KOH-PS, %	86	76
TI, mg/g	2.9	1.6
Urease, ΔpH	0.02	0.01
	Animal perfo	eding study)
Gain, g	236[a]	216[bc]
FCR	1.9[ab]	1.98[cd]

Swick (2008), sbmQC conference

Some amino acids are sensitive to heat treatment

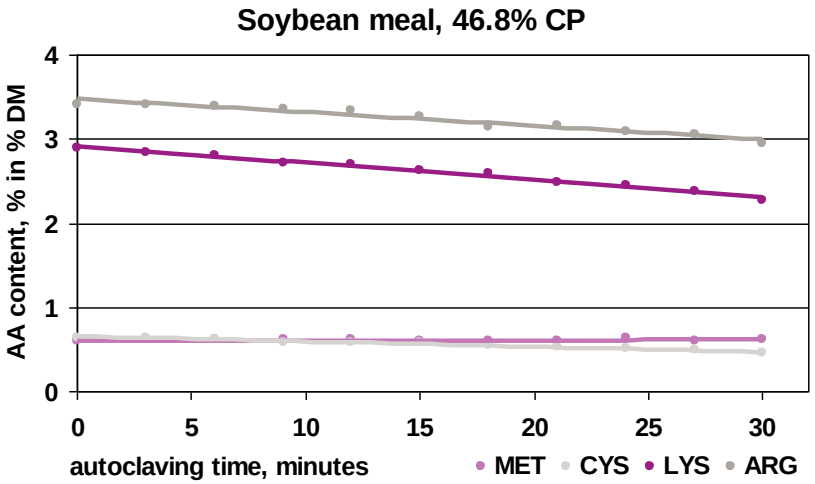
Autoclaving time (minutes)	Content, %			
	Lysine	Cystine	Methionine	Threonine
0	3.27	0.70	0.71	1.89
20	2.95	0.66	0.71	1.92
40	2.76	0.63	0.70	1.87

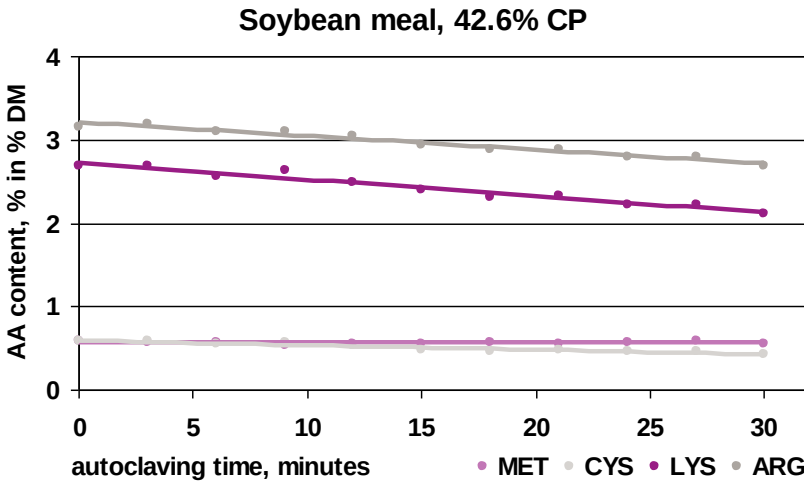
(Adapted from Parsons et al., 1992)

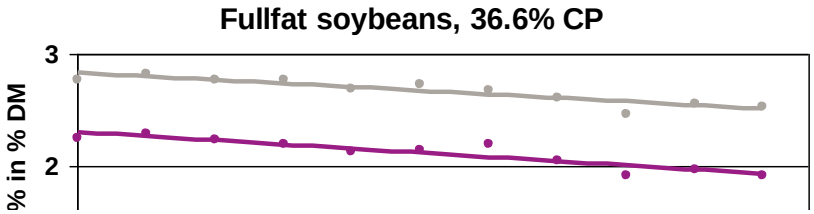
Effects of heat treatment on amino acid levels in soybean products

- 3 Soybean product samples were systematically heat damaged at DIL (Deutsches Institut für Lebensmitteltechnik)
  - Heat treatment in autoclave at 135 °C
  - Samples were taken in 3 min intervals
    starting at 0 until 30 min resulting in 10 samples
  - Sample analyses total amino acids

Some amino acids are sensitive to heat treatment



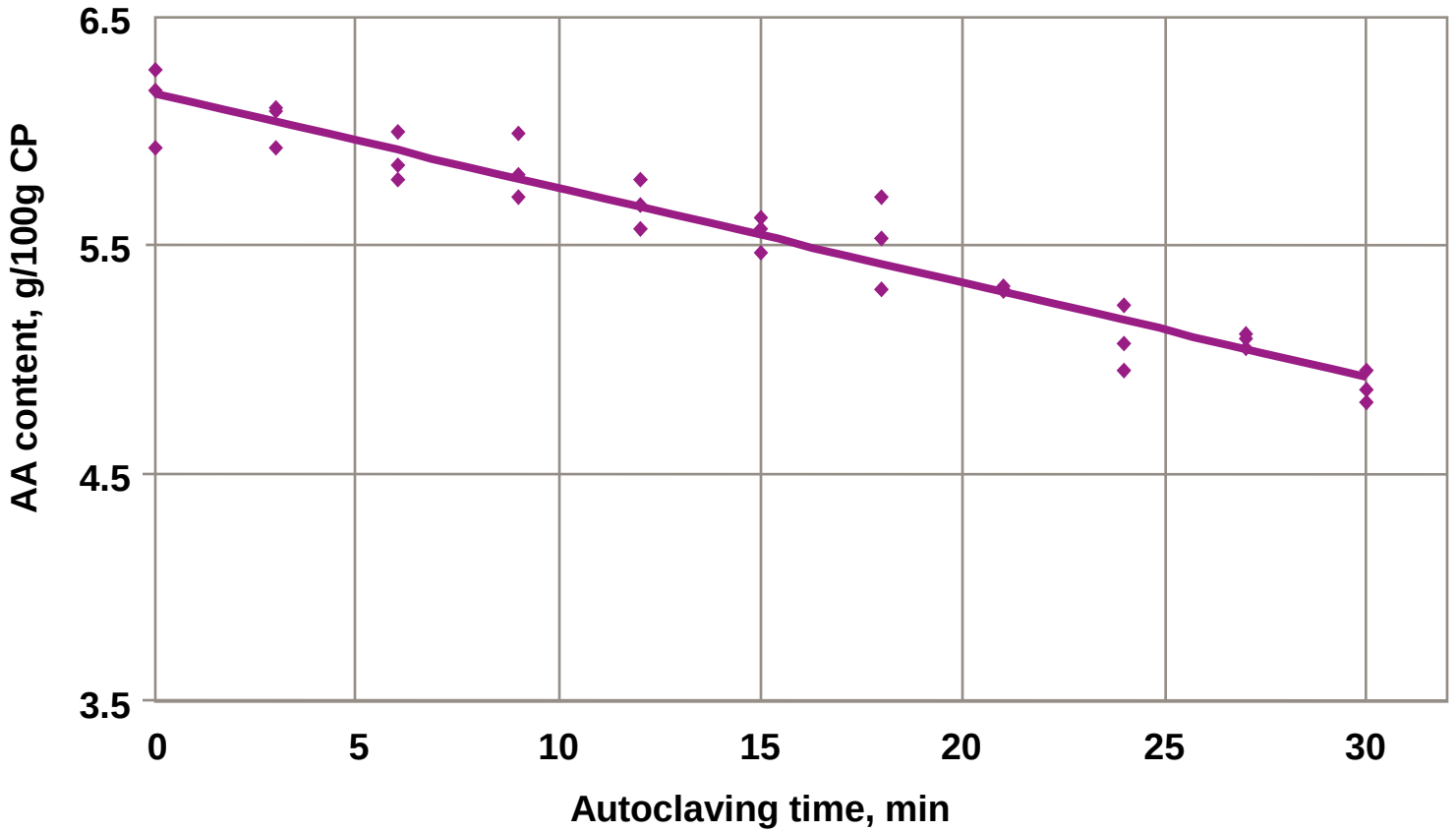




Fontaine et al. (2007)

Total lysine decreases linearly with heat treatment

All soybean products together expressed as % of CP



Heat Damage Indicator

AMINONIR® can measure heat damage in raw materials, based upon this an indicator was developed to allow the degree of damage to be measured, this is known as the:

Heat Damage Indicator (HDI)

- This allows the degree of damage to be expressed
- The higher the number the greater the damage (0 – 100)

But what happens in the animal

- Does the degree of heat damage (HDI) affect amino acid availability and thereby animal performance?
- Standardized ileal digestibility (SID) is currently our best measurement to approximate the availability of amino acids in the animal.

Amino acid digestibility has been shown to affect digestibility

Autoclaving time (minutes)	Content, %			
	Lysine	Cystine	Methionine	Threonine
0	3.27	0.70	0.71	1.89
20	2.95	0.66	0.71	1.92
40	2.76	0.63	0.70	1.87
	Digestibility, %			
0	91	82	86	84
20	78	69	86	86
40	69	62	83	80

(Adapted from Parsons et al., 1992)

Ileal digestibility of heat treated soybean meal and DDGS - broiler

- Soybean meal (47% CP) and DDGS were heat treated at DIL (Deutsches Institut für Lebensmitteltechnik)
  - 0, 20, 40 minutes at 135 °C

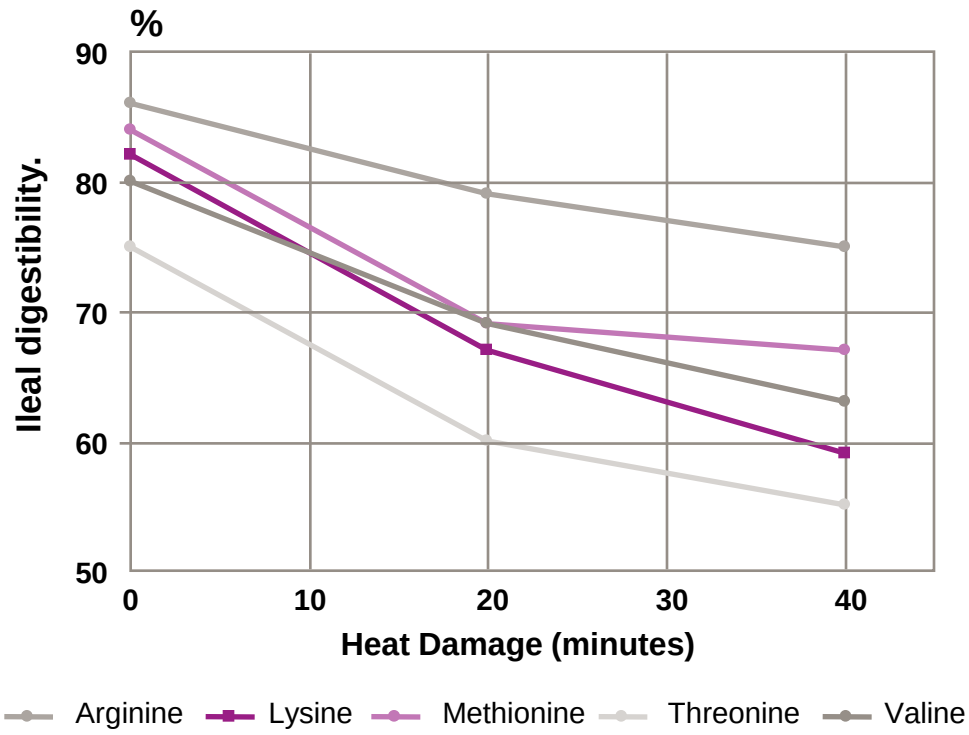
- A digestibility assay was conducted at University of Halle, Germany
  - 504 one-day-old Ross 308 broilers
  - Experiment start day – 14 day of age
  - Experimental feed for 5 days
  - Digesta of last two thirds of the ileum were collected
  - Inert marker: TiO_2

Inclusion levels (g/kg)	0	100	200
Corn	-	490	-
Soybean meal, solvent extracted	-	90	-
Wheat gluten	-	90	-
Soybean oil	-	50	-
L-Lysine·HCl	-	9.5	-
DL-Methionine	-	2.0	-
L-Cystine	-	2.4	-
L-Threonine	-	3.6	-
L-Tryptophan	-	0.4	-
L-Arginine	-	6.7	-
L-Isoleucine	-	3.3	-
L-Leucine	-	0.9	-
L-Valine	-	5.5	-
L-Phenylalanine	-	0.7	-
Premix	-	10	-
Dicalcium phosphate	-	20	-
Limestone	-	7	-
NaCl	-	3	-
Titanium dioxide	-	5	-
Cornstarch	200	100	0
Soybean meal (Expt 1)	0	100	200
DDGS (Expt 2)	0	100	200

Analyzed nutrient and amino acid content in SBM and DDGS

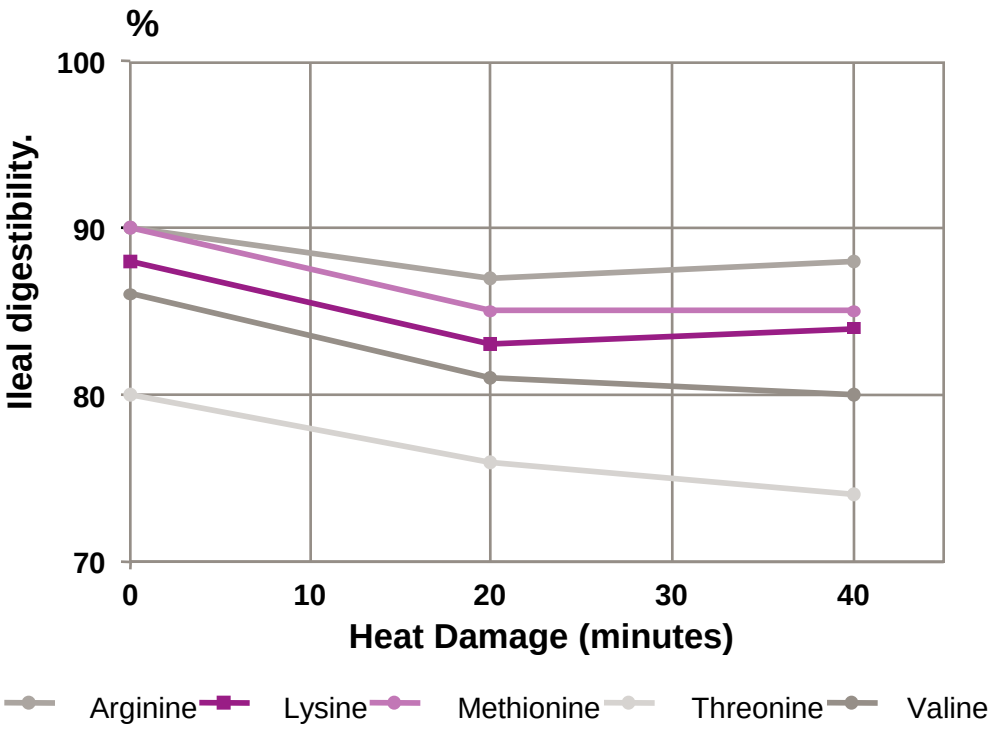
	Pure SBM			Pure DDGS		
Time of heat treatment	**0 min**	**20 min**	**40 min**	**0 min**	**20 min**	**40 min**
Nutrients in%:						
Dry matter	89.30	91.70	93.30	90.90	91.60	90.20
Crude ash	6.70	6.90	7.10	3.30	3.30	3.50
Crude protein	46.70	47.70	48.80	25.40	25.70	25.90
Crude fat	1.90	1.60	1.90	12.00	11.80	12.00
Crude fiber	5.60	5.70	6.00	6.50	6.70	6.60
Lysine	2.92	2.63	2.43	0.79	0.50	0.46
Methionine	0.63	0.67	0.69	0.52	0.50	0.51
Cystine	0.71	0.60	0.54	0.53	0.48	0.48
Methionine+Cystine	1.34	1.26	1.22	1.05	0.99	0.99
Threonine	1.87	1.97	2.06	0.98	0.95	0.96
Tryptophan	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Arginine	3.51	3.31	3.13	1.19	0.87	0.76
Isoleucine	2.18	2.29	2.34	0.92	0.90	0.91
Leucine	3.62	3.82	3.97	3.04	3.00	3.05
Valine	2.33	2.46	2.51	1.30	1.29	1.31
Histidine	1.28	1.32	1.36	0.78	0.73	0.72
Phenylalanine	2.47	2.59	2.69	1.23	1.21	1.23

Ileal digestibility - broiler
Results - soybean meal



Heat treatment of soybean meal				AMINODat®
Nutrient (%)	0	20 min	40 min	
Arg	86[a]	79[b]	75[b]	93
Lys	**82[a]**	**67[b]**	**59[b]**	**90**
Met	84[a]	69[b]	67[b]	91
Thr	75[a]	60[b]	55[b]	85
Val	80[a]	69[b]	63[b]	88

Ileal digestibility - broiler
Results - DDGS



Heat treatment of DDGS				AMINODat®
Nutrient (%)	0	20 min	40 min	
Arg	90[a]	87[b]	88[ab]	73
Lys	**88[a]**	**83[b]**	**84[ab]**	**75**
Met	90[a]	85[b]	85[ab]	86
Thr	80[a]	76[a]	74[a]	72
Val	86[a]	81[a]	80[a]	81

Ileal digestibility
Results demonstrate

- Heat damage of feed ingredients leads to :
  - a reduction in the total levels of certain heat sensitive amino acids, this is most pronounced for lysine, cystine and arginine
  - a reduction in the standardized ileal digestibility coefficients of amino acids in broilers for all essential amino acids

AMINORED®

Rapid Evaluation of Digestibility

- Combines the Heat Damage Indicator (HDI) with standardized ileal digestibility
- A feed ingredient sample is scanned with AMINONIR® .
- AMINORED® calculates specific Standardized Ileal Digestible Amino Acid levels for the sample, using the Heat Damage Indicator as a measure of quality.

AMINORED® validation

- A trial was designed to measure the impact of correction for total amino acids and standardized ileal digestibility in feed formulation using AMINORED®.

Experimental hypothesis

- AMINORED® can identify soybean meal quality
- Correction of the nutritional matrix of low quality soybean meal based on AMINORED® predictions allows recovery of performance to the same level achieved when using a good quality soybean meal.
- Analyzing the heat damaged soybean meal for only total amino acid content and correcting the formulation would result in a performance level between the negative control and that of the AMINORED® treatment.

- 4 treatments
  - Good quality soybean meal
  - Heat damaged soybean meal
  - Heat damaged soybean meal analyzed for total amino acid content
  - Heat damaged soybean meal analyzed by AMINORED®

Soybean meal production

- Soybean meal was produced by CREOL, Pessac, France
  - facility / pilot plant for oil extraction – medium scale
  - full fat soybeans were purchased and
    - gently extracted (good quality)
    - heat treated (poor quality)

	Good quality soybean meal	Heat damaged soybean meal
Residence time	50 minutes	120 minutes
Indirect steam pressure	1 bar	9 bars
Direct steam flow rate	Adjusted to reach 70 C in the exhaust of the vapors	Not defined
Target temperature of the bottom tray	> 100 C	>115 C
Heat Damage Indicator	**12**	**47**

Soybean meals

	Standardized	
	Low quality	**High quality**
Dry matter	88	88
Crude protein	47.33	47.28
Nitrogen	**7.57**	**7.56**
Heat Damage Indicator	**47**	**12**

		SID AA (% as is)		**Δ (%)**
AminoRED®	Lysine	2.14	2.56	**16.4**
	Methionine	0.53	0.57	**7.0**
	Cystine	0.49	0.55	**10.9**
	Met + Cys	1.02	1.12	**8.9**
	Threonine	1.43	1.56	**8.3**
	Tryptophan	0.54	0.54	**0.0**
	Arginine	2.98	3.19	**6.6**
	Isoleucine	1.70	1.83	**7.1**
	Leucine	2.86	3.13	**8.6**
	Valine	1.80	1.91	**5.8**
	Histidine	1.04	1.16	**10.3**
	Phenylalanine	1.93	2.07	**6.8**

Treatments

Treatment	Good Quality SBM	Heat Damaged SBM	HD SBM + Analyzed AA	HD SBM + AMINORED®
Basis of formulation	AMINONIR analysis + SID coefficient published by Evonik	Replacement of the good quality SBM to reach the same CP Level	Analyzed total AA + SID coefficient published by Evonik	Analyzed total AA + SID coefficient according to AMINORED®

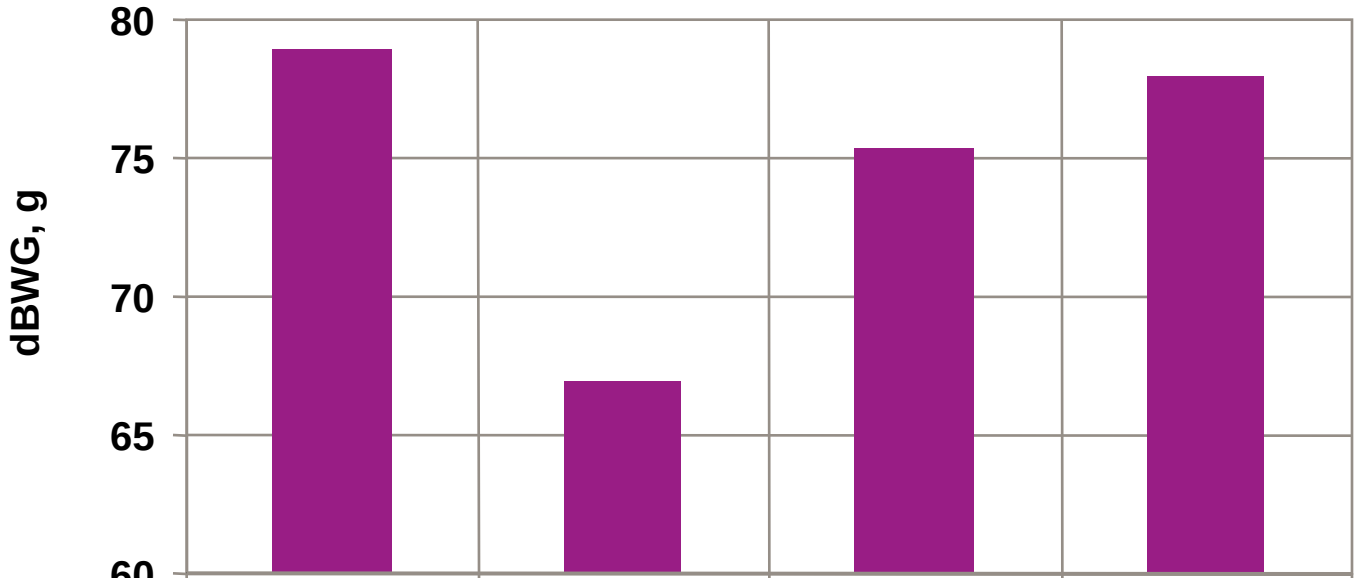
Diet Specifications

Nutrients	Limits		Good Quality SBM	Heat Damaged SBM	HD SBM + Analyzed AA	HD SBM + AMINORED®
Treatment	**All**					
Metabolizable Energy (MJ)	>=	13.2	13.2	13.2	13.2	13.2
Crude protein (%)	No limit	No limit	20.1	20.28	20.35	20.47
Nitrogen from soya (%)	=	2.29	2.29	2.29	2.29	2.29
Crude protein from soya (%)	=	14.3	14.3	14.3	14.3	14.3
Ether Extract (%)	<=	9	8.84	8.87	8.87	8.87
Total Lys		**1.10**	**1.10**	**1.03**	**1.10**	**1.14**
SID Lys	**>=**	**1.00**	**1.00**	**0.90**	**0.96**	**1.00**
SID Met	>=	0.47	0.47	0.46	0.47	0.49
SID Met+Cys	>=	0.74	0.74	0.71	0.72	0.74
SID Thr	>=	0.65	0.65	0.62	0.62	0.65
SID Trp	>=	0.22	0.22	0.23	0.23	0.23
SID Arg	>=	1.06	1.20	1.06	1.06	1.06
SID Ile	>=	0.70	0.74	0.70	0.70	0.70
SID Leu	>=	1.37	1.41	1.37	1.37	1.37
SID Val	>=	0.76	0.80	0.76	0.76	0.80

Experimental design

- **1200** Ross 308 broilers (278 g at 10d of age)
  - **4** dietary treatment x **15** replicates x 20 birds
- Birds were kept in pens
  - wooden shavings, bell drinker, feeder
- Experimental diets
  - pelleted
  - fed from day 10 to 28
  - feed intake, weight gain, feed conversion
  - carcass weight, breast meat yield

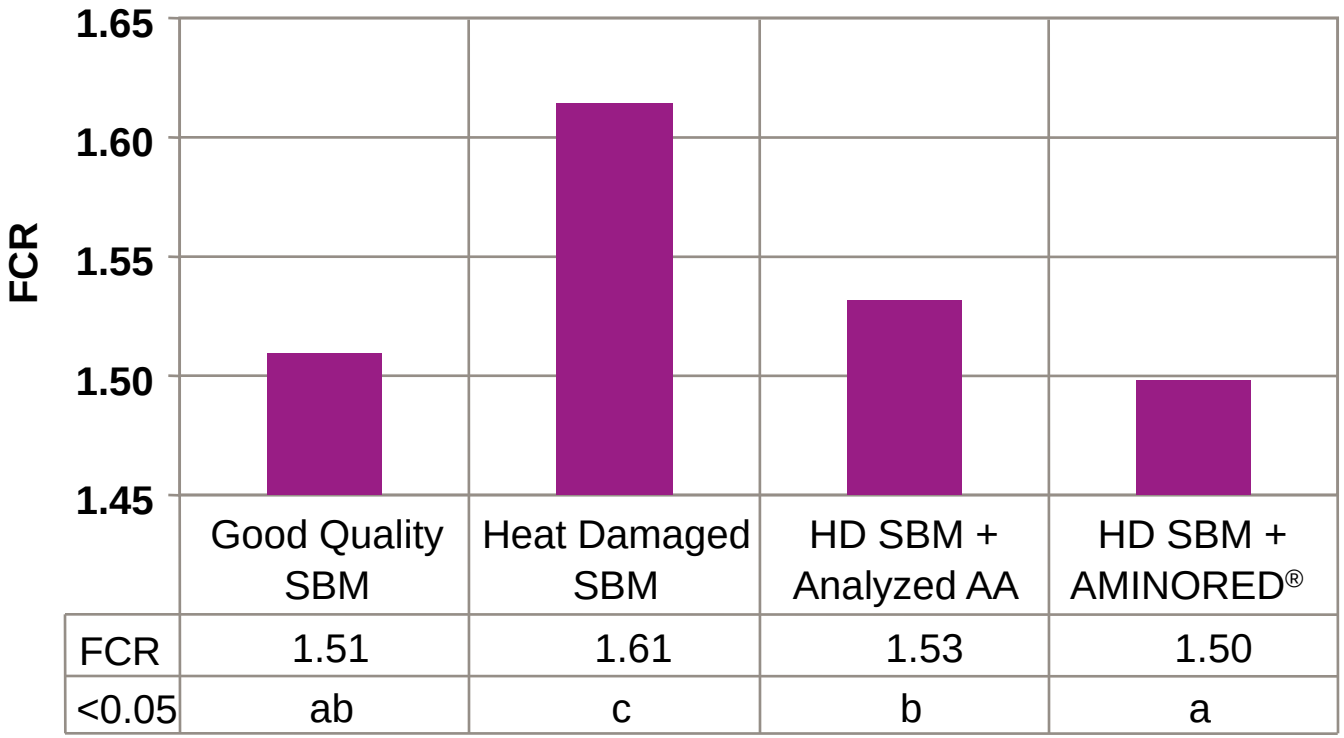
AMINORED® validation
Daily Body Weight Gain



	Good Quality SBM	Heat Damaged	HD SBM + Analyzed AA	HD SBM + AMINORED®
BWG	78.9	66.9	75.4	78
< 0.05	c	a	b	bc

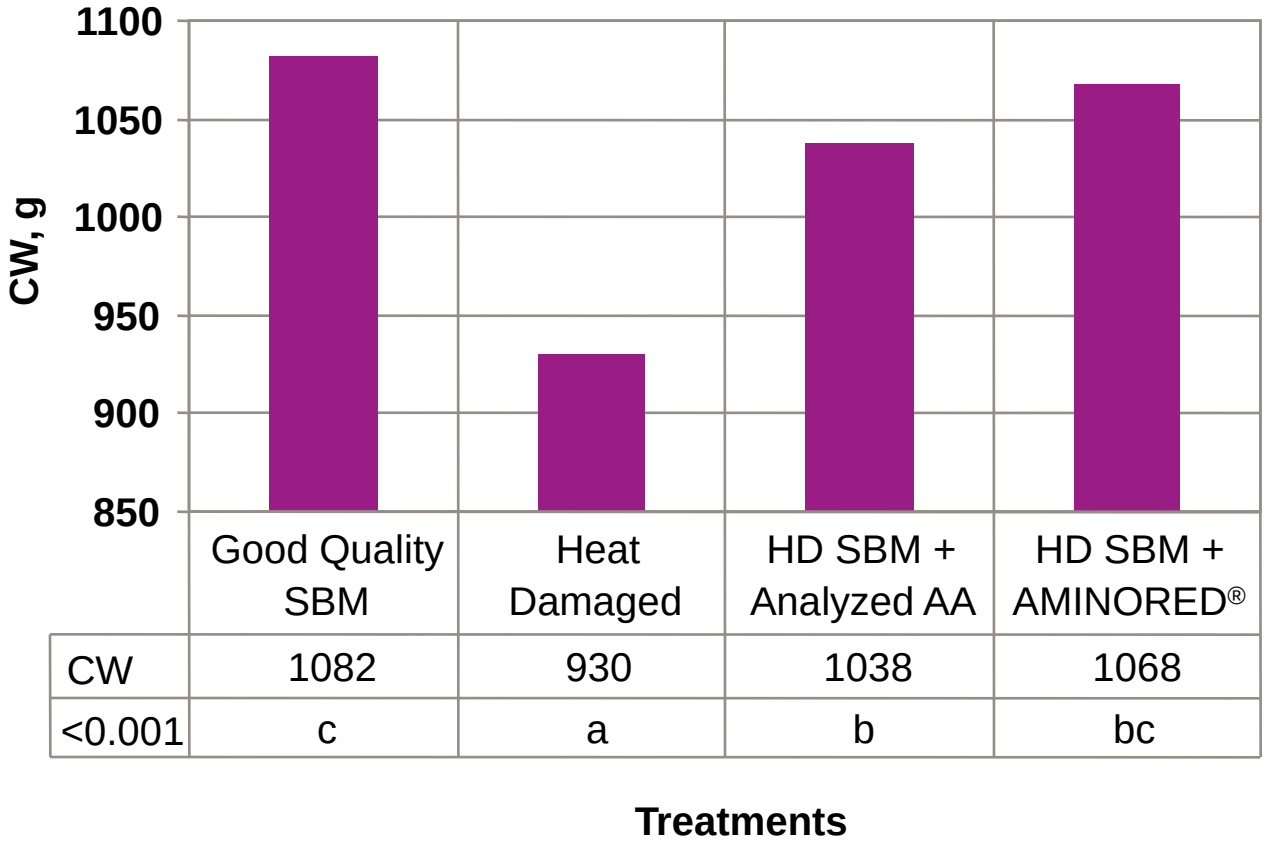
Treatments

AMINORED® validation
Feed Conversion Ratio



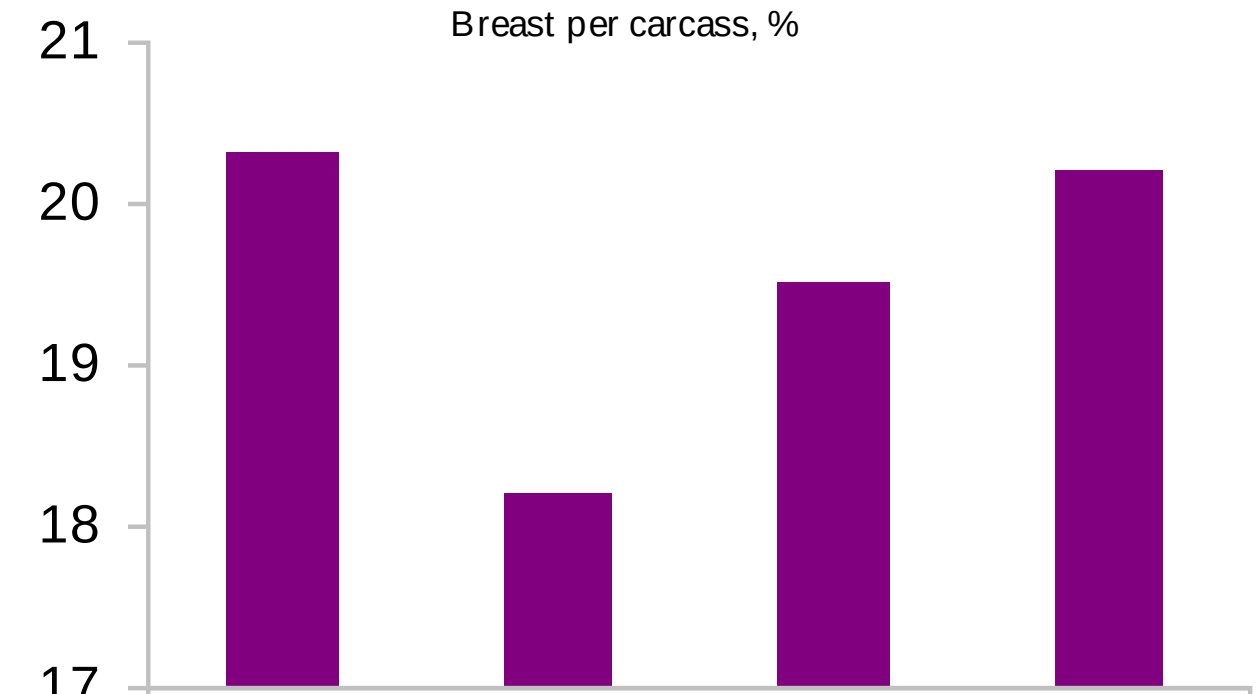
	Good Quality SBM	Heat Damaged SBM	HD SBM + Analyzed AA	HD SBM + AMINORED®
FCR	1.51	1.61	1.53	1.50
<0.05	ab	c	b	a

Carcass weight



	Good Quality SBM	Heat Damaged	HD SBM + Analyzed AA	HD SBM + AMINORED®
CW	1082	930	1038	1068
<0.001	c	a	b	bc

AMINORED® validation
Breast per Carcass



	Good Quality SBM	Heat Damaged SBM	HD SBM + Anlayzed AA	HD SBM + AMINORED
BpC, %	20.3	18.2	19.5	20.2
p<0.05	c	a	b	c

AMINORED® validation

- The trial completely validates AMINORED®.

In conclusion:

- SBM quality can be quantified by AMINORED®.
- It is possible to get good broiler performance with poor quality soybean meal as long as the level of digestible amino acids are adjusted according to quality of the raw materials.

Effect of heat damage on value of soybean meal samples

- Shadow price evaluation of different qualities
- Estimated effect on animal performance

Example of broiler grower diet formulation using two qualities of SBM (HDI 12 & 47)

– nutrient specifications used in Brill least cost formulation

Code	Name	Amount	100.00	*	Minimum	Maximum	Solution	Difference	Cost	Amount	Cost	Amount
1	WEIGHT (Kg)	1.0000			0.7200	1.0000	1.0000		38,807.9600	0.7829	10,391.5300	1.0581
2	DRY MATTER (%)	88.817	100.000				88.803	0.013				
3	ETHER EXTRACT (%)	7.636	8.598		4.000		7.596	0.041				
5	FIBER (%)	3.819	4.300			4.500	3.822	-0.002				
11	ASH (%)	6.589	7.419				6.519	0.070				
33	Crude Protein (%)	19.94	22.45		18.50		19.94					
103	ME / kcal (Poultry) (Kcal /Kg)	3,050	3,434		3,050		3,050		22,282.0000	2,847	214,694.6000	5,004
104	ME / MJ (Poultry) (MJ / Kg)	12.76	14.36				12.76					
140	True fec.dig. Lys (P (%)	0.950	1.070		0.950		0.950		6,376.6370	0.771	26,035.5200	1.683
141	True fec.dig.Met (P) (%)	0.456	0.514		0.400		0.456					
143	True fec.dig.M+C (P) (%)	0.710	0.799		0.710		0.710		3,122.4840	0.654	655,385.1000	12.556
144	True fec.dig.Thr (P) (%)	0.620	0.698		0.620		0.620		1,725.0460	0.578	452,534.0000	35.733
145	True fec.dig.Try (P) (%)	0.189	0.212				0.188					
146	True fec.dig.Arg (P) (%)	1.117	1.258				1.117					
147	True fec.dig.Iso (P) (%)	0.630	0.709		0.630		0.630		2,152.4040	0.597	3,371.6030	0.682
148	True fec.dig.Leu (P) (%)	1.350	1.520				1.350	-0.001				
149	True fec.dig.Val (P) (%)	0.763	0.859		0.730		0.763					
150	Lysine (%)	1.060	1.194				1.060					
151	Methionine (%)	0.487	0.549				0.487					
153	M+C (%)	0.804	0.905				0.804					
154	Threonine (%)	0.722	0.813				0.722					
155	Tryptophan (%)	0.225	0.254				0.225					
175	Calcium (%)	0.90	1.01		0.90		0.90		1,226.8530	0.75	68,122.4100	9.15
176	Total Phos. (%)	0.92	1.04				0.92					
177	Avail. Phos (%)	0.45	0.51		0.45		0.45		4,881.2880	0.32	2,965.9520	0.53
179	Sodium (%)	0.200	0.225		0.200		0.180	0.020	1,009.4150	0.164	169,094.4000	6.150
180	Chloride (%)	0.300	0.338		0.150	0.300	0.300		2,168.5380	0.118	640.9545	0.354

1000.00 | 1 Broiler | Feasible | 1000.00

1.0000

334,236.6240 | 333,668.2647 | 568.3593

Example of broiler grower diet formulation using two qualities of SBM (HDI 12 & 47)

– raw materials in Brill least cost formulation (Shadow price)

Code	Name	Amount	Price	*	Minimum	Maximum	Solution	Difference	Cost	Amount	Cost	Amount
2	Corn	55.2536	235.0000				55.2536		218.2493	58.3285	244.3280	39.0199
490	Soybean meal, HDI 12	19.7832	390.0000				19.7832		370.9229	22.4832	425.2321	
24	Rice bran	10.0000	150.0000			10.0000	10.0000			16	177.5848	
47	Rapeseed meal	5.0000	245.0000			5.0000	5.0000			57	255.3015	
71	Meat and bone meal, 48 % CP	4.0000	544.0000			4.0000	4.0000			56	566.6713	0.6395
249	Ricebran oil	3.3773	810.0000				3.3773		765.7775	6.8016	868.2029	2.4924
300	Dicalcium phosphate 22	1.0428	500.0000				1.0428		442.4807	2.3673	2,315.8850	0.9594
304	CACO3	0.3871	135.0000				0.3871			18.6120	895.4772	
309	NaCl	0.3276	225.0000				0.3276			0.3549	930.7313	0.0736
310	Premix	0.2500	5,500.0000		0.2500	0.2500	0.2500			18.5135	5,500.0000	
200	DL- Met, 99 % Degussa	0.1745	5,850.0000				0.1745		3,700.7450	0.1985	15,230.2700	0.1532
201	L-Lys-HCl	0.1674	2,800.0000				0.1674		21.7594	1.1668	5,236.2590	0.0853
302	Na-Bicarbonate	0.1004	600.0000				0.1004		104.3543	0.4621	5,786.8040	0.0618
311	Choline Chloride	0.1000	2,475.0000		0.1000		0.1000			0.9109	2,475.0000	
203	L-Threonine	0.0360	4,300.0000				0.0360		20 .0368	30.3512	9,866.7740	
11	Pearl Millet		220.0000						204.6 41	53.6263		
21	Corn gluten feed		135.0000						124.65 36	14.6359		
25	Rice bran, extr.		121.0000						94.6 95	7.5205		
58	Groundnut meal		350.0000						276.2771	15.6266		
491	Soybean meal, HDI 47		390.0000						357.7399	21.6057		

Δ 32 USD/MT

1000.00 | 1 Broiler | Feasible | 1000.00

1.0000

323,113.3648 | 323,113.3648

Thursday, March 04, 2010

– effect on feed price when SBM (HDI 47) is used at same price as SBM (HDI 12)

Code	Name	Amount	Price	*	Minimum	Maximum	Solution	Difference	Cost	Amount	Cost	Amount
2	Corn	53.0649	235.0000				55.2536	-2.1887	207.2137	63.6602	240.7690	37.3963
491	Soybean meal, HDI 47	21.6057	390.0000						340.2719	24.5544	440.7599	19.8250
24	Rice bran	10.0000	150.0000			10.0000	10.0000		150.0000	17.3506	179.4404	
47	Rapeseed meal	5.0000	245.0000			5.0000	5.0000		245.0000	14.9747	274.3265	
71	Meat and bone meal, 48 % CP	4.0000	544.0000			4.0000	4.0000		544.0000	6.5845	588.0552	
249	Ricebran oil	3.6799	810.0000				3.3773	0.3026	782.7584	6.9981	983.8044	2.8363
300	Dicalcium phosphate 22	1.0166	500.0000				1.0428	-0.0261	387.9999	2.5900	1,640.4470	0.9374
304	CACO3	0.3903	135.0000				0.3871			22.0597	900.5497	
309	NaCl	0.3075	225.0000				0.3276	-0.0202		0.3368	934.3325	0.0535
310	Premix	0.2500	5,500.0000		0.2500	0.2500	0.2500			21.9644	5,500.0000	
201	L-Lys-HCl	0.2297	2,800.0000				0.1674	0.0623	17.2137	1.1675	6,850.5000	0.1415
200	DL- Met, 99 % Degussa	0.1838	5,850.0000				0.1745		376.9494	12.1678	12,977.8500	0.1712
302	Na-Bicarbonate	0.1294	600.0000				0.1004	0.0290	101.8255	0.4911	9,213.7890	0.0879
311	Choline Chloride	0.1000	2,475.0000		0.1000		0.1000			0.8604	2,475.0000	
203	L-Threonine	0.0421	4,300.0000				0.0360		200.9206	35.5282	10,874.0400	0.0284
11	Pearl Millet		220.0000						205.3381	51.6050		
21	Corn gluten feed		135.0000						128.6741	14.2890		
25	Rice bran, extr.		121.0000						97.2165	7.3315		
58	Groundnut meal		350.0000						296.6317	15.4046		
490	Soybean meal, HDI 12		390.0000		N/A	N/A	19.7832	-19.7832	390.0000	19.7832		

1000.00 | 1 Broiler | Feasible | 1000.00

1.0000

330,083.4351 | 323,113.4033 | 6,970.0317

– effect on nutrient specs when SBM (HDI 47) is used with same matrix as SBM (HDI 12)

Code	Name	Amount	100.00	*	Minimum	Maximum	Solution	Difference	Cost	Amount	Cost	Amount
1	WEIGHT (Kg)	1.0000			1.0000	1.0000	1.0000		0.1370	1.0000	6,872.2820	1.0568
2	DRY MATTER (%)	88.777	100.000				88.777					
3	ETHER EXTRACT (%)	7.395	8.330				7.395					
5	FIBER (%)	3.801	4.282			4.500	3.801					
11	ASH (%)	6.517	7.341				6.517					
33	Crude Protein (%)	19.18	21.61				19.18	0.01				
103	ME / kcal (Poultry) (Kcal /Kg)	3,050	3,4				3,050					
104	ME / MJ (Poultry) (MJ / Kg)	12.76	14.37				12.76					
140	True fec.dig. Lys (P (%)	0.867	0.977				0.950	-0.083				
141	True fec.dig.Met (P) (%)	0.441	0.497				0.449	-0.007				
143	True fec.dig.M+C (P) (%)	0.689	0.776				0.710	-0.021				
144	True fec.dig.Thr (P) (%)	0.593	0.668				0.620	-0.027				
145	True fec.dig.Try (P) (%)	0.180	0.203				0.180					
146	True fec.dig.Arg (P) (%)	1.070	1.206				1.113	-0.042				
147	True fec.dig.Iso (P) (%)	0.604	0.681				0.630	-0.026				
148	True fec.dig.Leu (P) (%)	1.317	1.483				1.370	-0.053				
149	True fec.dig.Val (P) (%)	0.738	0.831				0.759	-0.022				
150	Lysine (%)	0.974	1.097				1.065	-0.091				
151	Methionine (%)	0.472	0.531				0.480	-0.008				
153	M+C (%)	0.781	0.880				0.805	-0.024				
154	Threonine (%)	0.693	0.781				0.723	-0.030				
155	Tryptophan (%)	0.215	0.243				0.215					
175	Calcium (%)	0.90	1.01				0.90					
176	Total Phos. (%)	0.92	1.03				0.92					
177	Avail. Phos (%)	0.45	0.51				0.45					
179	Sodium (%)	0.200	0.225				0.200					
180	Chloride (%)	0.300	0.338				0.300					

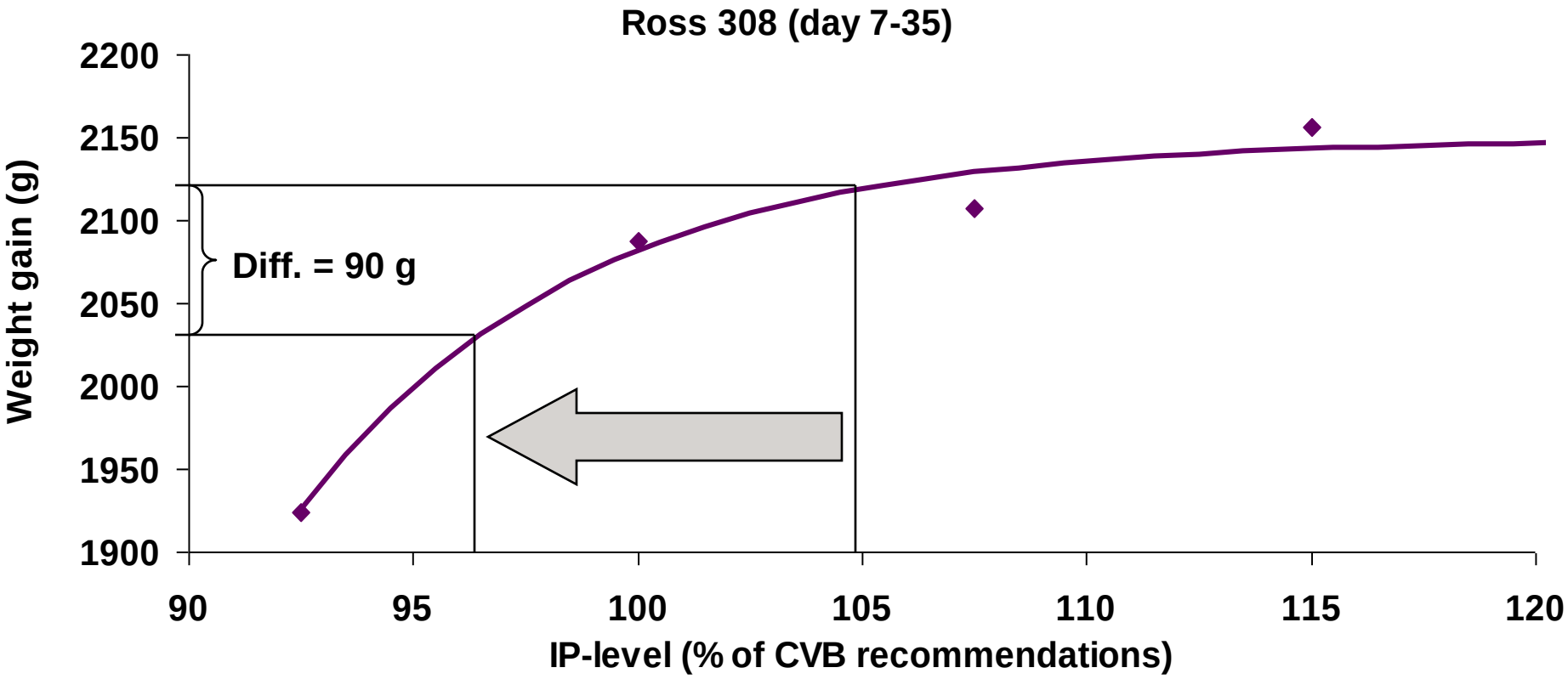
9% less

1000.00 | 1 Broiler | Feasible | 1000.00

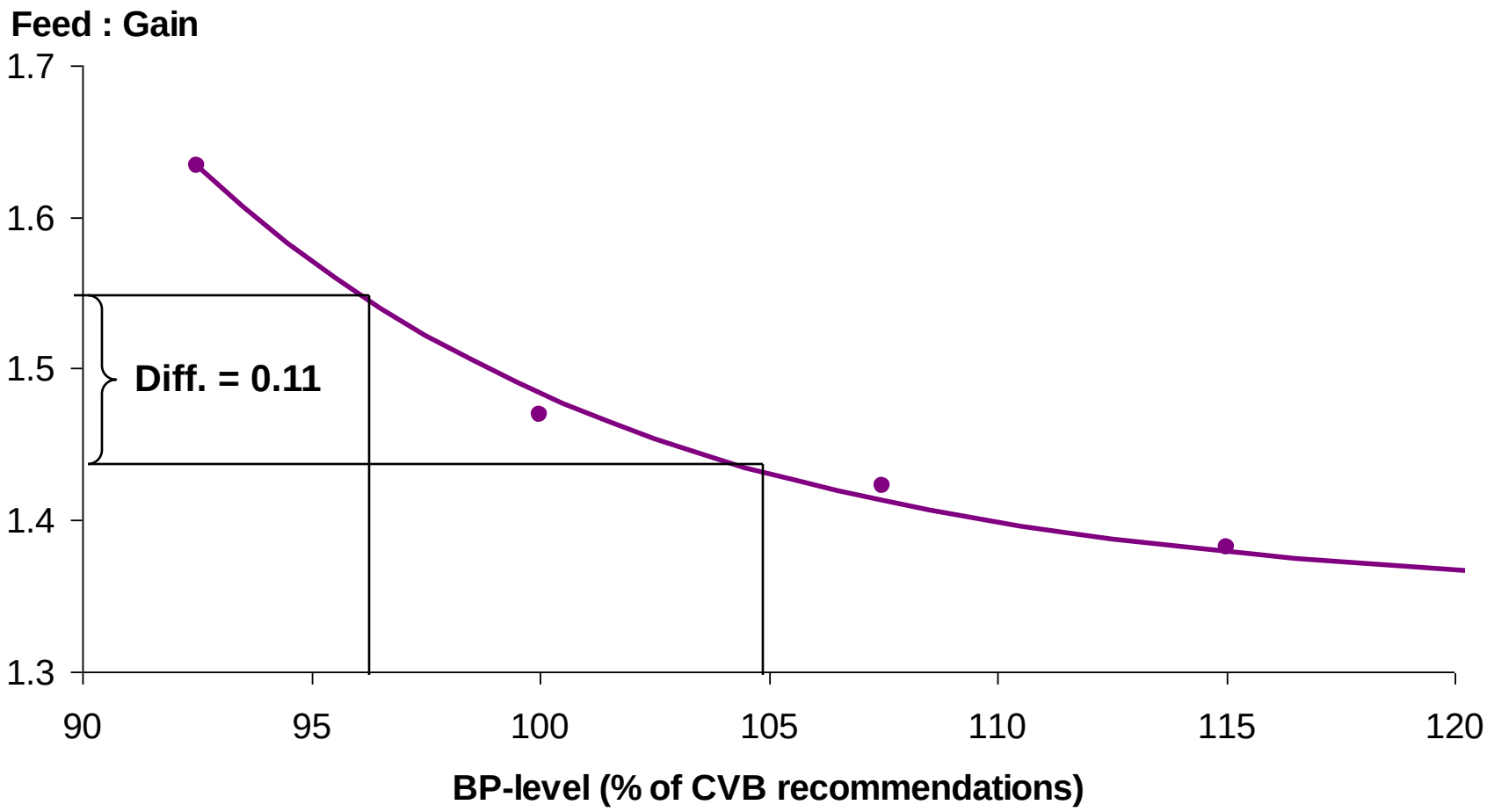
1.0000

325,873.8930 | 325,876.0293 | -2.1362

Accurate predictions are essential for good performance results



Accurate predictions are essential for good performance results



Impaired performance affect revenue substantially

Gross Margin Calculation scenario:

10 mill broilers
35 days at slaughter
1 US$/kg Live weight
Feed price 323 US$/MT

Total LW production (105 % CVB): 10 mill x 2.120 …. 21,200 MT
Total LW production (96 % CVB): 10 mill x 2.030 ….. 20,300 MT

Revenue: 21,200 x 1000 …… 21,200,000 US$
Revenue: 20,300 x 1000 …… 20,300,000 US$
Reduced revenue …… …….. 900,000 US$

… feed cost, and gross margin

Gross Margin Calculation scenario:

10 mill broilers
35 days at slaughter
1 US$/kg Live weight
Feed price 323 US$/MT

Total feed cost (105 % CVB): 21,200 x 1.43 x 323 ….. 9,792,068 US$
Total feed cost (96 % CVB): 20,300 x 1.54 x 323 ……. 10,097,626 US$
Additional feed cost …… …… 305,558 US$

Gross Margin

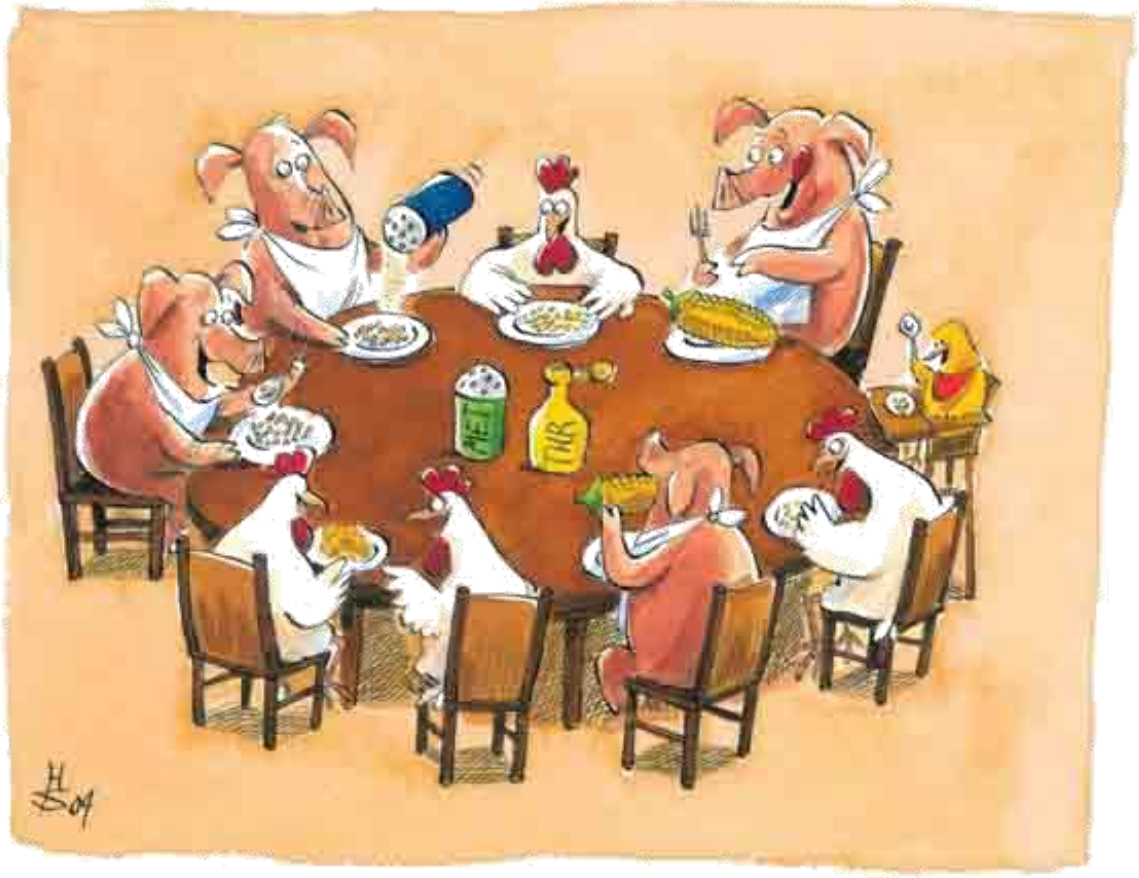
105 % CVB: 21,200,000 – 9,792,068 ……..11,407,932 US$
96 % CVB: 20,300,000 – 10,097,626 ……..10,202,374 US$
Reduced Gross Margin …… 1,205,558 US$

Conclusions

- Heat treatment affect total and digestible amino acid level in soybean meal and DDGS
- New fast tool to detect heat damage and predict digestible amino acid level was developed
- AMINORED® gives better understanding of the feed ingredient and thereby,
  - more accurate formulation
  - more consistent performance over time

Evonik Degussa

Turning knowledge into your profit



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