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Protein level is not a determinant of quality for soybean meal

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Introduction

Soybean meal is traded globally on protein basis. It is usually traded as a commodity based on specifications listed in the Table 1.

Table 1: Trading specifications of soybean meals

Parameter	Percent composition	
	Non-dehulled	Dehulled
Protein, %	42.5 – 44.0	46.5 – 48.0
Moisture, %	12.0 – 12.5	12.0 – 12.5
Fiber, %	7.0 max	3.5 max
Delta pH	< 0.2	< 0.2
KOHPS, %	>72.0	> 72.0

In general, any deficiency in protein is compensated at 1:1 (Annex) or 2:1 (NOPA) of the contractual price. Therefore protein is considered as the primary determinant of the quality of soybean meal. Recently some higher protein soybean meal of about 50% protein has been introduced to the market. They are manufactured from Brazilian or Indian soybeans. Generally they are sold at a premium to normal protein dehulled soybean meal (46.5%). However there have been no feeding trials to justify their price premium for broiler feeding. Therefore it is important to establish whether protein content has any relationship with the performance of soybean meal in poultry feeds. The fact is that almost all broiler feeds today are formulated based on digestible amino acids instead of protein. Many trials have demonstrated that the protein of broiler feeds per se is not relevant when formulating using digestible amino acids. Recently a trial conducted by Creswell and Swick, 2008 clearly showed that FCR and body weight gain are correlated to digestible amino acids level (NeohSB, 2008). Based on numerous trials done by ASA, David Creswell and Soon Soon Oilmills from 1995 to 2010, the protein levels of these trial soybean meals are plotted against their growth performances ie. body weight gain and FCR for day 0 to 21 and day 0 to 42 and the results are shown in Fig. 1, 2, 3 & 4. Based on these 28 data from the 7 trials there is no correlation between protein levels and growth performances. In some of these trials a different nutrient matrix with different levels of digestible amino acids may have been used for individual soybean meals which can partially explained the results.

Recent trials have demonstrated that there can be a large difference in growth performance of broilers when using soybean meals of similar proximate analysis. The performances of 4 soybean meals formulated with common specifications (base on US dehulled soybean meal) are shown in Table 2 (Creswell & Swick, 2008).

Figure 1: Protein levels versus body weight gain (g) at starter period (0- 21 days)

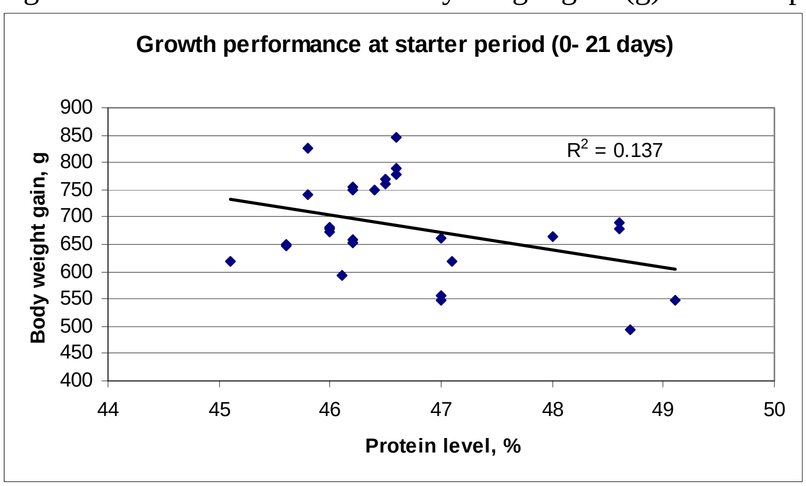
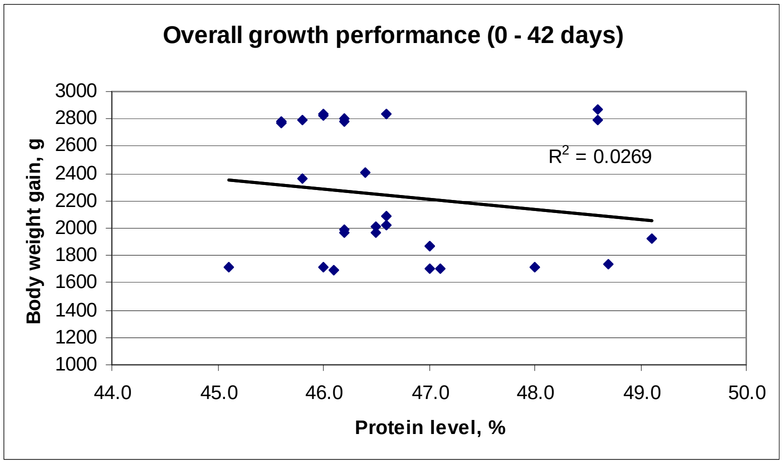


Figure 2: Protein level versus body weight gain (g) at overall period (0- 42 days)



Overall growth performance (0 - 42 days)
Body weight gain, g
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
R^2 = 0.0269
44.0
45.0
46.0
47.0
48.0
49.0
50.0
Protein level, %

Figure 3: Protein levels versus FCR at starter period (0- 21 days

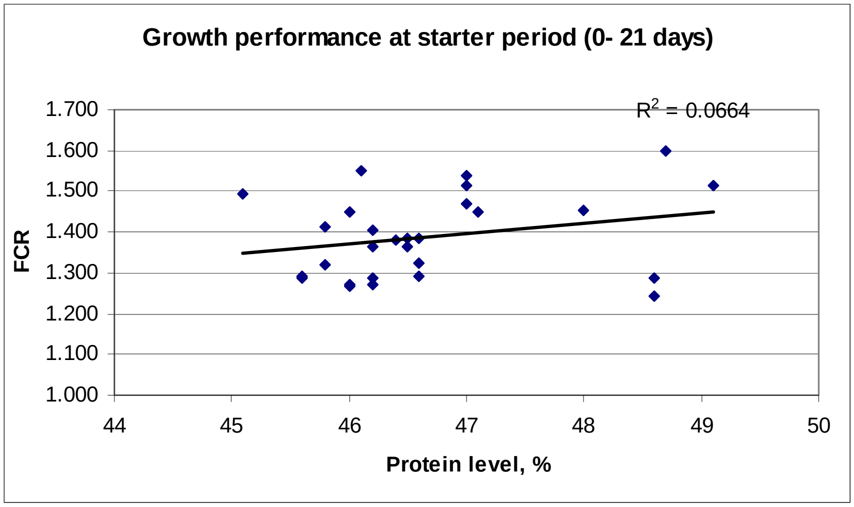


Figure 4: FCR against protein level at overall period (0- 42 days)

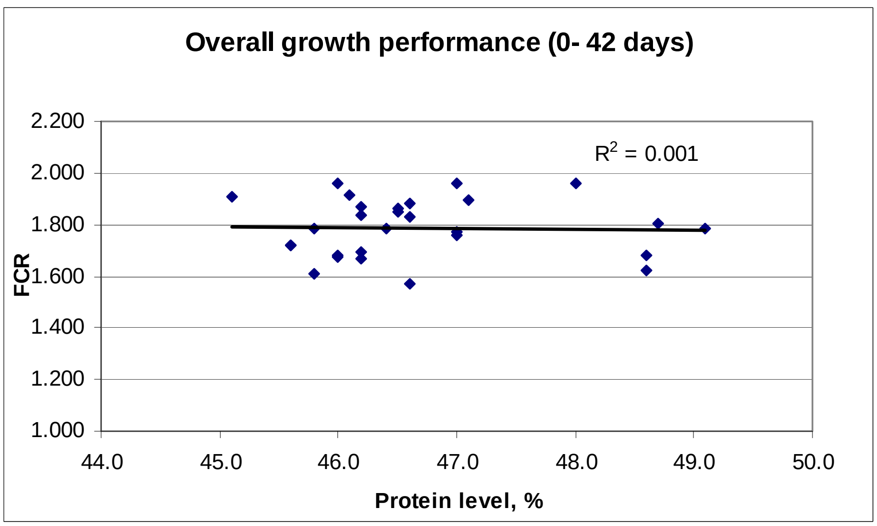


Table 2: Performance of 4 soybean meals when formulated with a common specification (US dehulled soymeal) for energy and digestible amino acids (40 days).

Type of soybean meal	Live weight, g	FCR
Indian	2812^{b}	1.765^{c}
Argentine	2837^{b}	1.672^{b}
USA	2869^{ab}	1.693^{b}
SoonSoon	2908^{a}	1.625^{a}

[a,b] Means within column with no common superscript differ significantly ($p<0.05$).

This trial showed that performance differences between the soybean meals can be up to 3.3% in live weight gain and 7.9% in FCR. Economic analysis of these 4 soybean meals base on their nutrient content showed a difference in value of up to USD 120.1/mt from one soybean meal to another, furthermore formulating with these soybean meals, using their correct energy levels and digestible amino acids can achieve a large saving in the cost of formulated feed of up to USD 34.41/mt

The question arising is whether by increasing the available/ digestible amino acids in soybean meal with better processing can allow the use of a lower protein soybean meal and still achieve the same results as using a higher protein soybean meal which is not optimally processed . In order to test this hypothesis, two trials were carried out not only to determine if two soybean meals with very different protein levels can perform similarly but also can a well processed dehulled soybean meal with a low protein level of 44.8% perform as well as a soybean meal with much higher protein of 48.4% protein. Can better processing overcome such a huge handicap? Can it allow the protein levels of soybean meals to be lowered significantly without compensation nutritionally for the lower protein content, and yet achieve good growth performance? The proximate analyses of the four soybean meal used in these two trials are presented below (Table 3).

Table 3 : Proximate Analysis of the 4 soybean meals used in the trial 1 and trial 2

Proximate results	SBM A SS SBM	SBM B Thai SBM	SBM C SS SBM	SBM D Ind. SBM
Moisture, %	12.1	11.0	12.9	11.8
Protein, %	46.7	49.9	44.8	48.4
Crude Fiber, %	2.3	2.4	2.3	4.2
Crude Fat, %	2.2	0.9	2.2	1.2
Ash,%	6.1	6.0	5.8	8.7
KOHPS, %	83.0	83.0	83.1	81.7
Delta pH	0.05	0.03	0.02	0.04

In the first trial, a dehulled soybean meal produced by Soon Soon Oilmills (SBM A) with a normal protein level of 46.7% was selected to be compared with another dehulled soybean meal obtained from a Thai crusher (SBM B) with a much higher protein level of 49.9% effectively giving a 7% difference in protein levels. The trial was conducted in 2 arms simultaneously. In the first arm, both soybean meals used the same nutrient matrix as per US dehulled soybean meal. Since the SBM B has 7% more protein level than SBM A, a similar growth performance for FCR and body weight gain would suggest that SBM A has 7% more nutrients than SBM B. In the second arm, the 2 soybean meals were assigned individually a nutrient specification deemed to be appropriate to them by David Creswell based on assays by Evonik Degussa. In this case, the digestible amino acids and AME of SBM A were up to 6% and 8% respectively higher than those used for US dehulled soybean meal. Similarly SBM B was assigned the same AME with US dehulled soybean meal but the digestible amino acids were assigned to be up to 5.4% higher than the US dehulled soybean meal specification. The 3 nutrient Matrixes are shown in Table 4.

Table 4: Nutrient Matrixes of SBM used in trial 1

Type of soybean meal	Thai (SBM B)	SS (SBM A)	US
ME, Kcal/kg	2450	2650	2450
Protein, %	50.3	48.15	47.5
Dig. Lysine, %	2.691	2.706	2.554
Dig. Methionine, %	0.593	0.596	0.576
Dig M+C, %	1.174	1.183	1.178
Dig.Tryptophan, %	0.586	0.593	0.576
Dig.Threonine, %	1.631	1.611	1.564
Dig. Arginine, %	3.358	3.289	3.192
Dig.Isoleucine, %	1.999	1.956	1.922
Dig. Valine, %	2.056	2.021	1.966

Digestible amino acid values for SS and Thai meals were as assayed by Evonik Degussa.
US specs were derived from previous work.

In the second trial, the limit of this hypothesis was tested. A dehulled soybean meal of only 44.8% protein (SBM C) was obtained from Soon Soon Oilmills. The protein level was effectively about 4% lower than the normal protein level of a dehulled soybean meal (46.5%). Against this is a dehulled Indian soybean meal of 48.4% protein (SBM D) or 4% higher in protein than the normal dehulled soybean meal level of 46.5%. There is effectively an 8% difference in protein level between these 2 soybean meals. Again the trial was conducted simultaneously in 2 arms. In the first arm, both soybean meals were assigned a common nutrient specification base on US dehulled soybean meal. In the second arm, the nutrient specification of the SBM C and SBM D were assigned by David Creswell and deemed to be appropriate for these types of soybean meals. The digestible lysine of SBM C was assigned to be 7.2 % higher than those used for US dehulled soybean meal, in contrast the digestible lysine for SBM D was assigned to be 3.7% lower than those used for US dehulled soybean meal. There is effectively an 11% difference in digestible lysine between the 2 soybean meals, despite the fact that soybean meal C has 8% lower protein than soybean meal D! Similarly the AME of soybean meal C was assigned to be 8.2% higher than those used for US dehulled soybean meal and the AME for soybean meal D was assigned to be 4.7% lower than those for US dehulled soybean meal. Effectively there is a 13.2% difference in assumed AME between the two soybean meals .The nutrient matrixes are presented in Table 5.

This 2nd trial will seek to establish to what extend the protein levels of a well processed soybean meal can lowered before serious performance degradation is detected and if proper processing can overcome a large difference in protein level of up to 8%. Another arm of the trial will also attempt to test whether digestible amino acids is a reliable tool for judging the quality of soybean meal. For example the difference of digestible lysine between the 2 soybean meals is set at 11% and the difference in protein level is 8%, so theoretically if the total lysine content relative to protein content and lysine digestibility coefficients are the same for the two soybean meals (the lysine to total protein ratio was tested higher for the soybean meal D meal at 6.19% compare with 6.17% for soybean meal C by Evonik Degusssa) , the digestible lysine for soybean meal C should be 8% lower than soybean meal D but instead it was assign a value which is 11% higher than soybean meal D. Therefore in real terms there is a 19% difference in assumed digestible lysine levels.

Table 5: Nutrient Matrixes of SBMs used in Trial 2

Nutrient	SS[1](SBM C)	Indian dehulled[2] SBM D	US[1]
ME, Kcal/kg	2650	2340	2450
Protein, %	47	46.5	47.5
Digest. Lysine, %	2.739	2.464	2.554
Digest. Methionine, %	0.601	0.576	0.576
Digest. MC, %	1.223	1.142	1.178
Digest. Tryptophan, %	0.616	0.57	0.576
Digest. Threonine, %	1.681	1.547	1.564
Digest. Arginine, %	3.367	3.039	3.192

Digest. Isoleucine, %	2.011	1.848	1.922
Digest. Valine, %	2.097	1.923	1.966

1,3 Derived largely from research conducted in Thailand in 2008
2 Derived from research on similar types of soybean meals

Trial 1

The trial was conducted at Bangkok Animal Research Center (BARC). A total of 240 day old Arbor Acres Plus broiler chicks were used in this trial. The chicks were randomly assigned to four treatments and each treatment had 6 replicates. The chicks were allocated equally over 24 pens and each pen contained 10 chicks. Four treatment diets were formulated with 2 different soybean meals with different nutrient specification as listed in Table 4. Diet formulations are shown in Table 6. Starter diets were offered to the birds from 0 to 16 days of age and grower diets was offered to the birds from 17 to 34 days of age. The feed was offered in crumble form from 0 to 14 days and was then changed to pellet form from day 15 to the end of trial. The diets and water were provided *ad libitum* throughout 34 days trial period.

Body weights of birds were determined at 1, 17 and 34 days of age. Total feed consumption was measured at 17 and 34 days of age. Fecal moisture of broiler was scored at day 34. Mortality and culled were recorded daily. Body weight gain, feed intake, FCR, mortality and culls and fecal scores were calculated and subjected to analysis of variance as randomized complete block design.

Table 6: Formulae and Nutrients content of the diets for Trial 1

Treatment	Starter (0- 16 d)				Grower (17-35 d)			
	1	2	3	4	1	2	3	4
Type of SBM	Thai	SS	Thai	SS	Thai	SS	Thai	SS
Formulation basic	Thai	SS	US	US	Thai	SS	US	US
Corn, %	57.73	59.56	55.15	55.15	63.68	64.41	61.99	61.99
SS SBM, %	0.00	35.40	0.00	37.20	0.00	29.40	0.00	30.60
Thai SBM , %	35.10	0.00	37.20	0.00	29.00	0.00	30.60	0.00
Palm oil, %	3.00	0.90	3.50	3.50	3.60	2.50	3.80	3.80
Limestone, %	1.30	1.30	1.30	1.30	1.200	1.200	1.200	1.200
MDCP 21, %	1.50	1.50	1.50	1.50	1.300	1.300	1.200	1.200
Salt, %	0.36	0.36	0.36	0.36	0.260	0.260	0.260	0.260
Sod. bicarbonate, %	0.20	0.20	0.20	0.20	0.200	0.200	0.200	0.200
Lysine HCL, %	0.16	0.14	0.16	0.16	0.160	0.140	0.170	0.170

DL Methionine, %	0.26	0.25	0.25	0.25	0.250	0.240	0.230	0.230
L Threonine, %	0.04	0.04	0.04	0.04	0.060	0.060	0.060	0.060
Choline chloride 60,	0.10	0.10	0.09	0.09	0.040	0.040	0.040	0.040
Vitamins/ mins, %	0.20	0.20	0.20	0.20	0.200	0.200	0.200	0.200
Coccidiostat, %	0.05	0.05	0.05	0.05	0.050	0.050	0.050	0.050
Total, %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Nutrient Minimum								
ME, Kcal/ kg	2950	2950	2950	2950	3100	3100	3100	3100
Protein, % (Actual)	22.4	21.9	22.2	22.7	19.8	19.4	19.6	20.0
Dig. Lysine, %	1.2	1.2	1.2	1.2	1.05	1.05	1.05	1.05
Dig. Methionine, %	0.444	0.444	0.444	0.444	0.399	0.399	0.399	0.399
Dig. MC, %	0.84	0.84	0.84	0.84	0.767	0.767	0.767	0.767
Dig. Tryptophan, %	0.192	0.192	0.192	0.192	0.178	0.178	0.178	0.178
Dig. Threonine, %	0.744	0.744	0.744	0.744	0.672	0.672	0.672	0.672
Dig. Arginine, %	1.26	1.26	1.26	1.26	1.134	1.134	1.134	1.134
Dig. Isoleucine, %	0.78	0.78	0.78	0.78	0.704	0.704	0.704	0.704
Dig. Valine, %	0.924	0.924	0.924	0.924	0.819	0.819	0.819	0.819
Calcium,%	0.84	0.84	0.84	0.84	0.72	0.72	0.72	0.72
Avail. P, %	0.42	0.42	0.42	0.42	0.36	0.36	0.36	0.36
Sodium, %	0.22	0.22	0.22	0.22	0.18	0.18	0.18	0.18
Choline, ppm	1850	1850	1850	1850	1450	1450	1450	1450

Results & Discussions

The growth performances of the broilers from 0-34 days are shown in Table 7. There were no significant differences among all diets in feed intake, body weight gain, FCR, livability and fecal scores. The best body weight gain (2387g) was obtained from SBM A with US nutrient matrix whereas the lowest FCR (1.547) was obtained from the same SBM A but with its own appropriate nutrient matrix. Diet using SBM B with its own specification gave the highest FCR (1.567) and it was 1.3% poorer than the best FCR (1.547). All diets gave similar fecal score showing that both soybean meals were of good quality and did not give any negative impact to the chickens. Although all diets for the 2 arms showed statistically no significant differences, SBM A performed better than SBM B despite a 7% handicap in protein level. When using a similar nutrient specification (US dehulled SBM), SBM A achieved weight gain of 2.2% higher than SBM B and the FCR for the diet using SBM A was 0.8% lower than that for SBM B. Interestingly when the SBM A was used in a diet where the nutrient matrixes was assumed to be 8.1% higher in AME and digestible lysine was set at 7% higher than US dehulled SBM level, SBM A still managed to perform better than SBM B using the dehulled US SBM nutrient matrix. This would suggest that the available nutrients of soybean meal A is even higher than the difference in protein level of 7% when compared with SBM B

Table 7: The growth performance of SS SBM (SBM A) and Thai SBM (SBM B) using 2 different nutrient specifications in broiler trial (0-34 days)

Treatment			Initial	Final	Body	Feed	Feed	Livabilit	Fecal
	Type of	Nutrient	body	Wt	weight	intake	conversi		score
Group	SBMs	Spec of	weight		gain		ratio[2]		
		SBMs	(g)	(g)	(g)	(g)		(%)	
1	Thai	Thai	43	2411	2368	3711	1.567	98.33	2.33
2	SS	SS	43	2398	2355	3642	1.547	98.33	2.17
3	Thai	US	43	2380	2337	3647	1.561	100.00	2.33
4	SS	US	43	2430	2387	3694	1.548	98.33	2.33
P-value				0.3985	0.4025	0.4397	0.6638	0.7656	0.8948
Pooled SEM				20.854	20.842	35.101	0.014	1.344	0.186
C.V.%				2.12	2.16	2.34	2.14	3.33	19.92

[1] Male broilers (Arbor Acres Plus).
[2] Feed conversion ratio corrected for mortality and culls.
Fecal score 1 = hard, 2 = soft, 3 = watery.

Trial 2

This trial was conducted at BARC as well. The trial protocol was exactly the same as trial 1 above except the starter diets were offered to the birds from day 0 to day 18 and the grower diets were offered from day 19 to day 35. Diet formulations and minimum nutrient requirements of the diets are shown in Table 8. The trial results are presented in Table 9.

Table 8 : Diet formulations and nutrient content of starter and grower phases for trial 2

Sbm type	Starter Diets				Grower Diets			
	SS		Indian dehulled		SS		Indian dehulled	
SBM nutrient spec.	SS	US	Indian	US	SS	US	Indian	US
Corn	575.1	520.9	494.9	520.9	624.6	589.1	573	589.1
SS SBM (SBM C)	313	344	0	0	255	278	0	0
Indian dehulled (SBM D)	0	0	356	344	0	0	287	278
Rice bran (fullfat)	60	60	60	60	60	60	60	60

Palm oil	10	34	48	34	25	38	45	38
Limestone	13.6	13.4	13.3	13.4	11.8	11.6	11.6	11.6
MDCP 21	14.7	14.5	14.5	14.5	12.2	12.1	12.1	12.1
Salt	3.9	3.9	4	3.9	2.4	2.4	2.4	2.4
Sodium bicarbonate	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Lysine HCL	1.8	1.6	1.7	1.6	1.7	1.7	1.8	1.7
DL Methionine	2.4	2.3	2.4	2.3	2.2	2.1	2.2	2.1
L Threonine	0.4	0.4	0.3	0.4	0.6	0.6	0.5	0.6
Choline chloride 60	1.1	1	0.9	1	0.5	0.4	0.4	0.4
Vitamins/t. minerals	2	2	2	2	2	2	2	2
Coccidiostat	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total, kg	1000	1000	1000	1000	1000	1000	1000	1000
Nutrients								
ME, kcal/kg	2950				3100			
Protein % (actual)	(20.2/21.4/21.4/21.4)				(17.8/18.8/18.8/18.8)			
Dig. Lysine, %	1.15				1			
Dig. Met %	0.4255				0.38			
Dig. M+C, %	0.805				0.73			
Dig. Tryp, %	0.184				0.17			
Dig. Thr, %	0.713				0.64			
Dig. Arginine, %	1.2075				1.08			
Dig. Isoleucine, %	0.7475				0.67			
Dig. Valine, %	0.8855				0.78			
Calcium, %	0.84				0.72			
Available P, %	0.42				0.36			
Sodium, %	0.22				0.16			
Choline , ppm	1850				1450			

Results & Discussion

Among all diets, SBM D performed significantly better than SBM C for FCR irrespective of which ingredient matrix were used . However there were no significant differences for body weight gains, feed intake and livability. SBM D using the US soybean meal specification gave the best body weight gain (2420g) and FCR (1.532). When formulating on individual specifications there was a difference in FCR of 3.2% in favor of SBM D .When a common nutrient specification was used, the FCR for SBM D was 5.8% better than SBM C. These results would seem to be reasonable considering that there is a 8% difference in protein levels between the two soybean meals and up to 11% difference in assigned digestible lysine levels , effectively giving in real terms a 19% difference in actual digestible lysine levels, because the difference in protein content is not reflected in the formulation of the test diets. The AME was also assigned to be up to 310kcal/kg or 13.2% higher . However the weight gained and FCR achieved using SBM C is within the breed standard (35 days weight is 2167gm and FCR is 1.589 for male). What is clear from this experiment is that using a well processed low protein dehulled soybean meal of 44.8% without adjusting proportionately for the lower protein will still give a good growth performance but it cannot overcome the a protein handicap of 8% and up to 19% theoretical difference in digestible amino acids with a 13.2% handicap in AME.

Table 9: The effect of soybean meal type and formulation specification on broiler performance (0-35 days of age).

Treatment			Initial body weight (g)	Final Body Weight (g)	Body Weight Gain (g)	Feed intake (g)	FCR[1]	Livability[4] (%)
Grou	SBM Types	SBM specifica						
1	SS (SBM C)	SS	44	2338	2294	3710	1.618 [b]	98.3
2	SS	US	44	2426	2382	3858	1.621 [b]	98.0
3	Indian dh (SBM D)	Indian dh	44	2442	2398	3761	1.568 [a]	100.0
4	Indian dh	US	44	2464	2420	3705	1.532 [a]	98.3
Pooled SEM				31.577	31.563	52.678	0.012	1.444
C.V. %				3.20	3.26	3.44	1.92	3.59

[a,b] Means within column with no common superscript differ significantly ($p<0.05$).
[1] FCR corrected for mortality and culls.
[4] Livabilty calculated on mortality.

Conclusions

These two trials have demonstrated that higher protein levels may not lead to higher broiler performance. The first trial shows that when using a similar nutrient specification, SBM A with 7% lower protein still perform as well or better as SBM B . Furthermore even when the AME for SBM A was increased by 8% while essential digestible amino acids levels were slightly increased by 0.5-1% over SBM B, SBM A still performed as well or better than SBM B. This clearly shows that protein level per se has no relationship with soybean meal performance at up to or possibly more than 7% difference in protein content. Interestingly even with a 7% handicap in AME, soybean meal SBM A still perform as well or better than SBM B , this is economically relevant as energy cost is the main cost in broiler feeding. Therefore when purchasing soybean meal base on protein, and paying a premium for higher protein content than 46.5% without verification of its performance can be a waste of money.

The results of trial 2 is very intriguing , while the weight gain for all diets were statistically not significant , the FCRs of SBM C was significantly poorer than SBM D. However this result must be viewed in the light that SBM C is 8% lower in protein than SBM D and in one of the arms it was assigned a higher digestible lysine value of 11% effectively creating a 19% difference in digestible lysine and the AME was set at 13.2% higher than SBM D .

Since SBM C performed similar to SBM D except for a lower FCR (however the overall performance was still within the breed standards), the whole validity of using digestible amino acids as the basis for soybean meal quality is in question. Consider even if the digestible coefficient of lysine digestibility is set at a low 80% for soybean meal D, then for soybean meal C it should be 99% which is impossible. Could it be that digestible amino acids are not the real determinants of protein quality and available amino acids are the real determinants? Indeed this has been proven many years ago by Batterham and Van Barneveld (1994) in pig feeding where it was determined that digestible amino acids may not be correlated to growth performance and available amino acid is the best determinant for amino acid utilization in pigs. The time is right for us to move on to available amino acids for poultry feed formulation.

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