Evaluation of Algal Meal as an energy and protein source in pig diets

4A-102

Report prepared for the Co-operative Research Centre for High Integrity Australian Pork

By

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Executive Summary

Micro and Macro Algae are now a focus of developing a sustainable resource that can be used to supply a substantial part of the diet of all phases of pig production. The production of Algae is rapidly gaining acceptance as a method of reducing the carbon output of many heavy industries that produce significant carbon output to the environment. The Algal product that is produced as a byproduct is available to the animal industries as a feed ingredient. Despite the potential use of algae as a valuable protein source for animals, there has been very little work research on the evaluation of algae as a feed ingredient for animals over the past 20-30 years.

A total of 80 male weaners (PrimeGro™ genetics) were weaned from the Research and innovation unit at an average age of 26 days (average weight 7.2 kg ± 0.89 kg) and transferred into individual weaner pens. Pigs were offered a commercial starter diet for an initial 5 day period to acclimatise to solid feed and the new environment. After this acclimatisation period, all pigs were individually weighed and allocated to one of the test diets:

1. 0% Algal meal control diet
2. 10% Algal meal diet

The 10% addition of the Algae to the diet was a direct replacement for Canola meal in the diet. The formulated diets were designed to be slightly above the estimated requirements in terms of amino acids for the age and weight of pig when keep in ideal conditions. Pigs were weaned at an average age of 26 days and transferred into individual pens in a climate controlled weaner facility. All weaners were individually weighed at entry (day -5), day 0, day 7, day 14 and day 21 with individual feed intakes calculated during these time periods.

The inclusion of 10% algal meal into a weaner diet as a replacement for canola meal did not support the same growth performance over a 21 day growth experiment. The 10% growth rate reduction was consistent with lower lysine and imbalance of DE to lysine. The lysine and methionine levels were down about 12% while the energy level was higher by 3% in the final diet. The lower level of total lysine and methionine as against what might be expected from the growth performance results suggests that the digestibility of the amino acids is as high as the Canola meal (approx 75%) and is likely to be higher.

The feed intake of the pigs on the algal meal diets was not affected until the third period of the experiment and suggests that the acceptance from a palatability point of view when added at 10% is not a major issue although the manipulation of the gut microbiome to algae meal is possibly of some concern.

The inclusion of algal meal once formulated correctly into the diet is unlikely to have any major negative effects on the performance of the piglets although the higher level of scouring would need to be examined in a commercial environment and formulated correctly into the diet. The high level of chloroplasts in Algae maybe causing this effect and this would be an important area to investigate.

The implications of this experiment are that the inclusion of Algal meal into pig diets will not cause any significant depression of performance if correctly formulated into the diet. This will allow more extensive experiment on pigs to determine the true value of the algal meal in the diet.

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1. Introduction

Micro and Macro Algae are now a focus of developing a sustainable resource that can be used to supply a substantial part of the diet of all phases of pig production. The production of Algae is rapidly gaining acceptance as a method of reducing the carbon output of many heavy industries that produce significant carbon output to the environment. The Algal product that is produced as a byproduct is available to the animal industries as a feed ingredient. At present there is some of this product available for evaluation.

Despite the potential use of algae as a valuable protein source for animals, there has been very little work research on the evaluation of algae as a feed ingredient for animals over the past 20-30 years. This may be due to the potential difficulties in harvesting, processing and including algae as an ingredient in livestock diets. Firstly, there may be difficulties in separating the biomass from the water. Furthermore, the removal of the intracellular water in algae is necessary to provide the greatest flexibility of using dried algae for animal feeding. Many feeding systems, particularly for pigs and poultry are designed to deliver relatively dry feed ingredients in diets.

Yap et al. (1982) replaced 33% of the soybean meal protein in a basal corn/soybean meal/skim milk diet fed to baby pigs up to 26 days of age, and found that various algae could be included up to at least 14% in these diets without adversely affecting growth performance. A sewage-grown algae mixture of mainly *Chlorella* and *Scendesmus* species was included in pig grower and finisher diets at levels up to 10 and 5%, respectively (Hintz and Heitman, 1967). At these levels, algae provided a satisfactory protein supplement for pigs, and growth performance was not affected provided the diets were adequately supplemented with B vitamins (Hintz and Heitman, 1967). Furthermore, the digestibility of protein in this algae mix was reported to be 72.1% (Hintz and Heitman, 1967), which is similar to the apparent nitrogen digestibility of 76.7% in *Arthrospira platensis* reported in rats by Po Chung et al. (1978). Earlier Hintz et al. (1966) reported that the protein digestibility in mixed algae growing on sewage was about 54% for pigs, and it was thought that the lower digestibility was due to the resistance of the complex algae cell-wall to digestion.

More recently Harrison et al. (1981), evaluated the feeding value of algae (predominantly *Synechocystis* sp.) for growing pigs by including 0, 15, 30 and 45% algae in isocaloric and isolysine diets between 32 to 52 and 64 to 84 kg liveweight. In the grower and finisher stages, algae could be included up to 15% and 30%, respectively, without adversely affecting feed intake, growth rate or feed conversion efficiency. Algae (*Spirulina platensis*) can be included to levels up to about 12% in poultry diets without adversely affecting growth and feed efficiency (Ross and Dominy, 1990).

From the above studies, algae certainly has potential as a protein source in pig diets, at least at levels up to about 10 - 20%. Maximum inclusion levels of 10 - 20% are often all that is required for high protein quality sources in pig and poultry diets. At these relatively low inclusions levels, the ingredient will still supply substantial quantities of protein and essential amino acids to diets. The apparent digestibility or bioavailability of protein and amino acids in good quality protein sources is often 80 - 90%. Although previous research indicates lower digestibility values of between 55 - 77% in algae, algae protein still has potential to be a valuable source of protein and amino acids in pig diets.

2. Methodology

The Algal Meal was sourced from James Cook University Pilot Scale Algae production system in Townsville. This product is a multi stain culture selected from Natural algal strains from the environment in Tarong Queensland. The culture was selected to utilize the carbon dioxide from a coal fired power plant. The composition of the culture is protected by MBD Energy and James Cook University.

Existing R&D Facility - James Cook University




The experiment was conducted at the Research and Innovation Unit, Corowa NSW (Rivalea Australia). A total of 80 male weaners (PrimeGro™ genetics) were weaned from the Research and innovation unit at an average age of 26 days (average weight 7.2 kg ± 0.89 kg) and transferred into individual weaner pens. Pigs were selected in one replicate on the 22nd February 2012. Pigs were offered a commercial starter diet for an initial 5 day period to acclimatise to solid feed and the new environment. After this acclimatisation period, all pigs were individually weighed and allocated to one of the test diets:

1. 0% Algal meal control diet
2. 10% Algal meal diet

Details of each of the experimental diets are displayed in Appendix 2.

The 10% addition of the Algae to the diet was a direct replacement for Canola meal in the diet. The formulated diets were designed to be slightly above the estimated requirements in terms of amino acids for the age and weight of pig when keep in ideal conditions. Digestible energy levels were formulated at similar levels to commercial practice for this age and weight of piglet.

Husbandry and management

Pigs were weaned at an average age of 26 days and transferred into individual pens in a climate controlled weaner facility. All weaners were individually weighed at entry (day -5), day 0, day 7, day 14 and day 21 with individual feed intakes calculated during these time periods. Pigs were provided ad libitum access to their allocated treatment diets for the entire experimental period, while water was freely available via a single nipple drinker in each pen.

All procedures carried out in this investigation were undertaken in accordance to the Rivalea Standard Operating Procedure for the Individual Weaner Facility (SOP-025).

Statistical analyses

Differences in growth performance due to the main effect of treatment were analysed using an analyses of variance for a randomised design. The experimental unit for the analyses was the individual animal. The feed intake and feed efficiency data from weaners that were noted as wasting a large amount of feed were removed from the statistical analyses. Differences in mortalities and removals due to the main effect of diet were analysed using chi squared analyses. All analyses were performed using SPSS 19th Edition.

3. Outcomes

The results of the experiment show that the inclusion of the Algal meal into the diet in place of canola meal did significantly reduce the live weight of the piglets by day 14 of the experiment and subsequently at the end of the experiment. The growth performance was significantly lower in period 2 (7-14 days of the experiment) ($p=0.003$) than any other period although over the entire experiment the growth rate was also significantly lower ($p=0.007$). Feed intake was significantly lower on the algal diet during the final period of the experiment ($p=0.048$) and this tended to influence the feed intake over the entire experiment which tended to be lower ($p= 0.071$). The feed efficiency was significantly poorer ($p=0.003$) during period 2 on the algal diet but there was no difference over the other periods of the experiment ($p=0.935$, $p=0.746$ for period 1 and 3 respectively). Over the entire experiment the influence of period 2 was significant and the feed efficiency was poorer on the algal based diets ($p=0.024$).

A comparison of the algal meal and the canola meal from Chemical analysis is shown in Table 2 indicates that the algal meal is lower in the first two limiting amino acids of lysine and methionine but higher in the lesser amino acids. The high gross energy measured on the algal meal of 20.7 MJ/kg suggests that there also should be a relatively high Digestible Energy. The high Digestible Energy and the lower lysine level will also significantly affect one of the main drivers of growth in the young pig, the ratio between DE and available lysine.

Table 1 -The performance of individual housed piglets fed a standard weaner diet and a diet where 10% of the Canola meal was replaced with an Algal Meal over 21 days.

Treatment	Control	Algal	Mean Difference	Significance	Std. Error Difference
Number of pigs	39	38			
Liveweight					
Day 0 (kg)	7.208	7.213	0.005	0.978	0.197
Day 7 (kg)	8.946	8.758	-0.188	0.475	0.262
Day 14 (kg)	12.256	11.532	-0.725	0.050	0.365
Day 21 (kg)	16.895	15.908	-0.987	0.040	0.473
Period 1 (0-7 days)					
Rate fo gain (kg/day)	0.248	0.221	-0.028	0.154	0.019
Feed Efficiency	1.407	1.391	-0.016	0.935	0.192
Average Daily Intake (kg/day)	0.332	0.316	-0.016	0.387	0.018
Period 2 (7-14 days)					
Rate fo gain (kg/day)	0.473	0.397	-0.076	0.002	0.023
Feed Efficiency	1.138	1.297	0.159	0.003	0.053
Average Daily Intake (kg/day)	0.531	0.499	-0.032	0.236	0.027
Period 1 and 2					
Rate fo gain (kg/day)	0.361	0.309	-0.052	0.003	0.017
Feed Efficiency	1.206	1.351	0.145	0.002	0.045
Average Daily Intake (kg/day)	0.432	0.408	-0.024	0.225	0.020
Period 3 (14-21 days)					
Rate fo gain (kg/day)	0.662	0.624	-0.038	0.172	0.027
Feed Efficiency	1.278	1.264	-0.013	0.746	0.042
Average Daily Intake (kg/day)	0.839	0.776	-0.063	0.048	0.031
Period 1,2 and 3					
Rate fo gain (kg/day)	0.461	0.414	-0.047	0.007	0.017
Feed Efficiency	1.231	1.295	0.064	0.024	0.028
Average Daily Intake (kg/day)	0.567	0.530	-0.037	0.071	0.020

Table 2 - The comparison of the composition of Algal meal and Canola meal.

Nutrient		**Algal Meal**	**Canola Meal**	**Difference**	**% Difference**
DIGESTIBLE ENERGY (DE)	MJ/KG	16.667	13.820	2.846	20.596
PROTEIN	%	52.222	40.449	11.773	29.105
FAT	%	5.556	3.371	2.185	64.815
ASH	%	11.067	7.865	3.201	40.705
CALCIUM	%	0.489	0.708	-0.219	-30.935
PHOSPHOROUS	%	1.533	1.191	0.342	28.742
AMINO ACIDS					
LYSINE (LYS)	%	1.833	2.109	-0.276	-13.071
Available LYSINE	%	1.467	1.607	-0.140	-8.718
METHIONINE	%	0.667	0.758	-0.092	-12.099
M+C	%	1.000	1.701	-0.701	-41.215
THREONINE	%	2.100	1.700	0.400	23.529

Nutrient		Algal Meal	Canola Meal	Difference	% Difference
ISOLEUCINE	%	1.844	1.563	0.282	18.013
TRYPTOPHAN	%	0.667	0.556	0.110	19.865
CYSTEINE	%	0.333	0.964	-0.631	-65.423
VALINE	%	3.089	2.028	1.061	52.305
HISTIDINE	%	6.556	1.102	5.453	494.745
LEUCINE	%	3.900	2.758	1.142	41.385
PHENYLALANINE	%	2.444	1.615	0.830	51.396
ARGININE	%	1.867	2.238	-0.372	-16.600
TYROSINE	%	1.267	1.213	0.053	4.383
ALANINE	%	3.833	1.831	2.002	109.305
ASPARTIC	%	3.789	3.022	0.766	25.357
GLYCINE	%	2.644	2.101	0.543	25.859
GLUTAMIC	%	4.656	7.135	-2.479	-34.749
RATIOS					
#LYS/DE	%/DE	0.110	0.153	-0.043	-27.917
#ALY/DE	%/DE	0.088	0.116	-0.028	-24.308
#MET/LYS		0.364	0.360	0.004	1.118
#M+C/LYS		0.545	0.807	-0.261	-32.377
#THR/LYS		1.145	0.806	0.339	42.103
#ISO/LYS		1.006	0.741	0.265	35.757
#TRY/LYS		0.364	0.264	0.100	37.888
#VAL/LYS		1.685	0.962	0.723	75.206
#PHE/LYS		1.333	0.766	0.568	74.159
#LEU/LYS		2.127	1.308	0.819	62.643
#HIS/LYS		3.576	0.523	3.053	584.169
#ARG/LYS		1.018	1.061	-0.043	-4.060

4. Application of Research

The inclusion of 10% algal meal into a weaner diet as a replacement for canola meal did not support the same growth performance over a 21 day growth experiment. The 10% growth rate reduction was consistent with lower lysine and imbalance of DE to lysine. The lysine and methionine levels were down about 12% while the energy level was higher by 3% in the final diet. The higher level of other amino acids was likely to be wasted as lysine is the first limiting amino acid and methionine is generally the second limiting amino acid. The lower level of total lysine and methionine as against what might be expected from the growth performance results suggests that the digestibility of the amino acids is as high as the Canola meal (approx 75%) and is likely to be higher. A titration or digestibility study would be ideal in determination of the actual digestibility values.

The poorer performance in period two indicates that there is a need for the pig to adjust to diets and develop the intestinal flora and fauna to cope with the Algal meal diets. In general the second period is where any digestive disruptions occur due to scouring from *E. coli* or any nutritional scours. The field staff did notice that the pigs on the Algal diets did have a scour although not severe and only a few pigs were lost to the experiment. This scour was very noticeable due to the green colour, which does indicate that the green chloroplasts in the Algal meal do pass through the animal and the digestion of these may need further investigation.

The feed intake of the pigs on the algal meal diets was not affected until the third period of the experiment and suggests that the acceptance from a palatability point of view when added at 10% is not a major issue although the manipulation of the gut microbiome to algae meal is possibly of some concern although a larger number of piglets raised in commercial environments would be required to better define this as an issue.

In conclusion we can suggest that the algal meal does have lower levels of lysine and methionine than Canola meal and needs to be carefully considered for future experiments designed to fully explore the digestibility of those amino acids. The inclusion of algal meal once formulated correctly into the diet is unlikely to have any major negative effects on the performance of the piglets although the higher level of scouring would need to be examined in a commercial environment and formulated correctly into the diet. The high level of chloroplasts in Algae maybe causing this effect and this would be an important area to investigate. Strain selection is likely to be a key in being able to control this potential problem if the actual causative components can be identified.

5. Conclusion

The implications of this experiment are that the inclusion of Algal meal into pig diets will not cause any significant depression of performance if correctly formulated into the diet. This will allow more extensive experiment on pigs to determine the true value of the algal meal in the diet.

6. Limitations/Risks

None identified from this project but the nature of Algal nutrient absorption would indicate that any toxins in the algal environment would be concentrated in the algal meal that is derived from the production of the algae.

7. Recommendations

As a result of the outcomes in this study the following recommendations have been made:
Further experiments are warranted to examine the actual digestibility of the amino acids in the algal meal and also to determine if higher levels of algal meal can be used in the diets of pigs.

Figure 1 - The green scour evident from the pigs fed the diets containing Algal meal

Figure 2 - The difference in cleanliness of the control pen on the left and the pens with algal fed pigs on the right.

8. References

Harrison, M.D., Copelin, J.L. and Combs, G.E. 1981. **The feeding value of waste grown algae for growing and finishing swine**. J. Anim. Sci. (suppl. 1):245–246.

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Appendix 1 - Diets

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=================================================  Rivalea Australia   (4124)
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:     Single-Mix         (FM)       * Corowa *         {6} JUNE 2012              ALL DATA           14:49
08/06/12  0001 :
: 925.1/2.10                      (    1)  Plant=1        David
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Formula basic data

Code : 9822 Name : 12N018 A CONTROL

Analysis

[VOLUME]	%	100.0	#TRY/LYS	G/G	0.202185	#ACY/ALY	G/G	0.292146
[DRYMAT]	%	89.155131	#VAL/LYS	G/G	0.68545	#AM+/ALY	G/G	0.473179
DE_PIG	MJ/KG	14.344947	SALT	%	0.762444	#ATH/ALY	G/G	0.609183
NE4G	MJ/KG	10.097095	%LEGUMES	%	14.863994	#AIS/ALY	G/G	0.515444
#ALY/NE4G	GM/MJ	0.128351	ABC	MEQ/KG	591.711891	#ATR/ALY	G/G	0.158869
PROTEIN	%	21.422474	SODIUM	%	0.27849	#AVA/ALY	G/G	0.567254
FAT	%	4.629411	POTASS	%	0.635837	#ATH/DE_	GM/MJ	0.055036
STARCH	%	36.704776	CHLORIDE	%	0.501048	BULKDENS	KG/HL	62.055378
FIBRE	%	3.123104	MAGNES	%	0.170472	IONOPHORE	PPM	0.0
ASH	%	5.207818	NA+K_CL	MEQ/KG	143.816519	DCAB	meq/KG	22.568868
CALCIUM	%	0.92378	CHOLINE	MG/KG	1848.073958	W6 FA	%	0.0
T:PHOS	%	0.743333	LACTOSE	%	5.945598	W3 FA	%	0.0
AV:PHOS	%	0.668796	N:D:F:	%	9.799732	W6:W3	G/G	0.0
ENZAVPHOS	%	0.646631	LINOLEIC	%	0.883018	SAT FA	%	0.0
CAL:PHOS	G/G	1.242753	A:D:F:	%	4.654249	MONO FA	%	0.0
CAL:AVPHOS	G/G	1.381259	RUMIN:ME	MJ/KG	12.187029	POLY FA	%	0.0
P:PHOS	%	0.206993	POULT:ME	MJ/KG	12.315706	ENDF	%	4.162138
CAL:ENZAVP	G/G	1.428604	LAYER:ME	KCALS/KG	2936.330612	GE	MJ/KG	16.881832
LYSINE	%	1.449199	SULPHUR	%	0.324854	RACTOP	PPM	0.0
ALYSINE	%	1.295977	COPPER	PPM	24.277858	VIT:K	MG/KG	1.585493
METHION	%	0.430532	COBALT	PPM	0.5574	VIT:B1	MG/KG	2.378239
M+C	%	0.793033	MANGANES	PPM	40.875985	VIT:B2	MG/KG	7.927464
THREO	%	0.93014	ZINC	PPM	2211.019175	VIT:B6	MG/KG	4.756478
ISOLEUC	%	0.800596	IRON	PPM	131.298618	VIT:B12	MG/KG	7.927464
TRYPTO	%	0.293006	IODINE	PPM	1.052866	NIACIN	MG/KG	31.709855
#LYS/DE_	GM/MJ	0.101025	SELENIUM	PPM	0.24154	PANTOTH:	MG/KG	23.782391
#ALY/DE_	GM/MJ	0.090344	CHROMIUM	PPB	545.01313	BIOTIN	MG/KG	0.0
#MET/LYS	G/G	0.297083	VIT:A	IU/KG	9909.329634	FOLIC	MG/KG	0.0
#M+C/LYS	G/G	0.547222	VIT:D3	IU/KG	1981.865927	VIT:C	MG/KG	0.0
#THR/LYS	G/G	0.64183	VIT:E	IU/KG	73.329039	SELPLEX	PPM	0.07432
#ISO/LYS	G/G	0.552441	#AME/ALY	G/G	0.272818			

Raw material	Available	%	[Kg]	Tonnes
1 WHEAT	[X]	58.585	585.85	0.0
300 CANOLA MEAL 36%	[X]	10.0	100.0	0.0
325 SOYABEANMEAL-48%	[X]	5.0	50.0	0.0
400 MEATMEAL	[X]	4.0	40.0	0.0
410 FISHMEAL 64%	[X]	7.4	74.0	0.0
450 WHEY POWDER 11%	[X]	10.0	100.0	0.0
500 WATER	[X]	1.0	10.0	0.0
502 NATUPHOS 5000	[X]	0.01	0.1	0.0
504 TALLOW-ENZYME	[X]	1.0	10.0	0.0
520 TALLOW-MIXER	[X]	1.5	15.0	0.0
605 DL-METHIONINE	[X]	0.04	0.4	0.0
615 ISOLEUCINE H/A	[X]	0.01	0.1	0.0

620	TRYPTOPHAN H/A	[X]	0.04	0.4	0.0
650	ZINC OXIDE	[X]	0.27	2.7	0.0
770	ENDOX	[X]	0.02	0.2	0.0
950	RED MICRO-GRITS	[X]	0.1	1.0	0.0
989	RONOZYME	[X]	0.03	0.3	0.0
1079	BROMELAIN	[X]	0.05	0.5	0.0
1551	LYSINE MICRO	[X]	0.43	4.3	0.0
1553	THREONINE MICRO	[X]	0.16	1.6	0.0
1560	BIOPLEX SOW REPLACE PAK MICRO	[X]	0.05	0.5	0.0
1563	VITAMIN BLEND A MICRO small	[X]	0.05	0.5	0.0
1564	VITAMIN BLEND B MICRO	[X]	0.08	0.8	0.0
1567	MINERAL 2 MICRO	[X]	0.09	0.9	0.0
1579	LINCO-SOL 5% MICRO	[X]	0.4	4.0	0.0
1581	FIT 4 MICRO	[X]	0.4	4.0	0.0
1585	SALT BIN MICRO	[X]	0.2	2.0	0.0
			100.915	1009.15	0.0

== Rivalea Australia (4124)
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: Single-Mix (FM) * Corowa * {6} JUNE 2012 ALL DATA 14:49
08/06/12 0003 :
: 925.1/2.10 (1) Plant=1 David
:

Formula basic data

Code : 9823 Name : 12N018 B ALGAE

Analysis

[VOLUME]	%	100.0	SERINE	%	0.786464	LAYER:ME	KCALS/KG	2714.868813
[DRYMAT]	%	89.251511	GLUTAMIN	%	3.885805	SULPHUR	%	0.263427
DE_PIG	MJ/KG	14.814822	PROLINE	%	1.160892	COPPER	PPM	20.55473
NE4G	MJ/KG	9.441549	OH_PROLI	%	0.894879	COBALT	PPM	0.464339
#ALY/NE4G	GM/MJ	0.122231	ASPARAG	%	1.413195	MANGANES	PPM	35.289747
DEENZYME	MJ/KG	13.356117	#LYS/DE_	GM/MJ	0.085251	ZINC	PPM	2200.965825
PROTEIN	%	20.828034	#ALY/DE_	GM/MJ	0.077899	IRON	PPM	112.679544
FAT	%	9.284413	#MET/LYS	G/G	0.287918	IODINE	PPM	0.959633
STARCH	%	36.435116	#M+C/LYS	G/G	0.509165	SELENIUM	PPM	0.213596
FIBRE	%	1.736805	#THR/LYS	G/G	0.617712	#AME/ALY	G/G	0.260845
ASH	%	4.513566	#ISO/LYS	G/G	0.524755	#ACY/ALY	G/G	0.276593
CALCIUM	%	0.861085	#TRY/LYS	G/G	0.193169	#AM+/ALY	G/G	0.431772
T:PHOS	%	0.638266	#VAL/LYS	G/G	0.644919	#ATH/ALY	G/G	0.59475
AV:PHOS	%	0.623556	AMETH	%	0.301029	#AIS/ALY	G/G	0.496402
ENZAVPHOS	%	0.557271	AM+C	%	0.498287	#ATR/ALY	G/G	0.150064
CAL:PHOS	G/G	1.349099	ATHREO	%	0.686373	#AVA/ALY	G/G	0.525349
CAL:AVPHOS	G/G	1.380926	AISOLEUC	%	0.572874	#ATH/DE_	GM/MJ	0.04633
P:PHOS	%	0.144656	ATRYPTO	%	0.173181	ATYROSIN	%	0.482702
CAL:ENZAVP	G/G	1.545181	AVALINE	%	0.60628	AALANINE	%	0.746007
LYSINE	%	1.262974	ACYSTINE	%	0.319202	AASPARTI	%	1.159858
ALYSINE	%	1.154053	AP+T	%	1.15911	AASPARAG	%	1.266485
METHION	%	0.363632	APHENYL	%	0.388812	AGLUTAMI	%	3.338831
M+C	%	0.643062	ALEUCINE	%	1.074604	AGLUT:IN	%	3.366191
THREO	%	0.780154	AHISTID	%	0.36944	AGLYCINE	%	0.866097
ISOLEUC	%	0.662752	AARGININ	%	0.849487	ASERINE	%	0.679971
TRYPTO	%	0.243967	SALT	%	0.752338	APROLINE	%	1.009033
CYSTINE	%	0.282365	%LEGUMES	%	4.952947	LNAA	GM	10.254661
VALINE	%	0.814516	ABC	MEQ/KG	487.578559	#TRY/LNA	G/G	0.076078
HISTIDIN	%	0.430878	SODIUM	%	0.27741	BULKDENS	KG/HL	56.429356
LEUCINE	%	1.210681	POTASS	%	0.495191	IONOPHORE	PPM	0.0
PHENYLAL	%	0.708276	CHLORIDE	%	0.49102	W6 FA	%	0.0
P+T	%	1.437005	MAGNES	%	0.123933	W3 FA	%	0.0
ARGININE	%	0.972181	NA+K_CL	MEQ/KG	109.14522	W6:W3	G/G	0.0
TYROSINE	%	0.601892	CHOLINE	MG/KG	1209.076112	SAT FA	%	0.0
T:EAA	%	7.797732	LACTOSE	%	5.943536	MONO FA	%	0.0
ALANINE	%	0.876181	N:D:F:	%	7.426647	POLY FA	%	0.0
ASPARTIC	%	1.365706	LINOLEIC	%	0.734799	ENDF	%	2.951305
GLYCINE	%	1.022021	A:D:F:	%	2.525379			
GLUTAMIC	%	3.852917	RUMIN:ME	MJ/KG	11.101139			

Raw material	Available	%	[Kg]	Tonnes
1 WHEAT	[X]	58.65	586.5	0.0

325	SOYABEANMEAL-48%	[X]	5.0	50.0	0.0
373	ALGAL MEAL	[X]	10.0	100.0	0.0
400	MEATMEAL	[X]	4.0	40.0	0.0
410	FISHMEAL 64%	[X]	7.4	74.0	0.0
450	WHEY POWDER 11%	[X]	10.0	100.0	0.0
500	WATER	[X]	1.0	10.0	0.0
502	NATUPHOS 5000	[X]	0.01	0.1	0.0
504	TALLOW-ENZYME	[X]	1.0	10.0	0.0
520	TALLOW-MIXER	[X]	1.5	15.0	0.0
605	DL-METHIONINE	[X]	0.04	0.4	0.0
615	ISOLEUCINE H/A	[X]	0.01	0.1	0.0
620	TRYPTOPHAN H/A	[X]	0.04	0.4	0.0
650	ZINC OXIDE	[X]	0.27	2.7	0.0
770	ENDOX	[X]	0.02	0.2	0.0
951	BLUE MICRO-GRITS	[X]	0.1	1.0	0.0
989	RONOZYME	[X]	0.03	0.3	0.0
1079	BROMELAIN	[X]	0.05	0.5	0.0
1551	LYSINE MICRO	[X]	0.43	4.3	0.0
1553	THREONINE MICRO	[X]	0.16	1.6	0.0
1560	BIOPLEX SOW REPLACE PAK MICRO	[X]	0.05	0.5	0.0
1563	VITAMIN BLEND A MICRO small	[X]	0.04	0.4	0.0
1564	VITAMIN BLEND B MICRO	[X]	0.075	0.75	0.0
1567	MINERAL 2 MICRO	[X]	0.075	0.75	0.0
1579	LINCO-SOL 5% MICRO	[X]	0.4	4.0	0.0
1581	FIT 4 MICRO	[X]	0.4	4.0	0.0
1585	SALT BIN MICRO	[X]	0.2	2.0	0.0
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			100.95	1009.5	0.0
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