Using Microencapsulated Ingredients to Enhance Efficacy and Improve Production Efficiency Within an Integrated Health Strategy.

2C-118

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

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January 2016

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Executive Summary

The pig production world has made a concerted move away from the use of antibiotics in normal production situations, with much of this change associated with perceived risks of antibiotic resistance. This change is warranted with recorded occurrences of pH sensitive bacteria establishing resistance.

Essential oils and organic acids (EO/OA) are among products offering the best alternatives to antibiotics, however, they need to be presented to the pH sensitive bacteria in a non-dissociated form. Protection technologies have been created to avoid normal degradation within the gut of the animals, to allow the delivery of these ingredients to where they can assist in reducing pH sensitive bacteria.

Zinc oxide is widely used at pharmaceutical levels to aid in the control of enteric disease in weaner pigs. Regulatory issues and the need to reduce environmental loads have resulted in reductions in allowable inclusion rates of zinc in many countries, and this will likely extend to Australian production systems in the near future. Industry must therefore look at alternative delivery methods that allow for lower inclusion levels without reduced efficacy, microencapsulation is one such method.

This study aimed to assess performance benefits offered by including microencapsulated blends of EO/OA, and to assess the ability to successfully reduce levels of zinc oxide fed to weaner pigs without compromising performance by offering a microencapsulated zinc oxide. The successful use of the microencapsulated products that are being investigated in this project will lead the Australian pig industry into the next generation of healthy production.

The inclusion of zinc oxide, in any form, resulted in significantly improved weight gain in the first week post-weaning, and this weight gain was associated with a tendency for both increased feed intake and improved feed conversion in pigs receiving zinc oxide. After the first week the significant advantage of zinc oxide was maintained in both feed intake and growth rate during weeks two and three, whilst those receiving the microencapsulated zinc oxide maintained a numerical advantage over the control only. There was no significant difference in performance during the fourth week post-weaning.

Inclusion of a microencapsulated blend of essential oils and organic acids significantly improved feed conversion in the fourth week of the experiment - in the presence or absence of microencapsulated zinc oxide. However, during week three, only the microencapsulated blend of EO/OA without the microencapsulated zinc was significantly different. Pigs receiving the microencapsulated EO/OA tended to be heavier at the end of the experimental period than the control treatments, however, the effect was not statistically significant.

Zinc oxide continues to be an important inclusion in the diet of weaner pigs, resulting in improvements in growth performance, as a function of both improvements in feed intake and conversion. The inclusion of a protected blend of essential oils and organic acids had a positive impact on the performance of pigs, with a strong tendency for enhanced efficiency of growth. The strong number of variables that were moving towards significance when these ingredients were combined warrants a more targeted assessment of these products within an integrated health strategy.

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1. Introduction

Throughout the pig production world there has been a concerted move away from reliance on antibiotics for use in normal production situations (Baker 2006). Much of this concern has been associated with perceived risks associated with antibiotic resistance, and there have been recorded occurrences of pH sensitive bacteria establishing resistance against some types of antibiotics (Nijsten *et al.* 1996).

Essential oils and organic acids (EO/OA) are among products that offer the best alternatives to antibiotics in animal production systems throughout the world (Roselli *et al.* 2005). However, the problem with this approach is that the EO/OA needs to be presented to the pH sensitive bacteria in a non-dissociated form. Protection technologies have been created to deliver feed additives, normally degraded by the natural production of pH within the gastrointestinal tract, to where these can assist in the reduction of pH sensitive bacteria (Piva *et al.* 2006). Microencapsulation of EO/OAs offers a real alternative to pig production industry delivering these alternatives both where they are needed and in the form they are needed.

Zinc oxide has been used widely in normal production systems at high levels (3,000 ppm) to aid in the control of enteric disease in weaner pigs (Poulsen 1995). Regulatory issues and the need to reduce environmental loads as a result of high zinc levels in effluent have resulted in reductions in the allowable inclusion rate of zinc in many countries (Case and Carlson 2002) and it is likely that this will extend to Australian production systems in the near future. As a consequence, industry must look at alternative delivery methods that allow for lower inclusion levels without reducing efficacy, the use of microencapsulation should allow us to achieve a successful result.

This study aims to assess performance benefits offered by the inclusion in weaner diets of microencapsulated blends of essential oils and organic acids that aid in the control of pH sensitive bacteria, and to assess the ability to successfully reduce the levels of zinc oxide fed to weaner pigs without compromising performance by offering a microencapsulated zinc oxide product.

The successful use of the microencapsulated products that are being investigated in this project will lead the Australian pig industry into the next generation of healthy production.

2. Methodology

This experiment was a randomised block design with zinc oxide source and the presence/absence of a microencapsulated essential oil/organic acid blend as factors.

There were five treatments, all diets were identical in formulation except for treatment inclusions (Appendix 1), bentonite was included when required to maintain inclusion volumes at 3,000 ppm (3 kg/t):

- control (-ve), standard commercial creep diet containing no zinc oxide

- control (+ve), standard commercial creep diet containing 3,000 ppm zinc oxide
- treatment 1, standard commercial creep diet containing 1,000 ppm of protected zinc oxide.
- treatment 2, standard commercial creep diet containing 1,000 ppm of protected organic acids and essential oils, with no zinc oxide
- treatment 3, standard commercial creep diet containing 1,000 ppm of protected organic acids and essential oils, with 1,000 ppm of protected zinc oxide.

Pigs entered the experiment at weaning (21 d, 5.78±0.09 kg) and finished the experiment at 49 days of age. Five weeks' worth of entries were utilised in this experiment with I0 pens of pigs (n=14) entered per week, resulting in 10 replicates per treatment. Upon entry pigs were sexed, assigned a pen, weighed and allocated to treatment. Pens were weighed weekly.

An individual block within the weaner facility consisted of ten pens of identical configuration (1 m x 2.8 m). Penning was open galvanised panelling with fully-slatted plastic floor tiles. Water was supplied ad libitum via one bowl and one nipple drinker per pen and supplementary radiant heat was provided via a bar heater. Feed was offered to each individual pen via a multi-space round adjustable plastic transit feeder, with diets offered ad libitum throughout the experimental period. Weekly feed disappearance was calculated from feed deliveries and weighed refusal on the final day of each week. Water usage was measured via individual water meters on each pen.

Pen was the experimental unit. To better understand the effects of treatment, data was split into ZnO treatments and EO/OA treatments and analysed separately. Data was analysed by ANOVA with treatment as factor, with entry week and sex being blocking factors, with differences between treatments ($P<0.05$) being determined by LSD. Mortality and morbidity was recorded for each pen and differences were determined by Chi-square analysis ($P<0.05$).

Medication for the control of enteric diseases was removed from the standard medication program. All treatments received the same medication program for the control of respiratory diseases. Upon arrival pigs received 0.25 ml Draxxin (*Tulathromycin* 100 mg/ml) as an intramuscular injection; Sol-u-Mox Powder (*Amoxicillin trihydrate* 870 mg/g) was pulsed in water for 3 days per week at a rate of 60 g/1,000 kg of live weight.

3. Outcomes

The inclusion of zinc oxide, in any form, resulted in significantly improved weight gain in the first week post-weaning ($P<0.05$, Table 1). This weight gain was associated with both an increase in feed intake ($P<0.10$) and a tendency for improved feed conversion in pigs receiving zinc oxide during this first week.

After the first week the significant advantage of zinc oxide was maintained in both feed intake and growth rate during weeks two and three, whilst those receiving the microencapsulated zinc oxide maintained a numerical advantage over the control only. There was no significant difference in performance during the fourth week post-weaning.

Table 1. Weight and growth performance of control weaner pigs (21 d) compared to weaner pigs receiving 3,000 ppm zinc oxide (ZnO) or 1,000 ppm of a microencapsulated zinc oxide (MicroZnO) for four weeks.

	Control	ZnO	MicroZnO	SED	P value
Entry Weight	5.7	5.7	5.9	0.29	0.766
Week 1 Weight	6.3[a]	6.5[b]	6.5[b]	0.08	0.028
Week 2 Weight	7.6[a]	8.2[b]	7.9[c]	0.12	<0.001
Week 3 Weight	9.8[a]	10.9[b]	10.3[c]	0.16	<0.001
Exit Weight	13.1[a]	14.2[b]	13.5[a]	0.24	<0.001
Week 1 ADG	0.069[a]	0.093[b]	0.097[b]	0.010	0.028
Week 1 ADFI	0.15	0.18	0.19	0.014	0.055
Week 1 FCR	2.34	2.00	2.07	0.155	0.106
Week 2 ADG	0.205[a]	0.274[b]	0.218[a]	0.009	<0.001
Week 2 ADFI	0.27[a]	0.34[b]	0.29[a]	0.011	<0.001
Week 2 FCR	1.34	1.25	1.35	0.050	0.094
Week 3 ADG	0.321[a]	0.383[b]	0.341[a]	0.011	<0.001
Week 3 ADFI	0.44[a]	0.50[b]	0.45[a]	0.012	<0.001
Week 3 FCR	1.39	1.32	1.34	0.032	0.120
Week 4 ADG	0.486	0.487	0.474	0.017	0.700
Week 4 ADFI	0.66	0.68	0.64	0.019	0.108
Week 4 FCR	1.37	1.40	1.35	0.025	0.169

[a,b,c]Means in a row with different superscripts differ significantly (P<0.05); ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio; SED, standard error of difference of the means.

There was no effect of treatment on the usage of water throughout the experimental period (Table 2).

Table 2. Water intake (litres/pig/day) of control weaner pigs (21 d) compared to weaner pigs receiving 3,000 ppm zinc oxide (ZnO) or 1,000 ppm of a microencapsulated zinc oxide (MicroZnO) for four weeks.

	Control	ZnO	MicroZnO	SED	P value
Week 1 Water	1.5	1.7	2.1	0.31	0.161
Week 2 Water	3.0	3.1	4.1	0.63	0.175
Week 3 Water	4.9	5.3	5.2	0.81	0.875
Week 4 Water	7.1	7.7	6.9	0.94	0.671

On a cumulative basis, the inclusion of zinc oxide, in either form, significantly increased growth rate across the first three weeks when compared with the control (Table 3), however, the growth rate of pigs receiving the traditional form of zinc oxide, where also significantly higher than the microencapsulated product over the first three weeks.

Across the whole experimental period, the inclusion of zinc oxide resulted in increased feed intake and a resultant increase in average daily gain when compared with other treatments. There was no difference in feed conversion across the experimental period.

Table 3. Cumulative growth performance of control weaner pigs (21 d) compared to weaner pigs receiving 3,000 ppm zinc oxide (ZnO) or 1,000 ppm of a microencapsulated zinc oxide (MicroZnO) across the four week experimental period.

	Control	ZnO	MicroZnO	SED	P value
day 7 ADG	0.069[a]	0.093[b]	0.097[b]	0.010	0.028
day 7 ADFI	0.15	0.18	0.19	0.014	0.055
day 7 FCR	2.34	2.00	2.07	0.155	0.106
day 14 ADG	0.132[a]	0.178[b]	0.153[c]	0.009	<0.001
day 14 ADFI	0.21[a]	0.26[b]	0.24[b]	0.011	0.002
day 14 FCR	1.60[a]	1.45[b]	1.57[ab]	0.057	0.043
day 21 ADG	0.194[a]	0.244[b]	0.214[c]	0.008	<0.001
day 21 ADFI	0.29[a]	0.34[b]	0.31[a]	0.010	<0.001
day 21 FCR	1.48[a]	1.38[b]	1.45[a]	0.031	0.011
day 28 ADG	0.263[a]	0.302[b]	0.276[a]	0.009	<0.001
day 28 ADFI	0.38[a]	0.42[b]	0.39[a]	0.011	0.004
day 28 FCR	1.44	1.40	1.42	0.023	0.225

[a,b,c]Means in a row with different superscripts differ significantly (P<0.05); ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio; SED, standard error of difference of the means.

There was no significant difference in the number of deaths or pigs removed for any of the zinc oxide treatments (Table 4).

Table 4. Mortality and removals for treatment of control weaner pigs (21 d) compared to weaner pigs receiving 3,000 ppm zinc oxide (ZnO) or 1,000 ppm of a microencapsulated zinc oxide (MicroZnO) across the four week experimental period.

	Control	ZnO	MicroZnO	χ^2	P value
Mortality	1	0	0		
Removals	3	3	1		
Total	4	3	1	1.78 (*d.f.* 2)	0.410

Combination of microencapsulated zinc oxide and microencapsulated blend of essential oils and organic acids significantly improved feed conversion in the fourth week of the experiment and single inclusion of microencapsulated blend of essential oils and organic acids significantly improved feed conversion in both third and fourth week of the experiment (P<0.05, Table 5).

There were no other significant differences in growth performance between treatments, however, pigs receiving EO/OA tended to be heavier at the end of the experimental period than the control treatments. However, the effect was not statistically significant.

Table 5. Weight and growth performance of control weaner pigs (21 d) compared to weaner pigs receiving 1,000 ppm of microencapsulated blend of essential oils and organic acids (EO/OA) or 1,000 ppm of EO/OA plus 1,000 ppm microencapsulated zinc oxide (EO/OA + MicroZnO) for four weeks.

	Control	EO/OA	EO/OA + MicroZnO	SED	P value
Entry Weight	5.6	5.9	5.8	0.34	0.814
Week 1 Weight	6.3	6.4	6.5	0.11	0.164
Week 2 Weight	7.6	7.8	8.1	0.19	0.097
Week 3 Weight	9.9	10.2	10.4	0.25	0.108
Exit Weight	13.2	13.6	13.9	0.30	0.094
Week 1 ADG	0.071	0.079	0.102	0.015	0.136
Week 1 ADFI	0.16	0.16	0.20	0.016	0.056
Week 1 FCR	2.33	2.28	2.40	0.251	0.874
Week 2 ADG	0.205	0.225	0.236	0.014	0.124
Week 2 ADFI	0.27	0.28	0.30	0.015	0.134
Week 2 FCR	1.34	1.25	1.30	0.067	0.396
Week 3 ADG	0.322	0.348	0.348	0.014	0.159
Week 3 ADFI	0.45	0.44	0.47	0.017	0.364
Week 3 FCR	1.40[a]	1.29[b]	1.39[a]	0.043	0.030
Week 4 ADG	0.490	0.489	0.506	0.013	0.352
Week 4 ADFI	0.67	0.62	0.66	0.018	0.051
Week 4 FCR	1.37[a]	1.28[b]	1.31[b]	0.026	0.013

[a,b,c]Means in a row with different superscripts differ significantly (P<0.05); ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio; SED, standard error of difference of the means.

There was no effect of treatment on the usage of water throughout the experimental period (Table 6).

Table 6. Water intake (litres/pig/day) of control weaner pigs (21 d) compared to weaner pigs receiving 1,000 ppm of microencapsulated blend of essential oils and organic acids (EO/OA) or 1,000 ppm of EO/OA plus 1,000 ppm microencapsulated zinc oxide (EO/OA + MicroZnO) for four weeks.

	Control	EO/OA	EO/OA + MicroZnO	SED	P value
Week 1 Water	1.5	1.9	2.1	0.35	0.290
Week 2 Water	3.0	3.3	2.8	0.42	0.488
Week 3 Water	5.0	5.5	5.2	0.66	0.757
Week 4 Water	7.3	7.7	7.5	1.09	0.925

Treatment effects on cumulative performance of weaner pigs were similar to those observed from the weekly data with limited statistically significant effects being observed, however across the whole experimental period those pigs that received the EO/OA converted feed significantly better than the control treatment, irrespective of the presence or absence of zinc oxide (Table 7). The inclusion of EO/OA tended to result in improvements in growth rate (P<0.10) and the effect of including a source of zinc oxide in the diet as previously observed was also apparent, however it was not significant in this set of treatments.

Table 7. Cumulative growth performance of control weaner pigs (21 d) compared to weaner pigs receiving 1,000 ppm of microencapsulated blend of essential oils and organic acids (EO/OA) or 1,000 ppm of EO/OA plus 1,000 ppm microencapsulated zinc oxide (EO/OA + MicroZnO) for four weeks.

	Control	EO/OA	EO/OA + MicroZnO	SED	P value
day 7 ADG	0.071	0.079	0.102	0.015	0.136
day 7 ADFI	0.16	0.16	0.20	0.016	0.056
day 7 FCR	2.33	2.28	2.40	0.251	0.874
day 14 ADG	0.134	0.147	0.164	0.013	0.097
day 14 ADFI	0.21	0.22	0.25	0.015	0.072
day 14 FCR	1.61	1.50	1.53	0.065	0.259
day 21 ADG	0.195	0.212	0.222	0.012	0.108
day 21 ADFI	0.29	0.29	0.32	0.014	0.131
day 21 FCR	1.49	1.38	1.44	0.043	0.053
day 28 ADG	0.265	0.278	0.290	0.011	0.094
day 28 ADFI	0.38	0.37	0.40	0.014	0.174
day 28 FCR	1.44[a]	1.34[b]	1.39[b]	0.027	0.005

[a,b,c]Means in a row with different superscripts differ significantly ($P<0.05$); ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio; SED, standard error of difference of the means.

There was no significant difference in the number of deaths or pigs removed for any of the EO/OA treatments (Table 8).

Table 8. Mortality and removals for treatment of control weaner pigs (21 d) compared to weaner pigs receiving 1,000 ppm of microencapsulated blend of essential oils and organic acids (EO/OA) or 1,000 ppm of EO/OA plus 1,000 ppm microencapsulated zinc oxide (EO/OA + MicroZnO) for four weeks.

	Control	EO/OA	EO/OA + MicroZnO	χ^2	P value
Mortality	1	0	2		
Removals	3	4	8		
Total	4	4	10	4.18 (*d.f.* 2)	0.124

4. Application of Research

This experiment showed the continued benefits of the inclusion of pharmaceutical levels of zinc oxide in the diet of weaner pigs. Whilst Australian producers are not currently restricted in the use of zinc oxide, environmental concerns within the European Union have led to restrictions in the concentration of zinc oxide able to be included in the diet of weaner pigs. This experiment has shown that there are solutions available to continue to deliver the benefits of including zinc oxide whilst reducing the potential for environmental impact.

5. Conclusion

Zinc oxide continues to be an important inclusion in the diet of weaner pigs, resulting in significant improvements in growth performance in newly weaned pigs, as a function of both improvements in feed intake and efficiency of production. In the event of regulatory changes associated with the impact of zinc on the environment, the microencapsulated zinc product would be an acceptable alternative to high levels of zinc, whilst maintaining the growth and health benefits associated with the use of zinc oxide.

The combination of microencapsulated zinc oxide and EO/OAs showed that in combination the benefits of zinc oxide in the period immediately post-weaning worked in combination with the essential oils and organic acids showing a strong tendency for enhanced exit weight ($P<0.10$) and achieving a significant reduction in FCR ($P<0.05$). The combination of microencapsulated zinc oxide and EO/OAs showed that in combination the benefits of zinc oxide in the period immediately post-weaning worked in combination with the essential oils and organic acids.

6. Limitations/Risks

When interpreting these results it should be noted that for many variables there was a strong trend being seen which was moving towards significance ($P<0.10$), an increase in the number of replicates available would likely have seen these variables become statistically significant ($P<0.05$).

7. Recommendations

As a result of the outcomes in this study the following recommendations have been made:

- The inclusion of a form of zinc oxide in the diets of newly weaned pigs continues to be warranted.
- The strong number of variables that were moving towards significance ($P<0.10$) warrants a more targeted assessment of these products within an integrated health strategy.

8. References

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Appendices

Appendix 1: Experimental Diets

Formula basic data

Code : OCH0411MCU   Name : WESTBROOK EXP 41 – CONTROL (-VE)

Raw material	%	[Kg]	Tonnes
14200 WHEAT 12.0	57.776667	866.65	1.155533
34600 SOYBEAN MEAL 46.0	10.0	150.0	0.2
34750 SOYCOMIL R (ADM)	2.2	33.0	0.044
40100 BLOOD MEAL 90.0	1.4	21.0	0.028
40680 MEAT MEAL 51.0	6.666667	100.0	0.133333
41200 FISH MEAL 60.0	2.533333	38.0	0.050667
43170 CHOCOLATE MILK POWDER	15.0	225.0	0.3
43400 NUPRO 2000 - ALLTECH	2.533333	38.0	0.050667
45581 STOCKFEED BLENDED OIL	0.533333	8.0	0.010667
52950 BETAINE (BETAFIN)	0.1	1.5	0.002
53000 DL METHIONINE	0.16	2.4	0.0032
53100 LYSINE HCL	0.3	4.5	0.006
53200 L-THREONINE	0.193333	2.9	0.003867
53300 L-TRYPTOPHAN	0.053333	0.8	0.001067
53800 ROVABIO XYLAN	0.05	0.75	0.001
60000 BENTONITE (FINE)	0.3	4.5	0.006
90100 BN STARTER PREMIX	0.2	3.0	0.004
	100.0	1500.0	2.0

Analysis

[VOLUME]	%	:	100.0	VALINE	%	:	1.0062	W3_FA	%	:	0.079579
DRYMATTER	%	:	90.978	M+C	%	:	0.903493	W6_FA	%	:	0.980207
PROTEIN	%	:	23.810727	AILYSPIG	%	:	1.335833	%WHEAT	%	:	57.776667
C_FIBRE	%	:	2.154087	CALCIUM	%	:	0.998706	#AILYS/DEP	%/MJ	:	0.089909
LACTOSE	%	:	5.625	PHOSPHORUS	%	:	0.83215	#MET/LYS	%/%	:	0.348182
DE_PIG_MJ	MJ/KG	:	14.857687	AV_PHOS	%	:	0.599409	#M+C/LYS	%/%	:	0.579053
LEUCINE	%	:	1.773328	#CAL/PHO	%	:	1.200152	#TRY/LYS	%/%	:	0.19972
ISOLEUCINE	%	:	0.921049	#CAL/AVPHO	%	:	1.66615	#THR/LYS	%/%	:	0.669732
LYSINE	%	:	1.560294	SODIUM	%	:	0.173897	#ISO/LYS	%/%	:	0.590305
METHION	%	:	0.543266	SALT	%	:	0.351057	#VAL/LYS	%/%	:	0.644879
THREONINE	%	:	1.044979	CHOLINE	MG/KG	:	1981.713333	W6:W3 CALC	%	:	12.317404
TRYPTOPHAN	%	:	0.311622	FAT/EE	%	:	5.67038	#LEUC/LYS	%/%	:	1.136534

Formula basic data

Code : OCH0412MCU Name : WESTBROOK EXP 41 - CONTROL (+VE)

Raw material	%	[Kg]	Tonnes
14200 WHEAT 12.0	57.776667	866.65	1.155533
34600 SOYBEAN MEAL 46.0	10.0	150.0	0.2
34750 SOYCOMIL R (ADM)	2.2	33.0	0.044
40100 BLOOD MEAL 90.0	1.4	21.0	0.028
40680 MEAT MEAL 51.0	6.666667	100.0	0.133333
41200 FISH MEAL 60.0	2.533333	38.0	0.050667
43170 CHOCOLATE MILK POWDER	15.0	225.0	0.3
43400 NUPRO 2000 - ALLTECH	2.533333	38.0	0.050667
45581 STOCKFEED BLENDED OIL	0.533333	8.0	0.010667
51610 ZINC OXIDE	0.3	4.5	0.006
52950 BETAINE (BETAFIN)	0.1	1.5	0.002
53000 DL METHIONINE	0.16	2.4	0.0032
53100 LYSINE HCL	0.3	4.5	0.006
53200 L-THREONINE	0.193333	2.9	0.003867
53300 L-TRYPTOPHAN	0.053333	0.8	0.001067
53800 ROVABIO XYLAN	0.05	0.75	0.001
90100 BN STARTER PREMIX	0.2	3.0	0.004
	100.0	1500.0	2.0

Analysis

[VOLUME]	%	:	100.0	VALINE	%	:	1.0062	W3_FA	%	:	0.079579
DRYMATTER	%	:	90.987	M+C	%	:	0.903493	W6_FA	%	:	0.980207
PROTEIN	%	:	23.810727	AILYSPIG	%	:	1.335833	%WHEAT	%	:	57.776667
C_FIBRE	%	:	2.154087	CALCIUM	%	:	0.998706	#AILYS/DEP	%/MJ	:	0.089909
LACTOSE	%	:	5.625	PHOSPHORUS	%	:	0.83215	#MET/LYS	%/%	:	0.348182
DE_PIG_MJ	MJ/KG	:	14.857687	AV_PHOS	%	:	0.599409	#M+C/LYS	%/%	:	0.579053
LEUCINE	%	:	1.773328	#CAL/PHO	%	:	1.200152	#TRY/LYS	%/%	:	0.19972
ISOLEUCINE	%	:	0.921049	#CAL/AVPHO	%	:	1.66615	#THR/LYS	%/%	:	0.669732
LYSINE	%	:	1.560294	SODIUM	%	:	0.173897	#ISO/LYS	%/%	:	0.590305
METHION	%	:	0.543266	SALT	%	:	0.351057	#VAL/LYS	%/%	:	0.644879
THREONINE	%	:	1.044979	CHOLINE	MG/KG	:	1981.713333	W6:W3 CALC	%	:	12.317404
TRYPTOPHAN	%	:	0.311622	FAT/EE	%	:	5.67038	#LEUC/LYS	%/%	:	1.136534

Formula basic data

Code : OCH0413MCU Name : WESTBROOK EXP 41 – TREATMENT 1

Raw material	%	[Kg]	Tonnes
14200 WHEAT 12.0	57.776667	866.65	1.155533
34600 SOYBEAN MEAL 46.0	10.0	150.0	0.2
34750 SOYCOMIL R (ADM)	2.2	33.0	0.044
40100 BLOOD MEAL 90.0	1.4	21.0	0.028
40680 MEAT MEAL 51.0	6.666667	100.0	0.133333
41200 FISH MEAL 60.0	2.533333	38.0	0.050667
43170 CHOCOLATE MILK POWDER	15.0	225.0	0.3
43400 NUPRO 2000 - ALLTECH	2.533333	38.0	0.050667
45581 STOCKFEED BLENDED OIL	0.533333	8.0	0.010667
51625 ZINCO PLUS (JEFO)	0.1	1.5	0.002
52950 BETAINE (BETAFIN)	0.1	1.5	0.002
53000 DL METHIONINE	0.16	2.4	0.0032
53100 LYSINE HCL	0.3	4.5	0.006
53200 L-THREONINE	0.193333	2.9	0.003867
53300 L-TRYPTOPHAN	0.053333	0.8	0.001067
53800 ROVABIO XYLAN	0.05	0.75	0.001
60000 BENTONITE (FINE)	0.2	3.0	0.004
90100 BN STARTER PREMIX	0.2	3.0	0.004
	100.0	1500.0	2.0

Analysis

[VOLUME]	%	:	100.0	VALINE	%	:	1.0062	W3_FA	%	:	0.079579
DRYMATTER	%	:	90.981	M+C	%	:	0.903493	W6_FA	%	:	0.980207
PROTEIN	%	:	23.810727	AILYSPIG	%	:	1.335833	%WHEAT	%	:	57.776667
C_FIBRE	%	:	2.154087	CALCIUM	%	:	0.998706	#AILYS/DEP	%/MJ	:	0.089909
LACTOSE	%	:	5.625	PHOSPHORUS	%	:	0.83215	#MET/LYS	%/%	:	0.348182
DE_PIG_MJ	MJ/KG	:	14.857687	AV_PHOS	%	:	0.599409	#M+C/LYS	%/%	:	0.579053
LEUCINE	%	:	1.773328	#CAL/PHO	%	:	1.200152	#TRY/LYS	%/%	:	0.19972
ISOLEUCINE	%	:	0.921049	#CAL/AVPHO	%	:	1.66615	#THR/LYS	%/%	:	0.669732
LYSINE	%	:	1.560294	SODIUM	%	:	0.173897	#ISO/LYS	%/%	:	0.590305
METHION	%	:	0.543266	SALT	%	:	0.351057	#VAL/LYS	%/%	:	0.644879
THREONINE	%	:	1.044979	CHOLINE	MG/KG	:	1981.713333	W6:W3 CALC	%	:	12.317404
TRYPTOPHAN	%	:	0.311622	FAT/EE	%	:	5.67038	#LEUC/LYS	%/%	:	1.136534

Formula basic data

Code : OCH0414MCU Name : WESTBROOK EXP 41 – TREATMENT 2

Raw material	%	[Kg]	Tonnes
14200 WHEAT 12.0	57.776667	866.65	1.155533
34600 SOYBEAN MEAL 46.0	10.0	150.0	0.2
34750 SOYCOMIL R (ADM)	2.2	33.0	0.044
40100 BLOOD MEAL 90.0	1.4	21.0	0.028
40680 MEAT MEAL 51.0	6.666667	100.0	0.133333
41200 FISH MEAL 60.0	2.533333	38.0	0.050667
43170 CHOCOLATE MILK POWDER	15.0	225.0	0.3
43400 NUPRO 2000 - ALLTECH	2.533333	38.0	0.050667
45581 STOCKFEED BLENDED OIL	0.533333	8.0	0.010667
52950 BETAINE (BETAFIN)	0.1	1.5	0.002
53000 DL METHIONINE	0.16	2.4	0.0032
53100 LYSINE HCL	0.3	4.5	0.006
53200 L-THREONINE	0.193333	2.9	0.003867
53300 L-TRYPTOPHAN	0.053333	0.8	0.001067
53800 ROVABIO XYLAN	0.05	0.75	0.001
58817 PORCINAT PLUS (JEFO)	0.1	1.5	0.002
60000 BENTONITE (FINE)	0.2	3.0	0.004
90100 BN STARTER PREMIX	0.2	3.0	0.004
	100.0	1500.0	2.0

Analysis

[VOLUME]	%	:	100.0	VALINE	%	:	1.0062	W3_FA	%	:	0.079579
DRYMATTER	%	:	90.978	M+C	%	:	0.903493	W6_FA	%	:	0.980207
PROTEIN	%	:	23.810727	AILYSPIG	%	:	1.335833	%WHEAT	%	:	57.776667
C_FIBRE	%	:	2.154087	CALCIUM	%	:	0.998706	#AILYS/DEP	%/MJ	:	0.089909
LACTOSE	%	:	5.625	PHOSPHORUS	%	:	0.83215	#MET/LYS	%/%	:	0.348182
DE_PIG_MJ	MJ/KG	:	14.857687	AV_PHOS	%	:	0.599409	#M+C/LYS	%/%	:	0.579053
LEUCINE	%	:	1.773328	#CAL/PHO	%	:	1.200152	#TRY/LYS	%/%	:	0.19972
ISOLEUCINE	%	:	0.921049	#CAL/AVPHO	%	:	1.66615	#THR/LYS	%/%	:	0.669732
LYSINE	%	:	1.560294	SODIUM	%	:	0.173897	#ISO/LYS	%/%	:	0.590305
METHION	%	:	0.543266	SALT	%	:	0.351057	#VAL/LYS	%/%	:	0.644879
THREONINE	%	:	1.044979	CHOLINE	MG/KG	:	1981.713333	W6:W3 CALC	%	:	12.317404
TRYPTOPHAN	%	:	0.311622	FAT/EE	%	:	5.67038	#LEUC/LYS	%/%	:	1.136534

Formula basic data

Code : OCH0415MCU Name : WESTBROOK EXP 41 – TREATMENT 3

Raw material	%	[Kg]	Tonnes
14200 WHEAT 12.0	57.776667	866.65	1.155533
34600 SOYBEAN MEAL 46.0	10.0	150.0	0.2
34750 SOYCOMIL R (ADM)	2.2	33.0	0.044
40100 BLOOD MEAL 90.0	1.4	21.0	0.028
40680 MEAT MEAL 51.0	6.666667	100.0	0.133333
41200 FISH MEAL 60.0	2.533333	38.0	0.050667
43170 CHOCOLATE MILK POWDER	15.0	225.0	0.3
43400 NUPRO 2000 - ALLTECH	2.533333	38.0	0.050667
45581 STOCKFEED BLENDED OIL	0.533333	8.0	0.010667
51625 ZINCO PLUS (JEFO)	0.1	1.5	0.002
52950 BETAINE (BETAFIN)	0.1	1.5	0.002
53000 DL METHIONINE	0.16	2.4	0.0032
53100 LYSINE HCL	0.3	4.5	0.006
53200 L-THREONINE	0.193333	2.9	0.003867
53300 L-TRYPTOPHAN	0.053333	0.8	0.001067
53800 ROVABIO XYLAN	0.05	0.75	0.001
58817 PORCINAT PLUS (JEFO)	0.1	1.5	0.002
60000 BENTONITE (FINE)	0.1	1.5	0.002
90100 BN STARTER PREMIX	0.2	3.0	0.004
	100.0	1500.0	2.0

Analysis

[VOLUME]	%	:	100.0	VALINE	%	:	1.0062	W3_FA	%	:	0.079579
DRYMATTER	%	:	90.981	M+C	%	:	0.903493	W6_FA	%	:	0.980207
PROTEIN	%	:	23.810727	AILYSPIG	%	:	1.335833	%WHEAT	%	:	57.776667
C_FIBRE	%	:	2.154087	CALCIUM	%	:	0.998706	#AILYS/DEP	%/MJ	:	0.089909
LACTOSE	%	:	5.625	PHOSPHORUS	%	:	0.83215	#MET/LYS	%/%	:	0.348182
DE_PIG_MJ	MJ/KG	:	14.857687	AV_PHOS	%	:	0.599409	#M+C/LYS	%/%	:	0.579053
LEUCINE	%	:	1.773328	#CAL/PHO	%	:	1.200152	#TRY/LYS	%/%	:	0.19972
ISOLEUCINE	%	:	0.921049	#CAL/AVPHO	%	:	1.66615	#THR/LYS	%/%	:	0.669732
LYSINE	%	:	1.560294	SODIUM	%	:	0.173897	#ISO/LYS	%/%	:	0.590305
METHION	%	:	0.543266	SALT	%	:	0.351057	#VAL/LYS	%/%	:	0.644879
THREONINE	%	:	1.044979	CHOLINE	MG/KG	:	1981.713333	W6:W3 CALC	%	:	12.317404
TRYPTOPHAN	%	:	0.311622	FAT/EE	%	:	5.67038	#LEUC/LYS	%/%	:	1.136534