Nutritional supplementation to increase the number of pigs weaned and fertility of sows which farrow and are mated during summer / early autumn

A3B-102

Final Report prepared for the Australasian Pork Research Institute Limited (APRIL)

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October 2022

Australasian Pork Research Institute Ltd APRIL

Executive Summary

Rationale: During a typical Australian summer, it is common for sows to experience heat stress, which can result in increased peripheral blood flow and, thus, a reduction in uterine and ovarian blood flow. In peri-parturient sows, a reduction in uterine blood flow may reduce nutrient support for uterine contractions which, in concert with heat induced reductions in feed intake will increase farrowing duration and delay lactogenesis, resulting in increased piglet mortality and reduced growth to weaning. In weaned sows, reduced ovarian blood flow will reduce gonadotrophin and nutritional support for folliculogenesis and oogenesis, potentially reducing ovulation rate, decreasing oocyte and corpora lutea function and, thus, reducing fertility and fecundity.

Study Design: A collaborative study between The University of Adelaide, Rivalea (Australia Pty Ltd.) and Feedworks was conducted to determine the effects of arginine supplementation with or without betaine from 7 days prior to farrowing until the first post-weaning oestrus, on piglet mortality and growth prior to weaning, as well as sow reproductive performance post-weaning. This study consisted of two replicates, one in summer and one in winter/spring (spring), with four dietary treatments applied from farrowing shed entry until first post-weaning oestrus: Control, standard diet; Betaine, standard diet plus betaine (0.2%); Arginine, standard diet plus arginine (L-arginine; 1.0%); Arginine plus Betaine, standard diet plus betaine (0.2%) and arginine (1.0%) (n = 130 sows per treatment per seasonal replicate). Numerous reproductive and lactation indices were measured.

Major Project Outcomes

During summer, the inclusion of arginine in sows reduced piglet mortality, adding arginine and betaine to sow diets improved subsequent reproductive performance, while the addition of betaine (regardless of the presence of arginine) also improved subsequent reproductive performance. Specific benefits were as follows

1. Regardless of the inclusion of betaine in the diet, arginine reduced piglet mortality between fostering and day 3 of lactation from 19.8% to 14.7% ($P < 0.01$), reduced the number of piglets which died from fostering to weaning (2.20 ± 0.13 versus 2.55 ± 0.13; $P = 0.06$), and reduced the number of live born piglets which died prior to weaning (2.86 ± 0.15 versus 3.33 ± 0.15; $P < 0.05$).
2. Subsequent reproductive performance:
    - Arginine and betaine together reduced the weaning to remating interval ($P < 0.05$) from 5.6 to 5.1 days, increased the number of piglets born alive from 12.3 to 12.9 piglets/litter, and decreased the number of piglets born dead from 1.7 to 1.0 at the subsequent litter ($P < 0.05$).
    - When the main effect of betaine was analysed, its inclusion increased the number of piglets born alive at the subsequent litter from 12.3 to 12.8, and decreased the number and percentage of still born piglets from 1.64 to 1.18 and 10.9 to 8.1%, respectively ($P < 0.05$).

During spring, there were no benefits of including either betaine and arginine, either together or separately, in the diets of sows from pre-farrowing to remating during spring, on measures recorded during the first and second lactation. Stillbirth rates were higher at the first farrowing, and litter size on day 25 of the first lactation was lower following supplementation of betaine and arginine separately ($P < 0.001$). This result appears to be contradictory to the bulk of the available literature, and may, therefore, require further validation.

<u>Benefit to the Industry.</u> It is clear from the current study that adding betaine and arginine to the diets of sows which farrow and lactate during summer improved piglet survival and subsequent reproduction of sows. However, there appeared to be no benefits of adding these supplements to the diets of sows during spring. Further work is required to validate these outcomes within commercial systems, to determine the cost-benefit of their addition and to facilitate adoption across the industry.

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1. Introduction

During summer, increased incidences of pregnancy failure and low litter sizes impair productivity. This decline in fertility can be attributed to impaired ovarian follicle growth and thus reduced oocyte and embryo quality during summer compared with winter (Bertoldo et al., 2010 and 2012; Swinbourne et al., 2014). This reduction in growth of the ovarian follicle-oocyte can have a number of negative outcomes, which are typical manifestations of 'seasonal infertility'. Sub-optimal follicle growth can lead to fewer ovulations, thus reducing the upper limit of potential litter size. Impaired follicle growth will also result in the ovulation of lower quality embryos which can have the following consequences: 1) fewer embryos surviving to implantation and being able to implant (and thus lower litter sizes); 2) failure to initiate maternal recognition of pregnancy and stimulate production of luteotrophic factors (resulting in pregnancy failure). Sub-optimal follicle growth will also result in impaired growth and development of the corpora lutea (responsible for maintaining pregnancy in the pig), resulting in sub-optimal intra-uterine conditions for embryo development and potentially increased sensitivity to luteolytic factors and decreased responsiveness to luteotrophic factors. Changes in endocrine (gonadotrophin) support for ovarian development, embryo development and implantation are believed to be the primary cause of seasonal infertility, and this has been the focus of much research. However, it is clear from many of these studies that altered secretion of gonadotrophins (luteinising hormone (LH) in particular) from the anterior pituitary is not the primary cause of seasonal infertility (Peltoniemi et al., 1997; Bassett et al., 2001; Halli et al., 2008).

Importantly, the impact of season on the delivery of gonadotrophins, nutrients and oxygen (blood flow) and development of the ovarian vasculature has not been investigated. In cattle, sheep and rabbits, thermal stress significantly reduces blood flow to the ovary and uterus (Roman-Ponce et al., 1978; Lublin and Wolfenson, 1996), with reduced uterine blood flow known to reduce fertility in both sheep and cattle (Roman-Ponce et al., 1978). Correct and adequate development of the intra-ovarian and intra-follicular blood system is critical to follicle and oocyte development (Berisha et al., 2016). A reduction in blood flow to the ovary would reduce the delivery of gonadotrophins to developing follicles, essentially impairing or halting their maturation and development thus reducing the number of follicles available for ovulation and impairing the developmental competence (quality) of the oocytes that are ovulated. Similarly, the delivery of the nutrients required to ensure optimal oocyte maturation will be decreased if blood flow to the ovary is reduced. Preliminary support for an effect of thermal stress on ovarian blood flow is provided by recent work in dairy cattle demonstrating that ovarian blood flow is significantly enhanced in cooled compared to heat stressed animals (Honig et al., 2016). Pre-ovulatory follicle vascularity and blood flow affect progesterone production by the corpus luteum in beef cattle (de Tarso et al., 2017) and horses (Ishak et al., 2017). It is, therefore, logical to suggest that a thermally induced reduction in blood supply to the ovary may be responsible, at least in part, for the common manifestations of summer infertility within pig production systems. Reduced blood flow to the uterus pre-ovulation will affect the preparation of the uterus for the impending pregnancy, as well as alter nutrient and endocrine support for embryo development and implantation post-mating. Therefore, nutritional strategies which promote blood flow to the ovary and uterus prior to ovulation may counteract some of the negative impacts of elevated temperature on sow and gilt fertility.

During a typical Australian summer, it is common for sows to experience heat stress prior to, and during, parturition. This can result in reduced feed intake, prolonged farrowing durations and reduced piglet performance (Muns et al., 2016), and a reduction in uterine blood flow, and thus delivery of oxygen and nutrients to the rapidly growing foetuses. The impact of temperature induced reductions in uterine blood flow at the end of gestation on conceptus development have not been investigated. However, blood flow to the uterus determines correct conceptus development, with inadequacies leading to impaired foetal development and thus reduced progeny viability at birth. We would, therefore, suggest that reduced uterine blood flow immediately before and during parturition would increase the severity of foetal hypoxia and reduce foetal growth in pigs. This is a suggestion supported by work in heat-stressed dairy cattle, with heat stress also increasing incidences of retained placenta and impairing mammary gland development. Importantly, prolonged parturitions delays uterine involution in sows and reduced pregnancy rates when mated post-weaning (Oliviero et al al., 2013; Bjorkman et al., 2017). It is, therefore, suggested that heat stress immediately prior to (5 – 7 days), and during parturition, will have the following detrimental impacts: 1., reduced uterine blood flow and thus increased incidence / severity of foetal hypoxia and reduced foetal growth and a consequential reduction in piglet performance; 2., extended parturitions and, therefore, delayed uterine involution and increased risk of intra-uterine infection, resulting in greater risk of lactation disorders and a reduction in fertility.

Based on its mode of action, and the evidence above, it is clear that dietary arginine supplementation has the potential to alleviate the negative impacts of heat stress on sow performance and the performance of her progeny. Dietary arginine supplementation improves blood flow to reproductive tissues in a number of species (pigs, cattle and horses; de Tarso et al., 2017; Ishak et al., 2017). Previous work with arginine in pigs has focussed on gestation (reviewed by Wu et al., 2017). Based on a recent, systematic review, arginine supplementation at 1% improved litter number and / or litter characteristics in 63% of studies (Palencia et al., 2016). However, to the best of my knowledge, the impact of supplementary arginine on ovarian function has not been investigated in the pig. Arginine acts as a substrate for nitric-oxide biosynthesis, which inhibits the actions of vasoconstrictors and promotes angiogenesis in pre-ovulatory follicles. Although not investigated in pigs, L-arginine supplementation increased follicle size and perfusion of the pre-ovulatory follicles, as well as increasing uterine arterial blood flow in mares (Kelley et al., 2013 and 2014). In cattle, rumen protected arginine increased ovarian blood flow and LH concentrations (Green et al., 2017) and increased oocyte developmental competence *in vitro*, possibly via changes in nitric oxide (Dubeibe et al., 2017). Finally in sheep, arginine pre- and post-insemination increased fertility in ewes (de Chavez et al., 2015). Interestingly, arginine supplementation during lactation resulted in more rapid uterine involution in mares (Kelley et al., 2013). Based on these data from other species, it can be concluded that: 1. arginine supplementation of sow diets prior to ovulation (so during the weaning to insemination period, and potentially during lactation), should improve sow ovarian function and thus fertility during summer; 2. arginine supplementation of sow diets prior to farrowing will improve oxygen and nutrient supply to the rapidly growing foetuses and promote uterine involution, thus improving piglet performance and sow fertility during summer.

2. Methodology

A total of 1,035 Large White x Landrace sows, parity 4.0 ± 0.07, was used in this study, which was conducted as two seasonal replicates: SUMMER (n = 515 sows), and SPRING (n = 520 sows). Dates for the seasonal replicates were as follows: Summer, lactation one - 13th January to 1st April 2020, lactation two - 3rd June to 26th August 2021; Spring, lactation one – 8th September to 10th December, lactation two – 4th February to 11th May 2021. Within season, sows were allocated to one of four dietary treatments, with treatments commencing at farrowing shed entry and ending at the first post-weaning oestrus. The four treatments were:

- Control, standard diet (n = 129 and 130 sows in summer and spring, respectively);
- Betaine, standard diet plus betaine (0.2%) (n = 130 sows in summer and spring, respectively);
- Arginine, standard diet plus arginine (1.0%) (n = 129 and 130 sows in summer and spring, respectively);
- Arginine plus Betaine, standard diet plus betaine (0.2%) and arginine (1.0%) (n = 127 and 130 sows in summer and spring, respectively).

Dietary specifications were as follows (see Appendix 1 for full analysis): Control (15.1 MJ DE, 17.7% CP, 1.03% lysine); Betaine (15.1 MJ DE, 17.7% CP, 1.03% lysine); Arginine (15.1 MJ DE, 18.5% CP, 1.02% lysine), Arginine plus Betaine (15.1 MJ DE, 18.5% CP, 1.02% lysine). Betaine was supplied by Feedworks Pty Ltd, and arginine (given as L-arginine) was purchased.

Dietary treatments started 5.5 ± 0.09 and 5.3 ± 0.09 days prior to farrowing in summer/autumn and spring, respectively, and continued until post-weaning service or day 10 after weaning The following measures were collected from all sows: liveweight and P2 backfat prior to start of dietary treatment and at weaning, as well as at entry into the farrowing shed and at weaning of the subsequent litter; daily feed intake; subsequent reproductive performance (weaning to remating interval; WRI), pregnancy rate, farrowing rate and litter size (total born, born alive, born dead) at first and subsequent farrowing. In addition, piglet mortalities prior to and after fostering (typically conducted in the first day after farrowing) were recorded, as was the number of piglets alive at day 25. Individual piglet birthweights were recorded for a subset of 20 litters per treatment per season at the subsequent farrowing.

All analysis was conducted using Genstat (20th Edition; VSNI). Comparisons between treatments and between seasons were made using a one-way analysis of variance model, unbalanced treatment size. Unless otherwise stated only main treatment effects were observed, and presented. Data are presented as Mean ± SEM. $P < 0.05$ were accepted as significant; with $P < 0.1$ accepted as trend.

3. Outcomes

Effects of season

Sows were heavier and fatter at farrowing shed entry in the summer compared with the spring replicate (284 ± 1.43 versus 277 ± 1.43 kg and 20 ± 0.23 versus 19 ± 0.23 mm; both $P < 0.01$). Sow weight and P2 at weaning were similar ($P > 0.05$) in summer and spring (261 ± 1.6 and 262 ± 1.6 kg and 17.4 ± 0.2 and 17.6 ± 0.2 mm, respectively). Average lactation feed intake was higher in summer compared with spring (7.2 ± 0.04 versus 6.2 ± 0.4 kg / day; $P < 0.01$). Gestation length was longer for sows which farrowed in summer compared with spring (116.2 ± 0.07 versus 115.5 ± 0.07 days; $P < 0.01$); however, subsequent gestation length was unaffected by replicate (116 ± 0.08 days).

Total litter size was similar ($P > 0.05$) for sows which farrowed in summer and spring (13.82 ± 0.15 and 13.92 ± 0.15; respectively). More piglets were born dead in spring compared with summer (1.30 ± 0.07 versus 1.06 ± 0.07, respectively; $P < 0.01$); however, the number and proportion of piglets dying between birth and weaning was higher in summer compared with spring (3.10 ± 0.10 versus 2.48 ± 0.10 and 0.24 ± 0.01 versus 0.21 ± 0.01, respectively; $P < 0.01$). Piglets were weaned at 30.5 ± 0.12 and 30.3 ± 0.12 days in summer and spring, respectively. Litter size and average piglet weight at day 25 post-birth were similar in summer and spring (9.7 ± 0.09 and 9.6 ± 0.09 piglets; 7.17 ± 0.05 and 7.16 ± 0.05 kg).

Effects of dietary treatment

<u>Summer</u>

The effects of treatment on sow and litter performance when treatments were imposed prior to, during, and immediately after a summer lactation are presented in Table 1. Sows receiving arginine ate less food during lactation compared with those receiving the control or betaine-supplemented diets (Table 1); however, backfat at weaning was higher for arginine-supplemented sows (Table 1). Regardless of the inclusion of betaine in the diet, arginine reduced the number of piglets which died from fostering to weaning (2.20 ± 0.13 versus 2.55 ± 0.13; $P = 0.04$), and the number of live born piglets which died prior to weaning (2.86 ± 0.15 versus 3.33 ± 0.15; $P < 0.05$).

Arginine and betaine together reduced the WRI mating interval ($P < 0.05$) from 5.6 to 5.1 days. In the subsequent lactation, arginine and betaine increased the number of piglets born alive from 12.3 to 12.9 piglets/litter and decreased the number of piglets born dead from 1.7 to 1.0 ($P < 0.05$). When the main effect of betaine was analysed, its inclusion increased the number of piglets born alive at the subsequent litter from 12.3 to 12.8, and decreased the number and percentage of still born piglets from 1.64 to 1.18 and 10.9 to 8.1%, respectively ($P < 0.05$).

Spring

The effects of treatment on sow and litter performance when treatments were imposed prior to, during, and immediately after a spring lactation are presented in Table 2. Stillbirth rates were higher at the first farrowing with arginine, and litter size on day 25 of the first lactation was lower, following supplementation of betaine and arginine separately ($P < 0.001$). There were no significant differences in any measurements in the subsequent lactation (Table 2).

Table 1 Sow and litter performance at lactation one and two, when treatments were imposed prior to, during and immediately after a summer lactation (lactation one).

	CONT	BET	ARG	BET + ARG	*Pooled SEM*	P
Lactation One						
N	129	130	129	127		
LW Shed Entry, kg	284.1	285.1	282.1	284.5	*1.41*	0.895
P2 Shed Entry, mm	19.6^{a}	19.2^{a}	20.0^{a}	21.3^{b}	*0.13*	<0.01
Sow ADFI (kg/day)	7.4^{b}	7.5^{b}	7.0^{a}	7.0^{a}	*0.05*	< 0.001
LW Shed exit, kg	260.3	264.8	258.5	260.1	*1.61*	0.550
P2 shed exit, mm	16.9^{a}	16.8^{a}	17.4^{b}	18.5^{b}	*0.22*	<0.05
P2 loss, mm	2.3	2.4	2.7	3.1	*0.13*	0.177
Total Born	14.3	13.7	13.6	13.7	*0.15*	0.418
Born Alive	12.5	12.4	12.6	12.6	*0.14*	0.746
Still born	1.14	1.08	0.98	1.04	*0.06*	0.810
Stillborn, %	8.3	7.4	7.0	7.0	*0.5*	0.748
Ave. Birthweight, kg	1.54	1.48	1.51	1.49	*0.01*	0.128
Pre-foster deaths	0.68	0.71	0.58	0.59	*0.05*	0.691
Post-foster deaths	2.70	2.46	2.15	2.20	*0.10*	0.164
Total deaths (live born)	3.46	3.28	2.76	2.89	*0.11*	0.10
Litter size, day 25	9.8	9.4	9.8	9.7	*0.10*	0.323
WRI (days)	5.6^{a}	6.4^{b}	6.5^{b}	5.1^{c}	*0.54*	0.037
Lactation Two						
N	69	74	65	77		
Total Born	14.2	13.9	13.4	14.3	*0.20*	0.414
Born Alive	12.3^{a}	12.6^{ab}	12.3^{a}	12.9^{b}	*0.18*	<0.05
Still born	1.7^{b}	1.3^{ab}	1.6^{b}	1.0^{a}	*0.09*	<0.05
Stillborn, %	10.7^{b}	9.5^{ab}	11.2^{b}	6.8^{a}	*0.60*	<0.05
Ave. Birthweight, kg	1.41	1.41	1.38	1.41	*0.01*	0.786
Pre-foster deaths	1.13	0.76	0.67	0.84	*0.08*	0.127

^{abc} Within a row, superscripts indicate a significant difference between individual treatments.

Table 2 Sow and litter performance at lactation one and two, when treatments were imposed prior to, during and immediately after a spring lactation (lactation one).

	CONT	BET	ARG	BET + ARG	*Pooled SEM*	P
Lactation One						
N	130	130	130	130		
LW Shed Entry, kg	275.8	279.0	276.6	275.5	*2.89*	0.824
P2 Shed Entry, mm	19.0	19.5	18.5	18.6	*0.45*	0.306
Sow ADFI (kg/day)	6.24[b]	5.99[a]	6.25[b]	6.22[b]	*0.07*	0.022
LW Shed exit, kg	262.0	261.6	264.8	260.1	*3.19*	0.774
P2 shed exit, mm	17.8	18.0	17.2	17.3	*0.43*	0.516
P2 loss, mm	1.2	1.5	1.5	1.5	*0.27*	0.781
Total Born	14.0	14.4	13.7	13.5	*0.31*	0.225
Born Alive	12.8	12.5	11.9	12.2	*0.28*	0.141
Still born	1.03[a]	1.44[b]	1.59[b]	1.14[ab]	*0.13*	<0.001
Stillborn, %	7.6	9.5	11.0	7.7	*0.10*	0.053
Ave. Birthweight, kg	1.48	1.47	1.45	1.47	*0.02*	0.730
Pre-foster deaths	0.61	0.61	0.73	0.54	*0.05*	0.479
Post-foster deaths	1.95	1.82	2.11	1.71	*0.08*	0.263
Total deaths (live born)	2.62	2.38	2.83	2.25	*0.09*	0.100
Litter size, day 25	9.99[b]	9.38[a]	9.22[a]	9.79[ab]	*0.94*	<0.001
WRI	5.35	5.30	5.22	5.24	*0.18*	0.995
Lactation Two						
N	67	65	60	66		
Total Born	14.5	13.4	13.6	13.7	*0.22*	0.392
Born Alive	13.2	12.2	12.2	12.5	*0.20*	0.253
Still born	1.13	1.06	1.70	1.32	*0.11*	0.180
Stillborn, %	7.2	7.4	11.4	8.3	*0.68*	0.122
Ave. Birthweight, kg	1.47	1.51	1.43	1.45	*0.02*	0.341
Pre-foster deaths	.39	0.48	0.49	0.37	*0.06*	0.826

[ab] Within a row, superscripts indicate a significant difference between individual treatments.

4. Application of Research

The current data demonstrated that adding arginine to the pre-farrow diets of sows during summer reduced piglet mortality throughout lactation, indicating a beneficial impact on piglet viability. The addition of arginine and betaine together, or betaine in isolation prior to, during, and immediately after lactation, improved subsequent reproductive performance of sows that farrowed and were mated during summer, indicating a positive effect on sow metabolic state and, perhaps, ovarian function as a result of these nutritional additives.

During spring, there were no benefits at farrowing, during lactation, or in the WRI of including either betaine and arginine, either together or separately, in diets on measures recorded during both the first and second lactations. Curiously, stillbirth rates were higher at the first farrowing, and litter size on day 25 of the first lactation was lower, following supplementation of betaine and arginine separately ($P < 0.001$). This result appears to be contradictory to the bulk of the available literature, and may, therefore, require further validation.

These data demonstrate that adding arginine and betaine to the diets of sows between farrowing shed entry and re-mating during summer is likely to improve piglet survival and improve subsequent sow reproductive performance. This will positively impact costs of production by increasing the efficiency of the breeding herd due to an increase in the number of live born piglets surviving to weaning during summer, and the increased live born piglets farrowed by sows mated during summer. Both betaine and arginine are readily available, and easily included in commercial diets and, are, therefore easy to adopt by producers. Considering the ease of adoption, these finding are likely to have a positive impact on the Australian pig industry. However, more commercial scale research is required to validate these promising outcomes across a wider sector of the industry, thus increasing producer confidence and adoption.

5. Conclusion

It is clear from the current study that adding betaine and arginine to the diets of sows which farrow and lactate during summer improved piglet survival and the subsequent reproduction of sows. However, there appeared to be no benefits, and potentially negative effects, of adding these supplements to the diets of sows during spring. Further work is required to validate these outcomes within commercial systems, to determine the cost-benefit of their addition and to facilitate adoption across the industry.

The primary outcomes of this study are as follows:

- Arginine supplementation during summer resulted in 0.5 extra live born piglets surviving to weaning.
- Betaine supplementation during summer resulted in 0.5 extra piglets born alive at the following farrowing.
- Combining betaine and arginine in sow diets during summer resulted in sows being mated 0.5 days earlier relative to weaning, and producing an additional 0.6 liveborn piglets at their subsequent farrowing.

6. Limitations/Risks

The limitation of this study is that it was conducted over one summer and one spring, and in one commercial facility. Therefore, considering the different genotypes present in Australia, and their different nutritional and management requirements, there is the risk that these findings may not apply across the industry.

Unfortunately, due to restrictions imposed by Covid-19, it was not possible to assess aspects of ovarian function and oocyte development in this project.

7. Recommendations

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

- Adding betaine (0.2%) and arginine (1%) to the pre-farrow, lactation and post-weaning diets will improve the performance of sows which farrow during summer, and into the following lactation.
- There appears to be little benefit to adding these supplements to sows which farrow during spring.
- Further commercial scale research should be conducted across a range of genotypes and over at least two summers to confirm these positive findings, and promote adoption.

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APPENDIX 1

Raw Material		9737 19R032 LAC HE CONTROL %	9738 19R032 LAC HE BETAINE %	9760 19R032 LAC HE + 1% ARG %	9761 19R032 LAC HE + BETAINE + 1%ARG %
9 ROLLED WHEAT	[X]	57.424992	56.924992	57.424992	56.924992
12 BARLEY	[X]	10.0	10.0	10.0	10.0
200 MILLMIX	[X]	6.666667	6.666667	6.666667	6.666667
300 CANOLA MEAL 38%	[X]	10.0	10.0	10.0	10.0
325 SOYABEANMEAL-46%	[X]	2.5	2.5	2.5	2.5
400 MEATMEAL 60%	[X]	3.33334	3.33334	3.33334	3.33334
514 SEMI REFINED FISH OIL	[X]	0.4	0.4	0.4	0.4
520 TALLOW-MIXER	[X]	6.0	6.0	6.0	6.0
521 LIQUID BETAINE	[X]	.	0.5	.	0.5
560 LIMESTONE	[X]	1.0	1.0	1.0	1.0
628 ARGININE	[ ]	.	.	1.0	1.0
661 MAGNESIUM SULPHATE(EPSOM SALTS	[X]	0.4	0.4	0.4	0.4
1095 KRAVE AP FLAVOUR	[X]	0.033333	0.033333	0.033333	0.033333
1539 POTASSIUM CHLORIDE MICRO	[X]	0.2	0.2	0.2	0.2
1540 ROVABIO ADVANCE T/FLEX 25% MIC	[X]	0.02	0.02	0.02	0.02
1541 QUANTUM BLUE 5G PHYTASE MICRO	[X]	0.01	0.01	0.01	0.01
1551 LYSINE MICRO	[X]	0.416667	0.416667	0.416667	0.416667
1553 THREONINE MICRO	[X]	0.133334	0.133334	0.133334	0.133334
1560 SOW REPLACE PAK MICRO	[X]	0.2	0.2	0.2	0.2
1566 PIG REPRODUCTION BLEND MICRO	[X]	0.05	0.05	0.05	0.05
1574 ENDOX MICRO	[X]	0.02	0.02	0.02	0.02
1583 TRYPTOPHAN MICRO	[X]	0.04	0.04	0.04	0.04
1585 SALT BIN MICRO	[X]	0.35	0.35	0.35	0.35
1592 ALL SPP VIT BLEND A MICRO lar	[X]	0.075	0.075	0.075	0.075
1598 ALL SPP VIT BLEND B MICRO (abo	[X]	0.05	0.05	0.05	0.05
1946 ARBOCEL	[X]	0.666667	0.666667	0.666667	0.666667
1955 PROTERNATIVE 10 TITAN	[X]	0.01	0.01	0.01	0.01
		100.0	100.0	101.0	101.0

Nutrient	Analysis	Analysis	Analysis	Analysis
DE_PIG	15.079128	15.062128	15.088246	15.071414
PROTEIN	17.717554	17.685054	18.512429	18.480251
FAT	8.056275	8.049775	7.97651	7.970074
T:CALCIUM	0.848213	0.847963	0.839815	0.839567
AV:PHOS	0.406567	0.406067	0.402541	0.402046
LYSINE	1.029905	1.028155	1.019708	1.017975
ARGININE	0.968854	0.965654	1.929558	1.92639
#ALY/DE_	0.058808	0.058775	0.05819	0.058158
#MET/LYS	0.272364	0.320437	0.272364	0.320437
#M+C/LYS	0.601236	0.648507	0.601236	0.648507
#THR/LYS	0.709498	0.708858	0.709498	0.708858
#ISO/LYS	0.618404	0.617171	0.618404	0.617171
#TRY/LYS	0.250991	0.25064	0.250991	0.25064
#VAL/LYS	0.776275	0.774824	0.776275	0.77482