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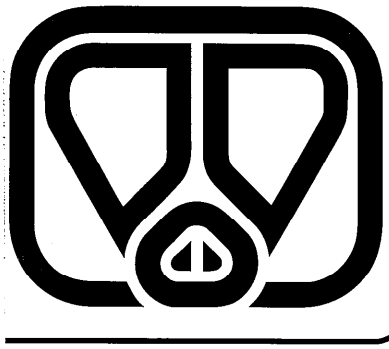
Spray-dried blood plasma and spray-dried blood cells in diets of weaned piglets



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SUMMARY

In a 33-day 2 x 2 factorial study, 720 cross-bred weaned piglets (7.6 kg) were used to examine whether spray-dried blood plasma (= SDBP) in a prestarter diet (first 8 days after weaning) affects the performance and occurrence of post-weaning diarrhoea in piglets. Moreover, the performance of piglets was studied after replacing high quality fish meal with granulated spray-dried blood cells (= SDBC) in a starter diet (day 9 - day 33).

Four experimental treatments were tested:

1 from day 1 to 8 a prestarter diet without SDBP and from day 9 to 33 a starter diet without SDBC;
2 from day 1 to 8 a prestarter diet without SDBP and from day 9 to 33 a starter diet with 2.5% SDBC replacing 4% fish meal;
3 from day 1 to 8 a prestarter diet with 5% SDBP replacing 5% fish meal and from day 9 to 33 a starter diet without SDBC;
4 from day 1 to 8 a prestarter diet with 5% SDBP replacing 5% fish meal and from day 9 to 33 a starter diet with 2.5% SDBC replacing 4% fish meal.

The diets were provided ad libitum.

The most important results and conclusions are given below:

- From day 1 to 8, the piglets fed the diet with SDBP performed better than the piglets fed the diet without SDBP. From day 1 to 33, the piglets fed the diet with SDBP tended to have a higher growth rate and a better feed conversion ratio.
- The health of the piglets and the economic results per delivered piglet were not effected by the presence of SDBP in the diet. However, the occurrence of post-weaning diarrhoea was low in all experimental treatments. On farms with post-weaning diarrhoea in the piglets diets with blood plasma probably will give economic profit.
- Piglets fed a starter diet containing 2.5% SDBC had similar performance and economic results as piglets fed a starter diet containing 4% fish meal.

1 INTRODUCTION

Post-weaning diarrhoea is a regularly occurring problem in the Dutch pig farming industry. Research has demonstrated that post-weaning diarrhoea occurs less frequently in piglets receiving feed containing blood plasma (AP-920) (Gatnau and Zimmerman 1990, Gatnau et al. 1993, Van der Peet-Schwering and Binnendijk 1995). It has also demonstrated that piglets eat more of this feed during the first two weeks following weaning and that they grow more rapidly. Similar results have been obtained by Hansen et al. (1991) and Coffey and Cromwell (1995).

The specific mechanism of blood plasma is still unknown. Gatnau et al. (1989) and Cain (1995) believe that the immunoglobulins in the blood plasma cause the small intestine to function better, as a result of which more feed can be absorbed and the growth rate increases. Ermer et al. (1994) suggest that the increase in feed intake is a palatability effect. Van der Peet-Schwering and Binnendijk (1995) have found that the effect of blood plasma on the performance is greatest in the first week after weaning. The effect is slightly decreased during the second week after weaning. Therefore they suggested that prestarter diet containing blood plasma could be provided for a shorter period than two weeks to decrease feed costs.

Blood plasma is made from the blood of slaughtered animals. The blood is separated into blood plasma and blood cells using a centrifuge, after which both products are spray-dried. The spray-dried blood cells are then granulated to improve the distribution properties of the product and to prevent the pellet from becoming dark. The products spray-dried blood plasma (AP-920) and granulated spray-dried blood cells (AP-301 G) are sold by the American Protein Corporation (Ames, Iowa, USA). The product spray-dried blood cells has a protein content of 92% and is possibly a suitable source of protein for piglets between six and ten weeks of age. AP-301G has a high lysine, threonine and tryptophane content but a low isoleucine content. Feng et al. (1995) found that 2.5% blood cells in starter diet led to similar results as 4% fish meal. Lynch (1995) found that the replacement of 4% fish meal by 2.5% blood cells in starter diet did not have a clear effect on the growth and feed intake of piglets but that it did have a positive effect on the feed conversion ratio.

Research has been carried out at the experimental farm in Rosmalen to examine whether the addition of 5% blood plasma (AP-920) to piglet feed during the first eight days after weaning decreases the occurrence of post-weaning diarrhoea and improves the performance and financial results. Moreover, the performance of piglets was studied after replacing high quality fish meal with granulated blood cells (AP-301G) in a starter diet (day 9 - day 33 after weaning).

2 MATERIALAND METHODS

2.1 Animals and experimental size

The research was conducted using weaned piglets with a Large White sire line as father and a rotation cross breeding sow as mother. The rotation cross breeding sow is a combination of Dutch Landrace, Large White sow line and Finnish Landrace. At an average age of four weeks and an average body weight of 7.6 kg the piglets were weaned and divided into groups for the experiment. The piglets were followed for 33 days from the moment of weaning. A total of 720 piglets in 10 batches were used in the experiment.

2.2 Experimental design

In this study four experimental treatments were tested:

1 from day 1 to 8 a prestarter diet without SDBP and from day 9 to 33 a starter diet without SDBC;
2 from day 1 to 8 a prestarter diet without SDBP and from day 9 to 33 a starter diet with 2.5% SDBC replacing 4% fish meal;
3 from day 1 to 8 a prestarter diet with 5% SDBP replacing 5% fish meal and from day 9 to 33 a starter diet without SDBC;
4 from day 1 to 8 a prestarter diet with 5% SDBP replacing 5% fish meal and from day 9 to 33 a starter diet with 2.5% SDBC replacing 4% fish meal.

The diets were provided ad libitum. The ingredients and the calculated chemical composition of the experimental diets are presented in appendix 1. Water was provided ad libitum during the whole period.

The experimental groups were compiled by means of a block design; this means that the piglets were grouped on the basis of the sex, weight and litter in which they were weaned. Groups were compiled consisting of both sexes at the start of the experiment (five barrows and five sows). The piglets from one litter were divided over the various treatments as much as possible. Piglets that weighed five kg or less at the moment of weaning, or that showed (visible) physical abnormalities were not used in the experiment. The piglets within one block were of approximately equal weight at weaning. The division of the four experimental groups over the pens within one block was at random. A compartment was always filled at the same time.

2.3 Housing and climate

The experiment was conducted in three rooms, two of which consisted of 6 pens for 10 piglets and one consisting of 12 pens for 10 piglets. The pens (2.65 m x 1.25 m) had a solid spherical floor that was heated and metal tribar slats. The rooms with 6 pens were mechanically ventilated. The aeration and heating were computer controlled. The room with 12 pens had a natural ventilation system consisting of air-inlets on both sides of the feeding path with a controllable ridge. In each of the 12 pens a micro climate was created for the piglets.
The room temperature was fixed at 27°C at the start of the experiment in both the naturally and mechanically ventilated rooms. Within five weeks, the room temperature was gradually lowered to 20°C. The floor temperature was fixed at 32°C at the start of the experiment and was lowered to 29°C within the first two weeks, after which it was lowered to 20°C in the following 3 weeks.

2.4 Data collection and data analysis

All the piglets were individually weighed just before the start of the experiment and on day 8 and 33 after weaning. The feed gift per pen was also registered. These data were used to calculate the following production characteristics: growth per day, feed intake per day and feed conversion ratio. Veterinary treatments were registered per animal. If an animal died, the date, weight and cause of death were registered. The dead animals were not included in the analyses of the weaner results.
During the first three weeks after weaning all the pens were assessed for the occurrence of post-weaning diarrhoea three times a

week (on Monday, Wednesday and Friday). The incidence of post-weaning diarrhoea was determined by looking at the consistency of the manure in the pen and by assessing the pigs. The consistency of the manure was divided into four classes, namely solid manure, normal manure (no diarrhoea), mild diarrhoea and watery diarrhoea. At the same time an estimate of the number of animals to fall in each class was made per pen. The experiment was set up in accordance with a 2 x 2 factorial design. The factors are blood plasma (included or not included in the prestarter diet) and blood cells (included or not included in the starter diet). The daily growth rate, feed intake and feed conversion ratio were analysed using analysis of variance (SAS, 1990) in accordance to model 1. In model 1, 'the pen' acts as the experimental unit:

$y = \mu$ + weight at weaning + batch + blood plasma + blood cells + blood plasma x blood cells + error (model 1).

The X^2-test was used to see whether there was a difference in mortality and number of veterinary treatments between the experimental groups. The incidence of post-weaning diarrhoea was analysed using logistic regression.

3 RESULTS

3.1 Performance during the weaning period

In table 1, the performance of the weaned piglets is given from day 1 to 8, day 9 to 33 and day 1 to 33. Only the main effects are shown, because no significant interaction took place between the factors blood plasma and blood cells.

In table 1, it is shown that in the first eight days of the experiment those piglets receiving a prestarter diet with 5% blood plasma clearly grew faster, had a higher feed intake and a better feed conversion ratio than those piglets receiving feed without blood plasma. From day 9 to 33, there were no significant differences in the feed intake and feed conversion ratio of pigs receiving starter diet with or without blood cells. Those piglets receiving starter diet including 2.5% blood cells tended to grow slightly less ($p = 0.11$). However the differences in growth were not significant. From day 9 to 33, there were no differences in growth rate, feed intake and feed conversion ratio between the piglets who were fed 5% or no blood plasma in the diet the first eight days after weaning.

The results from day 1 to 33 show that piglets receiving prestarter diet including 5% blood plasma in the first eight days of the weaner period had a tendency towards a higher growth ($p = 0.07$) and a better feed conversion ratio ($p = 0.06$). From day 1 to

Table 1: Performance of piglets receiving prestat-ter diet with or without blood plasma during the first eight days after weaning, after which they received starter diet with or without blood cells

	blood plasma		blood cells			significance[2]	
	without	with	without	with	SEM[1]	blood plasma	blood cells
number of animals	360	360	360	360			
Day 1 to 8:							
initial body weight (kg)	7.6	7.6	7.6	7.6			
growth (g/day)	195	232	210	217	5.0	***	n.s.
feed intake (kg/day)	0.23	0.25	0.24	0.24	0.004	***	n.s.
feed conversion ratio	1.23	1.11	1.18	1.16	0.024	***	n.s.
Day 9 to 33:							
body weight (kg)	9.2	9.5	9.4	9.4			
growth (g/day)	458	460	464	453	5.0	n.s.	n.s.
feed intake (kg/day)	0.73	0.73	0.73	0.73	0.007	n.s.	n.s.
feed conversion ratio	1.60	1.59	1.58	1.60	0.014	n.s.	n.s.
Day 1 to 33:							
final body weight (kg)	20.6	21.0	20.9	20.7			
growth (g/day)	393	404	402	395	4.0	#	n.s.
feed intake (kg/day)	0.61	0.61	0.61	0.61	0.006	n.s.	n.s.
feed conversion ratio	1.55	1.52	1.52	1.54	0.011	#	n.s.

[1] SEM = pooled standard error of the mean (gives an indication of the accuracy of the estimate of the variable measured)

[2] significance: n.s. = not significant, # = ($p < 0.10$), *** = ($p < 0.001$).

33, there was no difference in the feed intake of the piglets fed diets with or without blood plasma the first eight days after weaning. The results from day 1 to 33 also show that there was no difference in the performance of piglets fed diets with or without blood cells from day 9 to 33.

3.2 Health and mortality during the weaning period

3.2.1 The occurrence of post-weaning diarrhoea

In table 2, the occurrence and gravity of post-weaning diarrhoea are presented during the first three weeks of the weaner period. Since there was no interaction between the factors blood plasma and blood cells, only the main effects are given. Solid manure was not registered during the experiment.

In the first, second and third week, there is no difference in the occurrence and gravity of post-weaning diarrhoea in piglets fed diets with or without blood plasma in the first eight days after weaning. Neither were there differences in the occurrence or gravity of post-weaning diarrhoea in the first or second week in piglets that did or did not receive feed containing blood cells. Those piglets receiving starter feed containing 2.5% blood cells suffered slightly more mild diarrhoea (soft stools) in the third week after weaning.

3.2.2 Mortality and veterinaty treatments

In table 3, the number of deaths in animals and the number of animals that had to be treated for health problems are presented. The reasons for mortality and treatment are also given. Since there was no interaction between the factors blood plasma and blood cells, only the main effects are given. In table 3, it is shown that there was no difference in the mortality of piglets dependent of whether or not they received blood plasma in the prestarter diet or blood cells in the starter diet.

There was no difference in the number of treated animals and the reason for treatment between piglets which were or were not

Table 2: Occurrence and gravity of post-weaning diarrhoea (% of the number of observations) in piglets receiving prestarter diet with or without blood plasma during the first eight days after weaning, after which they received starter diet with or without blood cells

	blood plasma		blood cells		significance[1]	
	without	with	without	with	blood plasma	blood cells
number of animals	360	360	360	360		
First week after the start of the experiment:						
no diarrhoea	90.3	90.7	90.9	90.2		
mild diarrhoea	6.9	6.6	6.3	7.2	n.s.	n.s.
watery diarrhoea	2.8	2.7	2.8	2.6		
Second week after the start of the experiment:						
no diarrhoea	94.8	94.7	95.5	93.9		
mild diarrhoea	3.9	4.2	3.4	4.8	n.s.	n.s.
watery diarrhoea	1.3	1.1	1.1	1.3		
Third week after the start of the experiment:						
no diarrhoea	97.8	98.1	98.6	97.3		
mild diarrhoea	1.7	1.6	1.0	2.3	n.s.	*
watery diarrhoea	0.5	0.3	0.4	0.4		

[1] significance: n.s. = not significant, * = ($p < 0.05$)

Table 3: Mortality and veterinary treatment of piglets receiving prestarter diet with or without blood plasma during the first eight days after weaning, after which they received starter diet with or without blood cells

	blood plasma		blood cells		significance[1]	
	without	with	without	with	blood plasma	blood cells
number of of animals	360	360	360	360		
number of dead animals	5	6	5	6	n.s.	n.s.
reason for mortality:						
- intestinal problem	2	3	3	2	[2]	[2]
- respiratory problem	2	1	1	2	[2]	[2]
- diverse	1	2	1	2	[2]	[2]
number of treated piglets	34	36	42	28	n.s.	#
reason for treatment:						
- intestinal problem	11	15	14	12	n.s.	n.s.
- leg problem	10	16	16	10	n.s.	n.s.
- diverse	13	5	12	6	#	n.s.

[1]Significance: n.s. = not significant, # = ($p < 0.10$)
[2] Number was too low to test

given blood plasma in the feed. Slightly fewer piglets receiving 2.5% blood cells in their feed were treated ($p = 0.088$) than those not receiving blood cells in their feed. There were no clear differences in the reasons for treatment.

3.3 Economic results

The economic evaluation deals with the differences in performance, the costs of veterinary treatment and the labour costs involved in treating the animals. Since there is no experimental interaction between blood plasma and blood cells, the economic evaluation compares the experimental situations in which blood plasma or blood cells are included in the feed or not. The following basic assumptions were used for the economic evaluation:

- Yield:
  Piglet price is f 95.- at 25 kg (KWIN-V, 1996). Piglets lighter than 25 kg were f 2.54 less per kg.
- Feed costs:
  Prestarter diet without blood plasma: f 86.60 per 100 kg.
  Prestarter diet with blood plasma: f 116.70 per 100 kg.
  Starter diet without blood cells: f 59.60 per 100 kg.
  Starter diet with blood cells: f 59.30 per 100 kg.
- Medical costs:
  An average of 2 ml is injected per veterinary treatment. The costs of medicine are f 0.18 per ml.
- Labour costs:
  Labour costs are f 37.77 per hour. Observations at the Research Institute for Pig Husbandry have shown that it takes 1.13 minutes to individually treat a weaned piglet.

In table 4, the results of the economic evaluation per delivered piglet are presented. The economic results of piglets fed a prestarter diet containing blood plasma were similar to those of piglets fed a prestarter diet without blood plasma. There were also very few differences in the economic results of piglets fed a starter diet containing blood cells and those fed a starter diet without blood cells.

Table 4: Economic results per delivered piglet, for piglets receiving prestarter diet with or without blood plasma during the first eight days after weaning, after which they received starter diet with or without blood cells

	blood plasma		blood cells	
	without	with	without	with
Yield	f 83.82	f 84.84	f 84.33	f 84.33
Feed costs	f 12.81	f 13.86	f 13.35	f 13.30
Medical costs	f 0.04	f 0.04	f 0.04	f 0.03
Labour costs	f 0.07	f 0.07	f 0.08	f 0.06
Yield - costs	f 70.90	f 70.87	f 70.86	f 70.94

4 DISCUSSION AND CONCLUSIONS

4.1 Effect of blood plasma

Several experiments in both the Netherlands and abroad have demonstrated that the use of blood plasma in prestarter diet has a positive effect on both the performance and the health of piglets. Van der Peet-Schwering and Binnendijk (1995) have found that the effect of blood plasma on the performance is greatest in the first week after weaning and that the effect is slightly decreasing during the second week after weaning. They suggested that prestarter diet containing blood plasma could be provided for a shorter period than two weeks to decrease feed costs. Therefore follow up research was carried out into the effect of the addition of blood plasma to the prestarter diet for the first eight days on the performance and economic results.

The results demonstrated that adding blood plasma to the prestarter diet during the first eight days of the weaner period led to a clear improvement in the performance during this period. The results for the entire weaner period also demonstrated that the animals receiving prestarter diet with blood plasma achieved a somewhat higher growth and an improved feed conversion ratio than those animals receiving prestarter diet without blood plasma. However the improvement in growth and feed conversion ratio in the period from weaning up until 33 days after weaning was somewhat less than that in the previous study carried out by Van der Peet-Schwering and Binnendijk (1995).

The addition of blood plasma to the feed appeared not to have an effect on the occurrence of post-weaning diarrhoea and the number of animals requiring veterinary attention, contrary to the previous study. In this study, piglets not receiving blood plasma in the feed had considerably less diarrhoea and many fewer animals required veterinary attention because of intestinal problems than in the previous experiment. Therefore blood plasma seems to lead to less or no improvement in the health of the piglets if diarrhoea does not form a major problem on the farm. Coffey and Cromwell (1995) obtained similar results. They found that the positive effect of the addition of blood plasma to the feed on the performance is less under experimental conditions than under normal conditions on the farm.

There were no differences in the economic results per delivered piglet between animals who did or did not receive blood plasma in the feed. Thus adding blood plasma to the prestarter diet for a short period of time did not lead to economical advantages in this experiment. On farms, however, with post-weaning diarrhoea in the piglets, diets with blood plasma probably will give economic profit.

4.2 Effect of blood cells

Research was carried out to see whether the addition of 2.5% granulated blood cells to starter diet leads to similar performance as the addition of 4% fish meal to starter diet. Blood cells have a high protein content with a high digestibility. From day 9 to 33, the period in which starter diet was supplied, the piglets receiving blood cells in the starter diet tended to grow slightly less rapidly. Blood cells have a low isoleucine content. Therefore the isoleucine content of the feed containing blood cells was lower than that of the feed without blood cells. The isoleucine content of the feed with and without blood cells was calculated to be 6.2 and 7.1 gram per kg, respectively. The level of ileal digestible isoleucine in the feed was unknown. Research carried out by Van Diepen et al. (1993) demonstrated that piglets weighing between 18 - 40 kg require 5.1 g/kg ileal digestible isoleucine for maximum growth and 5.5 g/kg for an optimal feed conversion ratio. The ileal digestibility of isoleucine in the feed not containing synthetic isoleucine was 82% in that experiment. If this digestibility coefficient for isoleucine is taken as a standard, the ileal digestible isoleucine content of starter diet with and without blood cells would be 5.1 and 5.8 g/kg, respectively. Therefore the ileal digestible isoleucine content of starter diet without blood cells could be slightly too low. The results for the

whole weaner period demonstrated that there was no difference in the growth, feed intake and feed conversion ratio of animals who were and were not given blood cells in the starter diet.
During the third week after the start of the experiment those piglets receiving blood cells in the starter diet suffered slightly more post-weaning diarrhoea. However the number of piglets that were treated for gastro-intestinal problems remained the same. Therefore it can be concluded that feed containing blood cells does not effect the occurrence of diarrhoea in piglets.
The economic evaluation demonstrated that starter diets containing blood cells were slightly advantageous with a profit of f 0.08 per delivered piglet, as a result of slightly lower feed costs. It can be concluded that the addition of 2.5% blood cells to starter diet leads to comparable performance and economical results as the addition of 4% fish meal to starter diet.

4.3 Conclusions

- The addition of 5% blood plasma to pre-starter diet during the first eight days of the weaner period leads to clearly improved performance in this period and to slightly improved growth and feed conversion ratio from day 1 to 33.
- The health and economic results of piglets were not effected by the addition of blood plasma to the diet. However, the occurrence of post-weaning diarrhoea was low in all experimental treatments. On farms with post-weaning diarrhoea in the piglets, diets with blood plasma probably will give economic profit.
- The addition of 2.5% granulated blood cells to starter diet led in the period between day 9 and 33 and the period between weaning and day 33 after weaning to similar performance and economic results as did the addition of 4% fish meal to the starter diet. However it must be ensured that the isoleucine content of the feed containing blood cells is not too low.

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APPENDIX

Appendix 1: Ingredients and calculated chemical composition of the experimental diets (g/kg)

	prestarter diet		starter diet	
	without blood plasma	with blood plasma	without blood cells	with blood cells
spray-dried blood plasma	-	50	-	
spray-dried blood cells				25
wheypowder	**110**	110	40	40
fish meal	**50**		40	
barley	600	600	350	360
wheat	80	80	160	160
soya beans, heattreated	80	80	30	30
tapioca			130	130
sunflower seed, extracted	-	-	30	30
soya beans, extracted			120	130
animal fat	20	20	20	20
molasses			30	30
synthetic amino acids	3.7	3.5	4	2
vitamin+mineral premix	56.3	56.5	46	43
EW[1]	1.14	1.14	1.08	1.08
crude protein	174	178	177	177
crude fat	50	54	38	37
crude fibre	39	38	45	45
starch	391	383	393	392
ileal digestible lysine	10.3	10.3	9.3	9.3
ileal digestible meth.+cyst.	5.9	5.9	5.4	5.4
ileal digestible threonine	5.8	5.8	5.2	5.2
lactose	50	50	15	15
phosphorus	6.3	6.2	4.9	5
digestible phosphorus	3.9	3.9	3.4	3.4

[1] 1 EW = 8.79 MJ NE

PUBLISHED RESEARCH REPORTS

Report 5.1
Comparison of four housing systems for non-lactating sows. G.B.C. Backus et al., February 1997.