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Evaluation of feed alternatives in replacement of blood plasma in piglet feed

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ABSTRACT

A total of 308 commercial barrows (21 days of age) from Duroc boars and YYLL sows arrived the same day at the CRSAD Swine Research Unit. Four dietary treatments were applied during nursery time, from 5.6 to 12.0 kg bodyweight (phases I and II) while during the 3rd nursery stage (12.0 to 23.9 kg), a common feed was offered to animals. Monitoring of growth performance was then made up to 28 days before slaughter i.e. until the final average live weight of 106.7 kg ± 9.1. The following ingredients were incorporated into the piglets' diet: A) Control with 5% porcine blood plasma in phase I; B) Concentrated hydrolyzed soy (21.7 and 0.78% in phases I and II); C) Egg powder and fish hydrolysate (5 and 2% in phases I and II according to a 65:35 ratio); D) Yeast cultures (3.5% and 2.5% in phases I and II). The following additives were also incorporated into feeds of treatments B, C and D: a butyrate source at the rates of 1.2 kg and 0.8 kg/tonne in phases I and II and an aroma and sweetener at the rate of 1 kg/tonne in phase I. These isoproteic and isoenergetic feeds were mainly composed of whey permeate, wheat, corn, soybean meal and were all containing various amounts of hydrolyzed soy concentrate. All feeds from phases I and II contained an acidifying agent, high zinc levels (2500-2000 ppm), vitamin E (85 IU/kg) as well as antibiotics. Fixed quantities of phase I and II feeds were fed to piglets. From 5.6 to 8.0 kg of weight, the speed of ingestion of piglets receiving porcine blood plasma (control) was faster than treatments containing different alternatives. Daily consumption was greater by 36.3 g/day on average for the control group compared to the other three treatments ($P<0.0001$) which, at the same time, improved ADG of these piglets by 51.6 g/day on average ($P=0.001$). In phase II (8.0 to 12.0 kg), piglets consumption ingesting the various feed alternative replacements was higher ($P=0.003$) than the one of controls. Withdrawal of blood plasma from phase II feed has reduced consumption of the control animals as well as their ADG (decrease of 52.5 and 58.7 g/day

compared to treatments B and C). At the end of the nursery stage (56 days of age), significant trends have emerged. Piglets from treatment B ended the nursery period with a weight backlog of -0.86 kg and -0.92 kg compared to the group of piglets in treatments A and C (*P*=0.12); in the nursery their ADG tended to be lower than piglets from treatments A and C (*P*=0.09). Moreover, serum haptoglobin content, an indicator of inflammatory response, was higher in piglets that consumed large amounts of soy protein (treatment B) (*P*=0.009). Beside this, the feeding cost per kg of gain is less expensive by $0.08/kg for these piglets compared to that of treatments C and D (*P*=0.05). As for the animals from the treatment C, they reached similar performance as that of control group, this trend continuing until the end of finishing period. Although the response in terms of performance for animals from treatment D was rather intermediary at nursery stage between that of animals of treatment B and that of the groups A and C, pigs tended to finish the growing/finishing period with lighter final weight (-3.72 kg) than animals in treatment C (*P*=0.09). The statistical trend, however, shows that their final weight is equal to that of the control pigs and those of treatment B (*P*=0.09). Twenty-nine percent of growing pigs treated with medication came from treatment D, and among mortalities during the finishing stage, 3 out of 4 pigs were from this treatment as well. According to the context in which this study was conducted, it can be said that it is possible to achieve good performance in piglets by replacing blood plasma in feed with other nutritional substitutes. The diet formulated with egg powder (Isonova), fish hydrolysate (CPSP Special G), a butyrate source (Proformix 650) and an aroma and sweetener (CrystalFruity feed) demonstrated the closest results to that of animals fed with the diet containing blood plasma.

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1. BACKGROUND

Since the end of April 2013, porcine epidemic diarrhea (PED) wreaks havoc with our southern neighbors. The virus is now found in many American states and it was estimated during summer of 2014 that the number of piglet deaths in the US because of the virus was 7 million heads. At that time, PED continued to grow in the US but the infection was limited in Canada to a few cases in Ontario, and isolated cases in Manitoba, Quebec and PEI. In February 2014, one case only was identified in Quebec. In February 2015, the count was of 74 cases in Ontario, 8 in Manitoba, 1 in PEI and 12 in Quebec, mainly in Montérégie (Cardinal, 2015). Although all members of the Quebec and Canadian hog industry work together to prevent the spread of the disease, the risk of contamination is still present. Several actions have been put in place to control this episode, including those to strengthen biosecurity measures at the farms, during transportation, while washing and disinfecting trucks, and stopping blood plasma inclusion in piglet's feeds. In fact, the active PED virus has been identified in blood plasma which would have prompted most Quebec millers to remove this ingredient from all piglets' feeds. In Quebec and elsewhere, porcine blood plasma is a popular ingredient and the positive impact in young piglets is known and documented. This protein source, highly digestible and palatable, is popular since it improves feed intake of young piglets and reduces post-weaning diarrhea which has a positive impact on growth performance. His replacement in feeds by other ingredients does not guarantee the same effect on intestinal health and performance of piglets. Therefore, it is imperative to look for one or more substitutes that have similar efficiency. Moreover, its replacement by other substitutes could help encourage not using by-products of porcine origin into swine feeds.

2. OBJECTIVE

2.1 Principal objective

Evaluating the impact of replacing porcine blood plasma in piglet feed by other feed alternatives.

2.2 Specific objectives

More specifically, the assay is designed to:

- Compare growth performance (ADG, ADFI, FCR) of nursery piglets that consumed porcine blood plasma based diet to those ingesting feeds containing various feed alternatives that could replace blood plasma;

- Verify the residual effect of treatments applied in the nursery on finishing performance (weight, ADG).

3. METHODOLOGY

3.1 Animals and experimental design

A total of 308 barrows progeny (21 days of age) from Duroc males and Landrace x Yorkshire sows were transferred on the same day (October 23rd, 2014) at the Swine Research Unit of the Animal Science Research Centre of Deschambault in Quebec (CRSAD). The piglets were from two PRRS negative sow barns. The animal phase was conducted from weaning (5.64 kg ± 0.60) up to 28 days before slaughtering, i.e. until live weight of 106.68 kg ± 9.09 (February 17, 2015). Once entered, the piglets were weighed, individually identified and allocated in pens according to the different treatments. In the nursery section, 44 pens of 7 piglets (0.26 m^2/head or 2.8 ft^2/head) were used for the trial. An experimental complete block design has been planned and the blocking factor was the starting piglets' weight. Eleven complete blocks of 4 experimental treatments (11 pens/treatment) were randomly distributed among the 44 pens in the nursery section. The pen represents the experimental unit. Thereafter, the animals were transferred to 19 finishing pens at the rate of 17 heads/pen (0.72 m^2/head or 7.8 ft^2/head) and distributed so as to mix the 4 treatments received in the nursery section among those planned for finishing. The objective was to verify the residual effect at finishing on weight and average daily gain (ADG), of treatments received at the nursery. Monitoring of finishing performance, from 23.98 up to 106.68 kg bodyweight has been done before starting another finishing project. The latter is a livestock management trial starting 28 days before slaughter.

3.2 Treatments

Four dietary treatments were applied in nursery, which are:

- *Treatment A (Control or Trt A)*: Feeds with porcine blood plasma;
- *Treatment B* (*Trt B*): Feeds with hydrolyzed soy concentrate, butyrate source, aroma & sweetener;
- *Treatment C* (*Trt C*): Feeds with egg powder, fish hydrolysate, butyrate source, aroma & sweetener;
- *Treatment D* (*Trt D*): Feeds with yeast cultures, butyrate source, aroma & sweetener.

Treatment with blood plasma was only offered during phase I, which is the current practice according to nutrition experts who were consulted. An analysis confirming the blood plasma to be free of PED virus (PED negative) has also been carried out before its utilization. As for replacement alternatives, they were selected following consultations with nutrition experts and suppliers. They were recommended during phases I and II, as proposed by the nutrition experts except for some products such as blood plasma and aroma & sweetener that were offered in phase I only. The egg powder and fish hydrolysate were used in feed in a ratio 65:35, as recommended by the supplier and a sufficient inclusion of vitamin E (85 IU/kg) was used as antioxidant. During the nursery third phase, the piglets were all given a common feed. In addition to highly digestible protein sources proposed to replace blood plasma (hydrolyzed soy concentrate, egg powder, fish hydrolysate and yeast cultures), it was considered necessary to incorporate additives such as butyrate as well as aromas and sweeteners (Table 1). The goal was to boost piglets feed consumption, stimulate enzyme secretion to improve feed digestibility, stimulate the intestinal villi growth and balance the intestinal flora (Betit K. and Y. Girard, personal communication, August 2014). Note that the various dietary treatments contained all varying amounts of hydrolyzed soy protein. Treatment B was the one that contained the most hydrolyzed soy protein as the objective was to evaluate its impact as an alternative in piglets (Table 1).

3.3 Feed formulation and processing

The nursery experimental feeds (similar protein and energy levels) were formulated based on digestible amino acids and net energy. They were manufactured at Gerard Soucy Mill (Ste-Croix, Quebec). The phases I and II medicated feeds were granulated while the phase III medicated feed was pelleted. Micro-tracers (iron filings) of different colors (Micro-Tracers Inc., San Francisco, USA) were added in the feed formulas at manufacturing to help differentiate the different treatments. Follow-up was done at the mill during manufacturing and feed samples were collected to verify compliance regarding desired nutrient concentrations. Tables 1 and 2 show the ingredients used in the nursery feeds as well as their nutritional concentrations. In the finishing section, no dietary treatment was applied. All animals consumed the commercial pelleted feeds from La Coop La Seigneurie (St-Narcisse, Quebec) and pigs were all kept in the same environment.

3.4 Medication

All nursery feeds contained antibiotics, which are 440 ppm chlortetracycline hydrochloride (Aureomycin 220G, Zoetis Canada, Kirkland, Quebec) and 31.2 ppm tiamulin (Denagard, Novartis Animal Health, Mississauga, Ontario). Incoming piglets received a 1 ml intramuscular injection of vaccines against *Mycoplasma Hyopneumoniae* (Ingelvac MycoFLEX, Boehringer Ingelheim Ltd., Burlington, Ontario) and porcine circovirus type 2 (Ingelvac Circoflex, Boehringer Ingelheim, Burlington, Ontario) causing the Porcine Circovirus Associated Disease (PCVAD) (formerly named Postweaning multisystemic wasting syndrome (PMWS)), while a 2 ml intramuscular injection of RESPISURE One vaccine (Zoetis Canada, Kirkland, Quebec) was administered 3 weeks after their arrival to prevent infections caused by *Mycoplasma Hyopneumoniae*.

At transfer time to finishing section, a vaccine was also offered in drinking water (Enterisol Ileitis FF, Boehringer Ingelheim Ltd., Burlington, Ontario) to prevent ileitis caused by *Lawsonia intracellularis*. The commercial feeds in early finishing period (24-40 kg) contained 440 ppm chlortetracycline hydrochloride (Chlor100, Bio Agri Mix, Mitchell, Ontario). From 40 kg until the end of trial period, 22 ppm tylosin (Tylan 40, Elanco, Guelph, Ontario) was incorporated into feeds as growth factor.

Table 1: Piglet feed composition

Ingredients (kg per tonne)	Phase I (5 to 8 kg)				Phase II (8 to 12 kg)				Phase III (12 to 25 kg)
	Plasma (control)	Trt B	Trt C	Trt D	Plasma (control)	Trt B	Trt C	Trt D	
Whey permeate	217.39	217.39	217.39	217,39	86.96	86.96	86.96	86.96	-
Corn	185.57	121.22	149.97	113,38	304.06	302.64	314.14	297.05	460.83
Wheat	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
Soybean meal	150.00	150.00	150.00	150.00	250.00	250.00	250.00	250.00	273.24
Corn-Soy oil (50 : 50)	48.73	54.58	41.41	55.92	40.99	41.45	36.18	42.41	25.72
Hydrolysed soy concentrated [1]	113.82	**217.08**	152.20	188.55	78.07	**78.23**	52.28	57.85	-
Porcine blood plasma [2]	**50.00**	-	-	-	-			-	--
Egg powder [3]	-	-	**32.50**		-	-	**13.00**	-	-
Fish hydrolysate [4]	-	-	**17.50**		-	-	**7.00**	-	-
Yeast cultures [5]	-	-	-	**35.00**	-	-	-	**25.00**	-
Concentrated calcium butyrate [6]	-	**1.20**	**1.20**	**1.20**	-	**0.80**	**0.80**	**0.80**	-
Aroma, sweetener [7]	-	**1.00**	**1.00**	**1.00**	-	-	-	-	-
Biolys 70	5.82	6.16	6.18	6.01	6.25	6.24	6.25	6.14	6.34
DL-Methionine	2.17	2.47	2.06	2.56	1.95	1.95	1.79	2.02	1.46
L-Threonine	1.31	1.55	1.59	1.46	1.49	1.49	1.51	1.43	1.52
L-Tryptophan	0.23	0.18	0.26	0.22	0.14	0.14	0.17	0.17	0.23
Limestone	9.80	8.63	9.03	8.65	9.73	9.73	9.90	9.75	11.74
Monocalcium phosphate	3.48	4.84	4.44	4.95	7.39	7.40	7.24	7.47	7.28
Salt	-	2.04	1.61	2.04	2.48	2.48	2.31	2.49	4.58

Table 1: Piglet feed composition (continued)

Ingredients (kg per tonne)	Phase I (5 to 8 kg)				Phase II (8 to 12 kg)				Phase III (12 to 25 kg)
	Plasma (control)	Trt B	Trt C	Trt D	Plasma (control)	Trt B	TrtC	Trt D	
Acidifier [8]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
Zinc oxide	3.12	3.11	3.11	3.11	2.42	2.42	2.43	2.43	-
Choline chloride	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.50
Premix - vitamins and micro-minerals	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Phytase 750 FTU [9]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Aureomycin 220G [10]	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Denagard [11]	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75

[1] HP-300 (distributed by Jefo Nutrition Inc., St-Hyacinthe, Québec)

[2] AP-920 (distributed by Jefo Nutrition Inc., St-Hyacinthe, Québec)

[3] Isonova™ Spray-Dried Granulated Inedible Egg Product (distributed by Premier AG Resources, London, Ontario)

[4] CPSP Special G (distributed by Premier AG Resources, London, Ontario)

[5] PFS (distributed by Probiotech International, St-Hyacinthe, Québec)

[6] Proformix 650 (distributed by Probiotech International, St-Hyacinthe, Québec)

[7] Crystal feed fruity (distributed by Probiotech International, St-Hyacinthe, Québec)

[8] Porcinat+ (distributed by Jefo Nutrition Inc., St-Hyacinthe, Québec)

[9] Phyzyme® XP 2500 TPT (Halchemix Canada, Port Perry, Ontario)

[10] 440 ppm of chlortetracycline hydrochloride

[11] 31.2 ppm of tiamulin

Table 2: Piglet feed nutritional values concentration (as fed)

	Phase I (5 à 8 kg)				Phase II (8 à 12 kg)				Phase III (12 to 25 kg)
Chemical analyses and theorical values	Plasma (control)	Trt B	Trt C	Trt D	Plasma (control)	Trt B	Trt C	Trt D	
Dry matter (%)	90.90	91.80	91.70	91.50	91.00	91.30	90.80	91.10	90.00
Crude protein (%)	24.31	24.70	24.14	25.04	23.16	22.43	23.49	22.58	19.88
Crude fat (%)	5.90	6.37	6.77	5.80	5.44	5.78	5.79	5.53	4.57
Crude lysine (dig.) (%)[1]	1.71 (1.55)	1.57 (1.43)	1.56 (1.43)	1.63 (1.48)	1.55 (1.42)	1.51 (1.38)	1.64 (1.50)	1.49 (1.36)	1.39 (1.27)
Crude Methionine (dig.) (%)[1]	0.48 (0.45)	0.56 (0.53)	0.56 (0.53)	0.56 0.53)	0.49 (0.46)	0.50 (0.47)	0.48 (0.45)	0.52 (0.49)	0.41 (0.38)
Crude Meth+Cystine (dig.) (%)[1]	0.91 (0.82)	0.92 (0.83)	0.92 (0.83)	0.93 (0.84)	0.85 (0.77)	0.85 (0.77)	0.84 (0.76)	0.86 (0.78)	0.74 (0.67)
Crude threonine (dig.) (%)[1]	1.03 (0.90)	1.04 (0.91)	1.00 (0.88)	1.06 (0.93)	0.96 (0.85)	0.95 (0.84)	0.97 (0.86)	0.98 (0.87)	0.85 (0.76)
Crude tryptophane (dig.) (%)[1]	0. 33 (0.29)	0.32 (0.28)	0.31 (0.28)	0.33 (0.29)	0.30 (0.26)	0.29 (0.26)	0.30 (0.26)	0.29 (0.26)	0.26 (0.23)
Valine (%)[1]	1.13 (0.99)	1.12 (0.98)	1.10 (0.97)	1.15 (1.00)	1.06 (0.93)	1.03 (0.90	1.08 (0.95)	1.00 (0.88)	0.90 (0.79)
Isoleucine (%)[1]	0.95 (0.84)	1.03 (0.91)	1.00 (0.89)	1.06 (0.94)	0.96 (0.86)	0.93 (0.83)	0.97 (0.87)	0.90 (0.80)	0.80 (0.71)
Arginine (%)[1]	1.50 (1.37)	1.64 (1.51)	1.53 (1.41)	1.61 (1.48)	1.52 (1.41)	1.48 (1.37)	1.52 (1.41)	1.39 (1.29)	1.28 (1.19)
Glutamic acid (%)[1]	4.22	4.40	4.18	4.41	4.23	4.21	4.28	4.07	3.77
Calcium (%)	0.70	0.90	0.93	0.79	0.80	0.90	0.77	0.88	0.90
Phosphorus total (%)	0.69	0.65	0.66	0.69	0.67	0.69	0.67	0.67	0.55
Sodium (%)	0.30	0.29	0.29	0.25	0.20	0.19	0.21	0.20	0.32
Zinc (ppm)[2]	2 500	2 500	2 500	2 500	2 000	2 000	2 000	2 000	250
Copper (ppm)[2]	125	125	125	125	125	125	125	125	125
Lactose (%)[2]	17.5	17.5	17.5	17.5	7.0	7.0	7.0	7.0	-

Table 2: Piglet feed nutritional values concentration (as fed) (continued)

	Phase I (5 à 8 kg)				Phase II (8 à 12 kg)				Phase III (12 to 25 kg)
Chemical analyzes and theorical values	**Plasma (control)**	**Trt B**	**Trt C**	**Trt D**	**Plasma (control)**	**Trt B**	**Trt C**	**Trt D**	
Gross energy (GE; kcal/kg)[3]	4 159	4 182	4 194	4 155	4 178	4 146	4 213	4 176	4 085
Digestible energy (DE; kcal/kg)[4]	3 846	3 878	3872	3 858	3 835	3 851	3 832	3 834	3 786
Net energy (NE; kcal/kg)[2]	2 650	2 650	2 650	2 650	2 550	2 550	2 550	2 550	2 475
Digestible lysine / NE ratio[2]	5.47	5.47	5.47	5.47	5.25	5.25	5.25	5.25	4.85
Vitamin A (UI/kg)[2]	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Vitamin D (UI/kg)[2]	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Vitamin E (UI/kg)[2]	85	85	85	85	85	85	85	85	85

[1] Total amino acids (digestible). Total amino acids were chemically analyzed while digestible amino acids (SID) were calculated by considering the total amino acid analyzed and the conversion factors proposed by the formulation system.

[2] Values proposed by the formulation system.

[3] Analyzed from a bomb calorimeter

[4] Calculated from chemical analyzes of various components (CP, CF, NDF, ash) and a predictive equation proposed by Le Goff and Noblet (2001).

3.5 Feeding program

According to the program proposed for phases I and II, fixed quantities of feed were offered to each of the pens, as each of them was the experimental unit (Table 3). The feed was weighed beforehand, incorporated in an airtight container and placed in front of the pen (ex.: 7 heads/pen x 2.5 kg/head of phase I = 17.5 kg per pen; 7 heads/pen x 5 kg/head of phase II = 35 kg per pen). The change of feed for phases I and II was made when the amount of pre-weighed feed was consumed which means that depending on the piglets speed of ingestion, changes of feeds for each of the pens were not occurring all at the same time. However, the quantities of phase III served were weighed daily and offered *ad libitum*. The nursery section trial started (October 23rd, 2014) and ended the same day for all animals (November 27, 2014).

Table 3: Nursery feeding program

Phases	Weights, kg	Quantity offered, kg
I	5-8	2.5
II	8-12	5
III	12-25	~18

In finishing section, no feed treatment was applied. The feeding program included 4 phases (IV: 24-40 kg, V: 40-65 kg, VI: 65-90 kg, VII: 90-140 kg) and feeds were served *ad libitum*.

3.6 Nursery environmental conditions

The average nursery temperatures were 23.5 °C with minimum and maximum of 22.9 °C and 24.1°C.

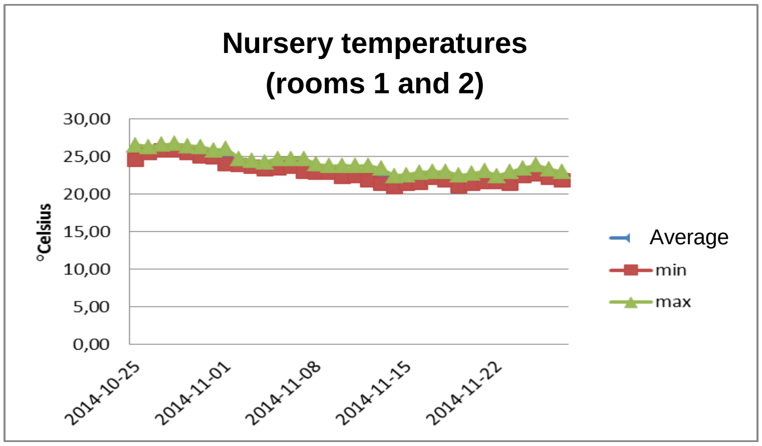

Figure 1: Average temperatures in the nursery

3.7 Measurements

The piglets were all individually weighed on the same day at the entrance of the nursery and at the end of this period (phase III). Intermediate weighing (end of phases I and II) were also carried out at the feed changes, but at various times depending on the pen. As described above, fixed quantities of feeds from phases I and II were weighed and provided to each pen. The phase changes varied from one pen to another according to the piglet's speed of ingestion. The date and time of change were noted for each pen. During phase III, the amounts served per pen were weighed and recorded every day as well as the feed refusal at the end of each week and at the end of the nursery period. Average daily gain, daily feed intake and feed:gain ratio were calculated by phase and pen for the entire duration of the nursery period.

The water meter readings were recorded for each pen at the entrance, at the end of phases I and II and then every 7 day period. Daily water consumption of each pen was therefore calculated.

Blood samples (10 ml/head) were also carried out at the end of phase II i.e. at 12.0 kg live weight. Two piglets per pen were sampled. A serum pool per pen was then performed for analysis (44 serum pools). Serum immunoglobulin G (IgG), hormone IGF-1 and haptoglobin were then measured to verify the immune (IgG), inflammatory (haptoglobin) and anabolic (IGF-1) status of piglets subject to the different treatments.

During the finishing period, all pigs were individually weighed on transfer day to the finishing section, at each feed change and at the end of the trial which took place February 17, 2015 at the weight of 106.68 kg. Measurements of fat and muscle thicknesses were also done with an ultrasound device between the 3rd and 4th last ribs of the live animal at final weighing.

3.8 Mortality and removal

From the beginning of the nursery period (phase I), 2 piglets of treatments B and C died from unknown reasons, which corresponds to 0.6% mortality in the nursery. Only one pen was treated for diarrhea (treatment C) for a short period of time at the beginning of nursery stage. Note that all piglets received antibiotics through the feed, 2500-2000 ppm of zinc and an acidifier during phases I and II. During the finishing period, 1 pig from treatment B and 3 animals from treatment D died, which corresponds to 1.2% mortality. A case of prolapse (Treatment B), 2 cases of lameness (treatment D) and an unknown death (treatment D) were recorded.

3.9 Feed sampling

Every day during the nursery period, a 250 g feed sample was taken. A homogeneous pool was formed at the end of each phase and sent to different laboratories for chemical analysis. Dry matter, fat, crude protein, gross energy, NDF and ash were analyzed as well as total amino acids. Results are found in Table 2.

3.10 Statistical analyses

Statistical analyses were performed using software R (R Core Team, 2012), based on a complete block design for the nursery period data, whereas those of the finishing period, they were conducted in a completely randomized design.

Experimental units for animal performance data in the nursery were pens for the following variables: feed and water consumption, feed:gain ratio, lysine ingested/head/day, ingested lysine/kg gain and cost of feed/kg gain. Analyses were performed using ANOVA with a mixed model including statistical treatments and blocks (based on the piglets' original weight) as explanatory variables. Regarding the finishing period data analysis (weight, average daily gain, fat and muscle thicknesses) as well as nursery weights and ADG, only individual data were considered. For these data, the animal was considered as the experimental unit and analyses were performed using ANOVA with a statistical model including treatment as explanatory variables. Tukey test was used for all data to perform comparisons between treatments.

The data presented in this report are adjusted means ("least square means"). A covariate (final weight) was applied to the backfat and muscle thicknesses measured at the end of the animal phase.

4. RESULTS AND DISCUSSION

During phase I (5.6 to 8.0 kg), excellent performance is observed among all piglets and water consumption is recorded within standards and similar between animals of different treatments. However, the speed of ingestion of piglets receiving porcine blood plasma (control) is faster than the other treatments (Table 4). This effect can be observed by the daily feed intake which is higher by 36.3 g on average for the control group compared to the other three treatments (*P* <0.0001). The fixed amount of 2.5 kg per head, offered in phase I, was consumed in 8.10 days for treatment with blood plasma while it was 9.45, 9.25 and 9.28 days for treatments B, C and D, respectively, which contained replacement alternatives to blood plasma. Therefore, control piglets showed a higher growth rate (51.6 grams per day on average) than piglets from other treatments (*P*=0.001), while feed:gain ratio was similar between all animals. Control animals consumed each day more crude or digestible lysine than other piglets (Table 4). Some authors report an effect of blood plasma on feed consumption and growth rate without seeing modification on the feed efficiency (Van Dijk et al., 2001). It is during the 2 first post-weaning weeks, with a more pronounced effect during the 1st week that blood plasma influence was felt (Van Dijk et al., 2001). One characteristic of this ingredient is to improve feed palatability and stimulate feed intake by piglets (Kats et al., 1994; Coffey and Cromwell, 2001; Van Dijk et al., 2001). Being an animal protein, more digestible than vegetable ones (Everts et al., 1999), and because of its amino acid composition and digestibility is close to that of sow's milk, plasma allows to stimulate piglets growth (Darragh and Moughan, 1998). During this same period, however, it was noted that piglets from treatment B, which feed contained as alternatives hydrolyzed soy protein, a butyrate source and aromas & sweeteners, showed a lower feed cost of $0.05 to $0.06/kg compared to treatments A and C, respectively (*P*=0.001).

In phase II (8.0 to 12.0 kg), the daily feed intake of the piglets consuming different replacement alternatives was similar among themselves, but higher than the control ones (*P*= 0.003). It was also observed that consumption time was shorter for piglets from treatments B, C and D than the control ones (Table 4). It was therefore observed a decrease in ADG of 52.5 and 58.7 g/day of the control piglets compared to the animals from treatments B and C (P=0.005). As seen commercially, the removal of blood plasma from the phase II diet (8.0-12.0 kg) causes a decrease in piglets feed intake (Bussières D., personal communication, November 2014).

When combining data from phases I and II, periods when the dietary treatments were offered, statistical differences between treatments disappear (Table 4). However, treatment B, in which is offered as alternative, hydrolyzed soy protein, a butyrate source and aromas & sweeteners, demonstrates a lower feed cost per kg of gain of $0.09/kg compared to the alternatives of treatments C and D ($1.60 vs. $1.69/kg gain) ($P$=0.05). The feed costs during this period were respectively of $5.52, $5.34, $5.61 and $5.54 per piglet for treatments A, B, C and D, or $0.18, $0.27, and $0.20 less per head for piglets from treatment B compared to the ones in groups A, C and D. In the third nursery period (Table 4), only the piglets from treatment C stand out from those of treatment B by a statistically higher average daily gain of 41.9 g/day (P=0.02). No difference between the 4 piglet groups appears at any time regarding the feed:gain ratio.

Considering the overall nursery period (5.6 to 23.9 kg), it is observed that the piglet performance is excellent, regardless of treatment. Although the results are not all significant, non-negligible trends and numerical differences are detectable between treatments. During the nursery period, the response of the piglets from treatment C (egg powder, fish hydrolysate, butyrate source, aroma & sweetener) is similar to that of the treatment with blood plasma in terms of final weight, average daily gain, daily feed intake, lysine and water consumption. Regarding piglets which consumed the alternatives of treatment D (yeast cultures, butyrate source, aroma & sweetener), they have a rather intermediate performance response lying in between treatments A and C piglets and the treatment B ones. Their weight at the end of the nursery period is close to that of treatment B (P=0.12) while the ADG of these piglets tends to be similar to that of piglets from treatments A and C at the end of the period (P=0.09). Concerning piglets from treatment B, these animals finished the nursery period with a backlog in weight. This gap is of -0.86 and -0.92 kg of weight compared to the piglets control group and those of treatment C (*P*=0.12); their ADG tends to be lower than that of treatments A (plasma) and C (egg powder, fish hydrolysate, butyrate source, aroma & sweetener). The downward trend of the ADG in treatment B was -24.5 and -25.4 g/d (*P*=0.09) compared to the treatments A and C in nursery. According to Skinner et al. (2014), a simple diet containing mainly soybean meal, corn and wheat (70-80% of the diet) would have the effect of reducing the average daily gain and feed efficiency of piglets in nursery compared with a complex diet containing blood protein, whey, digestible starch, oatmeal and barley. Consumption of large quantities of soybean meal (24, 34 and 37% for phases I, II and III, respectively) would have caused, according to these authors, an allergic reaction, initiated an immune response which would have altered the piglets condition (Skinner et al., 2014). In our study, the feed for the treatment B in the phase I contained 15% soybean meal and 21.7% hydrolyzed soy, however, the latter is a more digestible protein source than soybean meal (Cervantes-Pahm and Stein, 2014). In addition, serum haptoglobin content, an inflammatory response indicator, is higher in piglets that consumed large proportion of soy (soybean meal and hydrolyzed soy) (treatment B) (Table 5). Despite the high zinc content of phase I and II feeds (2500 and 2000 ppm), the highest concentration of haptoglobin in piglets' blood from the treatment B suggests that inflammation was stimulated and is probably associated with a higher level of vegetable protein ingestion. Vegetable protein is basically less digestible than animal protein (Pluske, 2012). Although the feed:gain ratio of the treatment B animals has not deteriorated in this study, this could have slowed down these piglets growth rate. However, according to the haptoglobin and IGF-1 levels observed in the literature, the observed inflammatory status in piglets would not have deteriorated. During inflammation, the amount of IGF-1 drop (Willing et al.2013), which is not the case in this study, and haptoglobin levels can reach concentrations of 1,010 µg/ml during inflammation (Floch et al., 2006). According to Piñeiro et al. (2009), concentrations of 580, 850 and 1420 µg/ml are observed in piglet reared in commercial conditions on days 7, 35 and 63 post-weaning. According to the progression of the haptoglobin levels observed by Sauerwein et al. (2005), a peak of 575-800 µg/ml would occur at 7-14 days post-weaning (34-44 days of age) and then decrease to values of 405-410 µg/ml on day 21 post-weaning (48-51 days of age). Piglets from treatment B had 38.3 days of age (17.3 days post weaning) at the end of the phase of treatments while the average content observed in serum (269.32 µg/ml) did not reach the levels reported by these authors. The combination of soy protein with a butyrate source and an aroma & sweetener probably reduced the inflammation effect. According to the supplier, the butyrate source used would stimulate intestinal villi growth and balance the piglet's intestinal flora (Betit K. and Y. Girard, personal communication, August 2014). It would stimulate digestive enzymes secretion, improve nutrient digestibility in addition to playing a role in tissues development and repair (Guilloteau et al., 2010). As for the aroma & sweetener used, it would have the characteristic of stimulating feed intake possibly through a similar effect like glutamate, such as that found in plasma (Betit K. and Y. Girard, personal communication, August 2014). Glutamine can increase intestinal cells proliferation by improving mucous membranes recovery (Willing et al., 2013). Glutamate and glutamine are important metabolic fuels that allow the small intestine to maintain its digestive function and protect the integrity of the intestinal mucosa (Wu, 2015). Besides the effect of treatment B on inflammatory response, the feeding cost per kg of gain for this treatment was less expensive ($ -0.08/kg) than treatments C and D (P=0.05). The feeding cost for the nursery period was $12.89, $12.11, $12.93 and $12.65 per piglet for treatments A, B, C and D, respectively or $0.78, $0.82 and $0.54 less per head for animals from the treatment B compared with groups A, C and D.

Regarding the immunoglobulins G (IgG) contents, the results show that regardless of dietary treatment, the serum concentrations of IgG are the same among the four piglet groups (Table 5). According to Remus et al. (2013), the piglet immune system would not be mature until at least 35 days old and it would slowly develop from the 21st day of age (Coffey, 2001) while Rooke et al. (2003) indicate that endogenous immunoglobulin synthesis would start between 7 and 28 days of age. The beginning of the endogenous synthesis would be variable depending on the amount of colostrum absorbed by piglets in the first 24 hours of life (Rooke et al., 2003). Being immunologically limited, young piglets can get protection from pathogens through contributions of colostrum and of immune-stimulatory feed components, acting at the intestine level. Blood plasma contains IgG and bioactive substances (Torrallardona, 2010) that can improve piglet's immunological ability (Coffey and Cromwell, 1995; Coffey, 2001). Because of its properties, plasma would prevent pathogens attachment to piglet's intestinal mucosa due to its immunoglobulins and glycoproteins content (Van Dijk et al., 2001). By preventing bacteria attachment to piglet's intestine, this would reduce the immune system activation and pro-inflammatory cytokines production (Torrallardona, 2010). In this study, at 17 days post-weaning (38 days of age), period when the samples were collected, the piglets' immune system might have been mature enough to maintain immunoglobulins production. The sampling time and a lower immune system stimulation because of the good sanitary status of the livestock could explain the observed concentrations.

Table 4: Piglet growth performance in nursery section[1,2]

	TREATMENTS					
Phase I (5-8 kg)	**Plasma (control)**	**Trt B**	**Trt C**	**Trt D**	**Standard Error**	***P***
ADG (g/head/day)	**367.73 b**	313.39 a	320.21 a	317.74 a	10.89	**0.001**
Feed : gain ratio	0.83	0.84	0.84	0.85	0.01	0.76
Daily feed intake (g/head/day)	**302.55 b**	263.09 a	268.18 a	267.45 a	5.20	**< 0.0001**
Crude Lysine (SID) (g/head/j) [3]	**5.17 b (4.69)**	4.13 a (3.76)	4.18 a (3.83)	4.36 a (3.96)	0.08	**< 0.0001**
g Crude Lysine (SID) / kg gain [3]	**14.10 b (12.78)**	**13.22 a (12.04)**	**13.14 a (12.05)**	13.78 ab (12.51)	0.24 (0.22)	**0.02 (0.05)**
$ Feed / kg gain	**0.83 b**	**0.77 a**	**0.82 b**	0.80 ab	0.01	**0.001**
Water consumption (l/head/day)	1.02	0.90	1.02	1.08	0.07	0.31
Duration (days)	8.10	9.45	9.26	9.28	-	-
Phase II (8-12 kg)						
ADG (g/head/day)	**427.78 b**	**480.32 a**	**486.46 a**	463.52 ab	12.52	**0.005**
Feed : gain ratio	1.38	1.35	1.36	1.39	0.04	0.91
Daily feed intake(g/head/day)	**586.45 b**	641.00 a	653.91 a	637.18 a	12.71	**0.003**
Crude Lysine (SID) (g/head/day) [3]	9.09 a (8.33)	9.68 a (8.85)	**10.73 b (9.81)**	9.49 a (8.66)	0.20 (0.18)	**< 0.0001**
g Crude Lysine (SID) / kg gain[3]	21.39 (19.59)	**20.44 (18.68)**	**22.33 (20.42)**	20.65 (18.85)	0.56 (0.51)	0.09 t (0.08 t)
$ Feed / kg gain	0.84	0.83	0.87	0.89	0.02	0.26
Water consumption (l/head/day)	2.20	2.20	2.27	2.24	0.16	0.98
Duration (days)	8.55	7.84	7.69	7.85	-	-

Table 4: Piglet growth performance in nursery section[1,2] (continued)

	TREATMENTS					
Phase III (12-24 kg)	**Plasma (control)**	**Trt B**	**Trt C**	**Trt D**	**Standard Error**	***P***
ADG (g/head/day)	668.12 ab	**636.64 a**	**678.54 b**	657.55 ab	9.73	**0.02**
Feed : gain ratio	1.47	1.49	1.46	1.48	0.02	0.71
Daily feed intake (g/head/day)	983.45	947.73	992.09	973.36	15.91	0.24
Crude Lysine (SID) (g/head/day) [3]	13.67 (12.49)	13.17 (12.04)	13.79 (12.60)	13.53 (12.36)	0.22 (0.20)	0.24
g Crude Lysine (SID) / kg gain[3]	20.50 (18.73)	20.71 (18.92)	20.35 (18.60)	20.63 (18.85)	0.23 (0.21)	0.71
$ Feed / kg gain	0.61	0.62	0.61	0.61	0.01	0.59
Water consumption (l/head/day)	3.71	3.17	3.77	3.40	0.25	0.31
Duration (day)	18.07	17.43	17.77	17.58	-	-
Phases I and II (5-12 kg)						
ADG (g/head/day)	397.58	388.95	392.83	384.26	9.54	0.79
Feed : gain ratio	1.13	1.12	1.13	1.14	0.02	0.90
Daily feed intake (g/head/day)	447.55	433.27	441.09	436.73	5.57	0.31
$ Feed / kg gain	1.68 ab	**1.60 a**	**1.69 b**	**1.69 b**	0.03	**0.05**
Duration (day)	16.65	17.29	16.95	17.13	-	-
Phases I, II and III (5-24 kg)						
Initial weight (kg)	5.63	5.63	5.66	5.65	0.07	0.99
Final weight (kg)	24.31	23.45	24.37	23.79	0.31	0.12
ADG (g/head/day)	**537.95**	**513.42**	**538.82**	522.68	8.32	**0.09 t**
Feed : gain ratio	1.35	1.35	1.34	1.36	0.01	0.78
Daily feed intake (g/head/day)	726.65	691.36	723.36	708.73	11.88	0.16

Table 4: Piglet growth performance in nursery section[1,2] (continued)

	TREATMENTS					
Phases I, II et III (5-24 kg)	**Plasma (control)**	**Trt B**	**Trt C**	**Trt D**	**Standard Error**	***P***
Crude Lysine (SID) (g/head/day) [3]	**10.55 b (9.64)**	**9.91 a (9.05)**	**10.54 b (9.63)**	10.17 ab (9.28)	0.16 (0.15)	**0.02**
g crude Lysine (SID) / kg gain [3]	19.62 (17.92)	19.34 (17.67)	19.57 (17.89)	19.46 (17.77)	0.13 (0.12)	0.45 (0.42)
$ Feed / kg gain	2.29 ab	**2.22 a**	**2.30 b**	**2.30 b**	0.02	**0.05**
Water consumption (l/head/day)	2.71	2.34	2.75	2.52	0.16	0.27
Duration (day)	34.72	34.72	34.72	34.72	-	-

[1] Least square means. The values on the same line with different letters are significantly different (P≤ 0.05).

[2] n=11 per treatment for feed:gain ratio, daily feed intake, daily crude lysine (SID) ingested per head, crude lysine (SID) ingested per kg of gain, cost of feed per kg of gain, daily water consumption per head. For weight and ADG at beginning, n=77 for each treatment whereas at the end of nursery period, n=77, 76, 76, 77 for treatments A, B, C and D.

[3] Total lysine (digestible lysine)

Table 5: Blood concentration parameters at the end of phase II[1]

	TREATMENTS (n=10 per treatment)					
	Plasma (control)	**Trt B**	**Trt C**	**Trt D**	**Standard Error**	***P***
Immunoglobulins G (mg/ml)	3.96	4.34	3.86	4.05	0.42	0.87
IGF-1 (ng/ml) [2]	206.80	221.20	243.69	220.84	14.18	0.34
Haptoglobin (µg/ml)	91.55 b	**269.32 a**	64.36 b	74.82 b	46.64	**0.009**

[1] Least square means. The values on the same line with different letters are significantly different (P≤ 0.05).

[2] «Insulin like growth factor-1»

According to the finishing period monitoring, we note that regardless the feed treatment applied in the nursery, weights and ADG are excellent (Table 6). It was observed that the response of pigs, that consumed the feeds of the treatment C (egg powder, fish hydrolysate, butyrate source, aroma & sweetener) during phases I and II in the nursery, is similar at finishing to that of the control group with blood plasma. The treatment C effect observed in the nursery was therefore maintained at finishing. Despite the animals from treatment B show a backlog concerning ADG and weight (P=0.09 and P=0.12, respectively) at the end of the nursery period, they remained the same weight as those of treatments A and C during finishing and those of treatment D as well (phase IV, V and VII; P=0.06, P=0.07 and P=0.09, respectively). In phase VI, the effect on weight is significant at the end of the phase (P=0.03). Although the response in terms of performance for the animals from treatment D (yeast cultures, butyrate source, aroma & sweetener) was rather intermediary between that of the animals from treatment B and of the groups A and C in the nursery, these pigs tended to reach a lighter final weight (-3.72 kg) than the animals from treatment C (egg powder, fish hydrolysate, butyrate source, aroma & sweetener). The statistical trend (P=0.09), however, shows that their final weight is equal to that of the control pigs and those of treatment B (Table 6) and that no significant difference stands out between treatments for ADG at finishing. Among pigs treated with medication at finishing, it is observed that 29% were from treatment D and that 3 of 4 pigs that died during the finishing period were from treatment D. Despite the fact that all pigs consumed the same feeds during the finishing period, consumption and feed:gain ratio of these animals could not be analyzed during that period. The redistribution of animals' pens for the management trial scheduled at the end of the finishing period being the reason. It is therefore difficult to establish a link between this effect and feed consumption. No particular management factor during finishing can explain the observed performance for the treatment D.

Finally, pigs reached final weight with backfat thicknesses differences. Indeed, pigs from treatment D completed the trial with less backfat than those of treatment B and with a loin muscle thickness similar to that of other treatments. It should be noted that backfat and muscle thicknesses measured in this study, as well as the final weights of pigs do not match with data collected at slaughter (carcass weight, fat and muscle thicknesses measured with Destron probe). The data for this project are a performance overview at the end of finishing which does not allow direct correlation with income from sale of carcasses.

However, it is interesting to do the exercise to evaluate the return on investment by establishing certain assumptions. Considering the deviations from the control group in terms of feed costs in the nursery and carcass weight, estimated economic return on investment was calculated (Tables 7 and 8). The assumption is that the gap between the final weights of the different alternatives (B, C and D) and control (A) remains the same on the carcass weight and that the resulting index stays the same regardless of treatment. For the animals from treatment C, despite the extra feed cost of $0.04/head at nursery than feeds with blood plasma, the carcass weight gain (0.88 kg) of these pigs would allow a return on investment amounting to $1.45/head (depending on pool prices observed between January and May 2015). In 2014, return on investment would have been $2.03/pig (Table 8). As for alternatives B and D, despite lower feed costs in the nursery ($-0.78 and $-0.24/head for treatments B and D, respectively) than the control group with plasma, a loss of $0.44 and $3.30/head could be recorded for these two respective treatments. Their final live weights were lower than the control pigs (-0.72 and -2.10 kg of carcass weight, respectively). In 2014 this revenue loss could have been $0.91 and $4.68/head, respectively (Table 8).

For information purposes, it is important to note that these estimates were made from numerical values by omitting the statistical differences obtained and that a fixed index of 110.73 was considered regardless of treatment. Only nursery feed costs were considered in these calculations. Those at finishing were not held into account based on the assumption that the finishing feed consumption was similar between the 4 pig groups.

Table 6: Pig growth performance in finishing section[1]

	TREATMENTS					
Phase IV (24-40 kg)	**Plasma (control)** (n=77)	**Trt B** (n=74	**Trt C** (n=76)	**Trt D** (n=76)	**Standard Error**	***P***
Initial weight (kg) [2]	24.31	23.65	24.37	23.67	0.30	0.17
Final weight (kg)	**38.88**	37.77	**38.82**	**37.45**	0.46	**0.06 t**
ADG (g/head/day)	**0.767**	0.743	0.761	**0.725**	13.10	**0.10 t**
Duration (days)	19	19	19	19	-	**-**
Phase V (40-65 kg)	(n=77)	(n=73)	(n=76)	(n=76)		
Initial weight (kg)	**38.88**	37.77	**38.82**	**37.45**	0.46	**0.06 t**
Final weight (kg)	**66.30**	64.83	**66.03**	**63.96**	0.70	**0.07 t**
ADG (g/head/day)	1.10	1.08	1.09	1.06	15.54	0.41
Duration (days)	25	25	25	25	-	-
Phase VI (65-90 kg)	(n=77)	(n=73)	(n=76)	(n=75)		
Initial weight (kg)	**66.30**	64.83	**66.03**	**63.96**	0.70	**0.07 t**
Final weight (kg)	**91.59 a**	89.88 ab	**91.83 a**	**88.39 b**	0.92	**0.03**
ADG (g/head/day)	1.05	1.04	1.07	1.02	16.74	0.17
Duration (days)	24	24	24	24	-	-
Phase VII (90-107 kg)	(n=77)	(n=73)	(n=76)	(n=73)		
Initial weight (kg)	**91.59 a**	89.88 ab	**91.83 a**	**88.39 b**	0.92	**0.03**
Final weight(kg)	107.08	106.18	**108.18**	**104.46**	1.06	**0.09 t**
ADG (g/head/day)	1.11	1.16	1.17	1.15	24.47	0.25
Duration (days)	14	14	14	14	-	-

Table 6: Pig growth performance in finishing section[1] (continued)

Overall period (24-107 kg)	Plasma (control) (n=77)	Trt B (n=73)	Trt C (n=76)	Trt D (n=73)	Standard Error	*P*
Initial weight (kg)	24.31	23.65	24.37	23.67	0.30	0.17
Final weight (kg)	107.08	106.18	**108.18**	**104.46**	1.02	**0.09 t**
ADG (g/head/day)	1.01	1.01	1.02	0.986	11.22	0.16
Duration (days)	82	82	82	82	-	-

[1]Least square means. The values on the same line with different letters are significantly different (P≤ 0.05).
[2]Some initial weights in phase IV are not quite identical to those at the end of nursery (phase III – Table 4) since piglets were not all retained in the allocation made at transfer to the finishing section for the management trial starting at the end of the finishing period.

Table 7: Measurements of muscle and fat thicknesses on live animal[1]

	TREATMENTS					
	Plasma (control) (n=77)	Trt B (n=73)	Trt C (n=76)	Trt D (n=73)	Standard Error	*P*
Final weight(kg)	107.08 ab	106.18 ab	**108.18 a**	**104.46 b**	1.02	**0.09 t**
Fat thicknesses (mm) [2]	16.13 ab	**17.05 a**	16.38 ab	**15.51 b**	0.37	**0.002**
Muscle thicknesses (mm) [2]	61.67	60.66	61.14	61.97	0.42	0.17

[1]Least square means. The values on the same line with different letters are significantly different (P≤ 0.05).
[2] Final weight was the covariable used.

Table 8: Estimated monetary return on investment in 2015 ($/pig)

Replacement alternatives		B	C	D
Cumulative pool price in 2015 (index 110.73)[1]		152.58		
Carcass deviation compared to control (kg/head)[2,3]		-0.72	+0.88	-2.10
Feeding cost deviation compared to control ($/head)[4]		-0.78	+0.04	-0.24
Carcass weight deviation compared to control (kg)[3]	**-2.10**	-2.76	-3.58	**-3.30**
	-1.60	-1.92	-2.74	-2.46
	-1.20	-1.25	-2.07	-1.79
	-0.72	**-0.44**	-1.26	-0.98
	-0.46	0.00	-0.82	-0.55
	-0.24	0.37	-0.45	-0.16
	-0.14	0.54	-0.28	0.00
	0.00	0.78	-0.04	0.24
	0.02	0.82	0.00	0.28
	0.40	1.46	0.64	0.92
	0.80	2.13	1.31	1.59
	0.88	2.27	**1.45**	1.73

[1] Écho-PORC (week of April 27st to May 3rd 2015)

[2] Final live weight: 107.08, 106.18, 108.18 and 104.46 kg for treatments A (control), B, C and D, respectively.

[3] Calculated from the live bodyweight differential compared to control and according to a 80% carcass yield.

[4] Feeding cost per head from 5.6 to 23.9 kg of bodyweight: $12.89, $12.11, $12.93 and $12.65 for treatments A, B, C and D, respectively.

Table 9: Estimated monetary return on investment in 2014 ($/pig)

Replacement alternatives		B	C	D
Cumulative pool price in 2015 (index 110.73)[1]		211.98		
Carcass deviation compared to control (kg/head)[2, 3]		-0.72	+0.88	-2.10
Feeding cost deviation compared to control ($/head)[4]		-0.78	+0.04	-0.24
Carcass weight deviation compared to control (kg)[3]	**-2.10**	-4.14	-4.96	**-4.68**
	-1.60	-2.98	-3.80	-3.52
	-1.20	-2.04	-2.86	-2.58
	-0.72	**-0.91**	-1.73	-1.45
	-0.46	-0.31	-1.13	-0.85
	-0.24	0.00	-0.32	-0.60
	-0.10	0.54	-0.28	0.00
	0.00	0.78	-0.04	0.24
	0.02	0.82	0.00	0.28
	0.40	1.72	1.18	0.90
	0.80	2.66	1.84	2.12
	0.88	2.85	**2.03**	2.31

[1] Écho-PORC (week of January 5th to January 11th 2015) and «Mise en marché des Éleveurs de porcs du Québec, compilation CDPQ, May 7th 2015».

[2] Final live weight: 107.08, 106.18, 108.18 and 104.46 kg for treatments A (control), B, C and D, respectively.

[3] Calculated from the live bodyweight differential compared to control and according to a 80% carcass yield.

[4] Feeding cost per head from 5.6 to 24 kg of bodyweight: $12.89, $12.11, $12.93 and $12.65 for treatments A, B, C and D, respectively.

CONCLUSION

According to the context in which this study was conducted, it is possible to replace porcine blood plasma by a combination of feed alternatives with attributes approximating those of plasma. Although statistical differences and trends appear between alternatives evaluated, it can be stated that animal's growth performance in the nursery and finishing periods was excellent, regardless of the treatment applied. In nursery, no difference between the 4 piglet groups appeared on feed:gain ratio. The piglets that consumed during phases I and II in nursery, an alternative diet based on egg powder (Isonova), fish hydrolysate (CPSP Special G), a butyrate source (Proformix 650) and aroma & sweetener (Crystal feed fruity) demonstrated equivalent performance (ADG, weight) to those in the nursery group of animals with blood plasma. Moreover, the observed effect of this treatment in the nursery was maintained during the finishing period. According to the economic assessment done, a return on investment of $1.45 per head (depending on cumulative pool prices between January and May 2015) would be possible in 2015 while it would have been of $2.03 per pig in 2014.

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