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Longitudinal Characterization of Sow and Growing Pig Blood Criteria

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Summary

A total of 10 high-health sows and 141 high-health offspring (DNA 600 × 241) from the sows' first litter were used to characterize circulating blood criteria concentrations over three parities of the sow and in the piglets from weaning until market. Non-fasted blood samples were collected from the same sows at entry into the farrowing house, 3 d before their first farrowing cycle, and then at weaning for their first, second, and third litters. Additionally, non-fasted blood samples were collected from each pig at weaning (d 18 of life), end of the nursery period (d 70 of life), midpoint of the finisher (d 123 of life), and end of the finisher (d 161 of life). Whole blood samples were analyzed for a panel of 24 blood criteria, including proteins, vitamins, and minerals, using iCheck (BioAnalyt, Teltow, Germany), iSTAT Alinity (Abbott, Abbott Park, IL), and VetScan (Zoetis, Parsippany, NJ)-based rapid analysis technologies. Sows and offspring were fed corn-soybean meal-based diets formulated to meet or exceed the nutrient requirement estimates established by NRC (2012) and diets were typical of those fed in commercial production. All pigs were healthy throughout the course of blood collection. These data provide a broad characterization of whole blood criteria concentrations for the first three parities of sows and from weaning through harvest of the offspring from the sow's first litter.

Introduction

Measurement of different blood criteria is often performed for a variety of diagnostic and research purposes. Some published literature describes normal ranges (sometimes called reference values); however, the origin of these measures is often not clearly described. Furthermore, many of these values are dated and may not properly reflect current genetics, feeding practices, or management strategies. There is a need to determine the concentration of different blood criteria in modern swine production of healthy animals. Therefore, the objective was to characterize circulating blood criteria over three parities of sows and in first-litter pigs from weaning until market.

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Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment (IACUC #4942). This study was conducted at the Kansas State University Swine Teaching and Research Center (Manhattan, KS).

Animals and sampling

A total of 10 sows and litters (DNA 600 × 241) were used for this analysis. The same sows were sampled at entry into the farrowing house, 3 d before their first farrowing cycle, and then at weaning for their first, second, and third litters. A total of 141 piglets from the sows' first litter were sampled at weaning (d 18 ± 1), the end of the nursery phase (d 70 ± 1 of life), a mid-timepoint in the finisher (d 123 ± 1 of life), and at the end of the finishing phase (d 161 ± 1 of life). Sows and pigs were generally considered healthy, characterized as being free from infections caused by porcine enteric coronaviruses, porcine reproductive and respiratory syndrome virus, or *Mycoplasma hyopneumoniae*. Additionally, no clinical signs consistent with active infections with *Escherichia coli* or *Salmonella* were observed.

Blood was drawn (7 mL) from sows and pigs from the jugular vein. A 21-gauge × 1-in. needle was used for weanling pigs, and an 18-gauge × 1.5-in. needle for nursery pigs, finishing pigs, and sows. The samples were kept on a turntable in a 7-mL vacutainer tube (VACUETTE Lithium Heparin, Greiner Bio-one, Kremsmünster, Austria) for no more than 15 min before analysis. Blood samples were analyzed using three different pen-side rapid analysis methods (iSTAT CHEM8+ cartridge, Abbott, Abbott Park, IL; Comprehensive Diagnostic VetScan Rotors, Zoetis, Parsippany, NJ; iCheck Vitamin E test, BioAnalyt, Teltow, Germany). Blood criteria including alanine aminotransferase, albumin, albumin to globulin ratio, alkaline phosphatase, amylase, bilirubin, blood urea nitrogen, calcium, creatinine, globulin, glucose, phosphorus, potassium, sodium, and total protein were analyzed from 0.1 mL of whole blood using comprehensive diagnostic VetScan rotors. The anion gap, bicarbonate, carbon dioxide, chloride, hematocrit, hemoglobin, ionized calcium, and pH were analyzed from 0.1 mL of whole blood using iSTAT CHEM8+ cartridges. Circulating levels of vitamin E were analyzed from 0.5 mL of whole blood using iCheck Vitamin E test.

Performance data collection

Sow lactation performance measurements were collected from parity 1 to 4, including total born, total born alive, percent stillborn, percent mummy, piglet birth weight, total weaned, pig weaning weight, and preweaning mortality. During gestation, sows were housed in pens containing approximately 30 sows. During lactation, sows were housed individually in an environmentally controlled and mechanically ventilated barn. Pig body weight was collected on d 18, 70, 123, and 161 of life. Carcass data were collected at harvest for all pigs. During the nursery phase, pigs were housed in a single room, an environmentally controlled and mechanically ventilated nursery containing 86 pens. During the finishing phase, pigs were housed in a mechanically ventilated barn containing 36 pens.

Diets provided

Although dietary treatments were not used for this analysis, sows and pigs included in the sampling participated in other concurrent experiments. Sows included in the study were randomly assigned to dietary treatments during parity 1 only. Sows were provided common corn-soybean meal gestation and lactation diets after weaning from

parity 1 until parity 3. Pigs were used in independent nursery and finishing feeding trials. Dietary treatments used in the nursery and finishing trials were corn-soybean meal-based, formulated to represent commercially relevant feeding programs, and to meet or exceed NRC (2012) nutrient requirement estimates. Dietary treatments were randomized to the population of animals, with approximately an even distribution of pigs sampled across each treatment. Dietary treatments had minimal effects on blood criteria.

Statistical analysis

Descriptive statistics were used to show the means and standard deviation of each blood criterion and performance measurement collected for both sows and growing pigs at each collection timepoint.

Results and Discussion

Descriptive statistics for the sow and offspring illustrate that the population sampled represented performance levels similar to those observed in commercial production (Tables 1 and 2). Sow blood criteria concentrations are shown in Table 3 and offspring blood criteria concentrations are shown in Table 4. These data provide a broad characterization of whole blood criteria concentrations for the first three parities of sows and from weaning through harvest of the offspring from the sow's first litter.

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Table 1. Descriptive statistics of the sow population measured[1]

	Parity			
Item	1	2	3	4
Average sow weight, lb				
Entry	453.1 ± 24.4	---	---	598.8 ± 35.3
Weaning	416.8 ± 43.1	---	---	585.6 ± 47.4
Caliper, units				
Entry	14.5 ± 2.4	---	---	16.0 ± 1.3
Weaning	12.7 ± 2.2	---	---	16.1 ± 1.4
Backfat, in				
Entry	0.53 ± 0.09	---	---	0.49 ± 0.08
Weaning	0.45 ± 0.09	---	---	0.48 ± 0.09
Loin depth, in				
Entry	1.93 ± 0.19	---	---	1.89 ± 0.16
Weaning	1.80 ± 0.15	---	---	1.93 ± 0.07
Total born, n	15.0 ± 3.8	17.7 ± 2.2	17.2 ± 2.0	17.9 ± 3.7
Total born alive, n	14.1 ± 3.7	16.6 ± 1.4	15.7 ± 2.6	15.7 ± 2.5
Stillborn, %	4.1 ± 4.8	2.5 ± 7.6	8.5 ± 10.0	5.1 ± 7.0
Mummy, %	1.9 ± 4.4	2.8 ± 5.4	0.6 ± 1.9	4.1 ± 4.2
Total weaned, n	13.5 ± 1.1	15.9 ± 0.8	12.9 ± 1.7	13.7 ± 2.1
Pre-wean mortality, %	6.1 ± 8.7	3.7 ± 4.7	16.6 ± 12.1	12.3 ± 9.9
Average piglet weight, lb				
d 1	3.3 ± 0.5	3.4 ± 0.5	3.3 ± 0.4	3.1 ± 0.2
Weaning	11.8 ± 1.8	12.2 ± 1.0	13.4 ± 0.5	13.3 ± 1.1

[1] Data from 10 sows (DNA Line 241; Parity 0 to 4) were used. Values reported as mean ± standard deviation.

Table 2. Descriptive statistics of pig population sampled[1]

Item	
Average weight, lb	
d 18	11.6 ± 2.7
d 70	71.8 ± 12.6
d 123	185.5 ± 21.6
d 161	287.3 ± 29.1
Carcass characteristics	
Hot carcass weight, lb	229.2 ± 22.0
Percent lean, %	54.2 ± 1.7
Backfat depth, in	0.66 ± 0.19
Loin depth, in	2.63 ± 0.11

[1] Data from growing pigs (DNA 241 × 600; n = 141) were used. Values reported as mean ± standard deviation.

Table 3. Observed blood criteria values in healthy sows[1]

	Sampling timepoint			
	Pre-farrow	Weaning		
Item[2]	Parity 1	Parity 1	Parity 2	Parity 3
Alanine aminotransferase, U/L†	25.6 ± 3.3	26.6 ± 5.2	36.9 ± 15.8	34.0 ± 30.2
Albumin, g/dL†	3.86 ± 0.26	3.69 ± 0.48	3.98 ± 0.29	4.16 ± 0.36
Albumin:globulin ratio†	1.30 ± 0.26	1.25 ± 0.40	1.17 ± 0.26	1.28 ± 0.30
Alkaline phosphatase, U/L†	57.1 ± 23.4	76.7 ± 47.9	79.8 ± 48.0	50.0 ± 34.2
Amylase, U/L†	843 ± 239	886 ± 216	1,054 ± 223	1,003 ± 224
Anion gap, mmol/L*	16.4 ± 1.2	17.0 ± 1.8	15.2 ± 2.4	16.7 ± 1.9
Bicarbonate, mEq/L*	27.8 ± 1.8	25.5 ± 1.6	29.9 ± 2.7	27.7 ± 1.8
Bilirubin, mg/dL†	0.32 ± 0.06	0.28 ± 0.06	0.29 ± 0.04	0.31 ± 0.03
Blood urea nitrogen, mg/dL†	7.8 ± 1.6	11.4 ± 4.3	14.3 ± 3.0	13.9 ± 3.0
Calcium, mg/dL†	10.7 ± 0.53	10.7 ± 0.25	11.3 ± 0.48	11.3 ± 0.45
Carbon dioxide, mmol/L*	28.6 ± 1.6	26.8 ± 1.8	30.7 ± 2.6	28.8 ± 2.0
Chloride, mmol/L*	101.4 ± 2.6	100.5 ± 1.4	99.7 ± 1.6	101.1 ± 1.7
Creatinine, mg/dL†	2.32 ± 0.25	1.79 ± 0.23	1.74 ± 0.19	2.43 ± 0.37
Globulin, g/dL†	3.07 ± 0.56	3.16 ± 0.72	3.53 ± 0.61	3.37 ± 0.61
Glucose, mg/dL†	89.1 ± 16.5	99.3 ± 7.5	97.6 ± 9.0	89.0 ± 12.0
Hematocrit, % PCV*	28.7 ± 5.1	27.3 ± 3.1	32.1 ± 1.6	31.6 ± 2.7
Hemoglobin, g/dL*	9.8 ± 1.7	9.3 ± 1.0	10.9 ± 0.6	10.7 ± 0.9
Ionized calcium, mmol/L*	1.27 ± 0.05	1.27 ± 0.04	1.25 ± 0.13	1.27 ± 0.12
pH*	7.47 ± 0.06	7.51 ± 0.05	7.44 ± 0.02	7.44 ± 0.04
Phosphorus, mg/dL†	6.96 ± 0.78	6.43 ± 0.78	6.42 ± 0.84	6.74 ± 1.27
Potassium, mmol/L†	4.64 ± 0.46	4.86 ± 0.38	4.96 ± 0.35	5.00 ± 0.62
Sodium, mmol/L†	139.9 ± 2.7	137.7 ± 2.3	140.6 ± 2.1	141.3 ± 2.8
Total protein, g/dL†	6.91 ± 0.50	6.85 ± 0.48	7.51 ± 0.40	7.52 ± 0.40
Vitamin E, mg/L‡	1.41 ± 0.10	1.79 ± 0.33	2.78 ± 0.88	2.43 ± 0.27

[1] Data from 10 sows (DNA Line 241; Parity 0 to 3) were used. Values reported as mean ± standard deviation.

[2] All blood criteria were analyzed using an *i-STAT Alinity (Abbott, Abbott Park, IL), †VetScan (Zoetis, Parsippany, NJ), or ‡iCheck Vitamin E (BioAnalyt, Teltow, Germany).

Table 4. Observed blood criteria values in healthy growing pigs[1]

	Day of life, d			
Item[2]	18	70	123	161
Alanine aminotransferase, U/L†	40.0 ± 12.0	35.0 ± 8.5	35.2 ± 6.9	41.3 ± 7.4
Albumin, g/dL†	3.07 ± 0.46	3.35 ± 0.39	3.96 ± 0.34	4.24 ± 0.28
Albumin:globulin ratio†	1.52 ± 0.50	1.19 ± 0.29	1.52 ± 0.28	1.64 ± 0.29
Alkaline phosphatase, U/L†	600.0 ± 245.6	139.7 ± 37.1	122.7 ± 23.2	115.1 ± 22.6
Amylase, U/L†	1,129 ± 324	1,289 ± 342	1,336 ± 337	1,307 ± 351
Anion gap, mmol/L*	17.0 ± 1.2	17.0 ± 1.5	16.7 ± 1.1	16.1 ± 1.4
Bicarbonate, mEq/L*	21.1 ± 2.2	28.3 ± 2.5	30.2 ± 1.9	30.6 ± 2.0
Bilirubin, mg/dL†	0.53 ± 0.14	0.22 ± 0.04	0.29 ± 0.03	0.29 ± 0.02
Blood urea nitrogen, mg/dL†	4.57 ± 2.46	4.02 ± 1.37	8.12 ± 3.40	11.13 ± 4.24
Calcium, mg/dL†	11.9 ± 0.84	12.0 ± 0.56	11.5 ± 0.39	11.7 ± 0.35
Carbon dioxide, mmol/L*	22.1 ± 2.2	29.4 ± 2.5	31.1 ± 1.8	31.6 ± 2.0
Chloride, mmol/L*	101.7 ± 2.8	102.1 ± 2.2	99.7 ± 1.8	99.6 ± 1.9
Creatinine, mg/dL†	0.83 ± 0.18	1.06 ± 0.71	1.47 ± 0.20	1.66 ± 0.22
Globulin, g/dL†	2.19 ± 0.55	2.92 ± 0.45	2.65 ± 0.34	2.65 ± 0.39
Glucose, mg/dL†	118.7 ± 14.9	115.4 ± 9.9	98.8 ± 8.5	91.6 ± 9.3
Hematocrit, % PCV*	31.3 ± 2.4	31.6 ± 3.3	33.0 ± 3.6	36.7 ± 3.6
Hemoglobin, g/dL*	10.6 ± 0.8	10.8 ± 1.1	11.2 ± 1.2	12.5 ± 1.2
Ionized calcium, mmol/L*	1.42 ± 0.06	1.41 ± 0.05	1.38 ± 0.04	1.32 ± 0.05
pH*	7.43 ± 0.05	7.36 ± 0.07	7.40 ± 0.06	7.36 ± 0.06
Phosphorus, mg/dL†	8.53 ± 1.19	9.84 ± 0.87	9.23 ± 0.59	8.62 ± 0.57
Potassium, mmol/L†	5.28 ± 0.81	6.88 ± 0.76	5.66 ± 0.60	5.83 ± 0.66
Sodium, mmol/L†	138.8 ± 4.1	146.8 ± 3.5	142.6 ± 2.1	143.2 ± 2.4
Total protein, g/dL†	5.25 ± 0.51	6.28 ± 0.43	6.62 ± 0.34	6.89 ± 0.35
Vitamin E, mg/L‡	3.78 ± 1.23	1.49 ± 0.57	1.23 ± 0.46	1.79 ± 0.48

[1] Data from growing pigs (DNA 241 × 600; n = 141) were used. Values reported as mean ± standard deviation.

[2] All blood criteria were analyzed using an *i-STAT Alinity (Abbott, Abbott Park, IL), †VetScan (Zoetis, Parsippany, NJ), or ‡iCheck Vitamin E (BioAnalyt, Teltow, Germany).