Tonisity Px
Scientific Summary

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How and Why Does Tonisity Px Work?

- Tonisity Px is the first isotonic drink for pigs that contains key amino acids that support the intestinal cells. In the background, Px also delivers the right combination of electrolytes, sugar and water to deliver optimal hydration to pigs.

- Tonisity Px is very palatable to pigs of all ages, meaning that they will drink it voluntarily, even when they might not drink water. Px does not need to be delivered through a Dosatron®.

Why Px vs. Brand X?

Tonisity Px accomplishes rehydration, delivers microenteral nutrition and tastes great to pigs!

Px has been developed to apply the principles of oral rehydration therapy (ORT) and microenteral nutrition to swine production. Px is distinctly different from other electrolyte products on the market.

Background

(1) Oral Rehydration Therapy

Historically, simple salt-and-sugar solutions have been used in humans (especially children) to treat dehydration caused by both bacterial and viral diarrhea. ORT was first used on a wide scale in the India/Pakistan/Bangladesh wars of 1971 and successfully reduced mortality from 40% to 3% in the refugee camps.[1] This was accomplished by the simple act of having the parents spoon small amounts of ORT into the children's mouths, instead of using intravenous drips (which were not available in the situation). The initial ORT recipe developed in 1971 was subsequently adopted by the World Health Organization and became known as 'WHO Juice'. There have been slight updates to electrolyte and osmolarity concentrations, but the WHO recipe is still recommended as a first-line treatment for diarrhea epidemics today.

Veterinary medicine has used ORT products to treat diarrhea in most species for over 40 years.[2–5] The use of ORT in piglets was first reported in 1980 using a solution of glucose and glycine.[6] In that report, piglets were experimentally infected with enterotoxigenic E. coli or rotavirus and then given either a solution of glucose/glycine or plain water. The same researchers then performed a study of naturally occurring diarrhea in a farm setting, using the same ORT. In the experimental scenario, pre-weaning mortality was significantly reduced from 24% to 11.6% ($P < 0.05$).[6]

Until now, very few studies have been published to show the actual benefits of ORT in swine. The studies summarized below aim to change that paradigm.

(2) Microenteral Nutrition

Studies in humans with various medical or surgical conditions have shown the benefit of providing the right nutrients to the intestine, early in the course of disease. Fasting in the face of intestinal disease or surgery is no longer recommended in human medical guidelines.[7,8] Consensus recommendations now suggest that early enteral nutrition should be provided, and that it should be in a simple, easily digested form.

Tonisity Px takes the next logical step — since pigs are used as a model for human medicine and the monogastric digestive system — and applies those principles to nutrition for the stressed pig or pig with diarrhea.

(3) Palatability

Anything that is meant to be ingested should also be palatable, particularly for pigs. The pig's acute sense of smell and taste is well-known and has been well studied. Not all ORT solutions are palatable to pigs. Px has a combination of flavours that pigs find highly appealing, which increases their intake of the product at the times when they need it most.

Detail of the Cellular Physiology

The fundamental principle of ORT is to supply simple sugars, electrolytes and water to restore hydration and glucose levels in the body. The small intestinal cells (enterocytes) can only absorb simple sugars such as glucose, fructose and galactose, which then enter the blood stream and are used for glycolysis. The transport of these simple sugars into the enterocyte relies upon Na-K-ATPase dependent transporters in the enterocyte cell membrane. These transporters are dependent on having baseline concentrations of sodium and potassium available to them in order to accomplish their task. When the intestine is under stress and the digestive processes are impaired, it is particularly important to provide these three things – sugar, sodium and potassium — so that enterocytes can do their work most efficiently and so that water can be absorbed.

ORT solutions generally contain monosaccharides (usually glucose) and electrolytes. ORT solutions are also usually isotonic, with an osmolarity of about 270-300 mOsm/l. In its basic formulation, Px would qualify as a strong ORT product because it is appropriately balanced AND has good palatability to swine.

However, Px is unique because it also contains certain proprietary ingredients that are formulated to support the metabolic functions of the enterocytes themselves. It also contains ingredients that make it highly palatable to swine.

The Px Formula

Tonisity Px was born out of a collaboration between a pet food manufacturer, a food chemist and a veterinarian who specializes in emergency/ critical care. Between them they bring over 100 years of experience to the scientific formulation of Px.

Summary of Trials

Tonisity has conducted over 20 trials involving over 450 litters, 6,000 suckling pigs and 1,340 weanling pigs in three countries. Key findings from those trials are presented here. All trials documented here have been performed on actual production farms under field conditions.

Effect of Tonisity Px on Suckling Pig Mortality and Weaning Weight (15-001)

Introduction

The aim of this study by Tonisity was to assess the impact of Px on pre-weaning mortality and weight gain in suckling pigs. A randomised, controlled prospective clinical trial was performed.

Materials and Methods

One hundred twelve sows (Landrace x Large White or Danbred) and their litters (1,496 piglets) from two farrowing batches were used in the study. The farm was located in central Spain, and was a farrow-to-nursery operation with 2,500 sows with an average live-born of 13.1 pigs and a historic pre-weaning mortality of 13.7%. The farm has a history of scours during lactation with *Clostridium difficile, Clostridium perfringens, Escherichia coli* and type A rotavirus.

Sows and their litters were randomised to one of two groups. Litters in the Px group received 500 mL of Px in an open pan, once daily from day 2-8 of life. Litters in the control group received nothing. All piglets had access to an automatic drinker. The amount of Px consumed was recorded daily.

On the day of farrowing, piglets were individually ear-tagged and weighed. Piglets were again weighed at day 8 and day 19. Creep feed was started in all litters at day 10. Mortality and apparent cause of death were recorded daily.

Results

Piglets in the Px group weighed more than the control group at day 8 ($P < 0.1$) and 240 grams (0.53 lbs) more at day 19 ($P < 0.05$). Pigs in the Px group had a higher average daily gain both in the first week ($P < 0.1$) and until day 19 ($P < 0.05$). Day 19 mortality in the Px group was 5.2% compared to 6.7% in the control group, a reduction of 17% ($P < 0.001$), though both groups had much lower mortality than was usual for the farm.

Table 1. Weight Gain and Mortality in Suckling Pigs

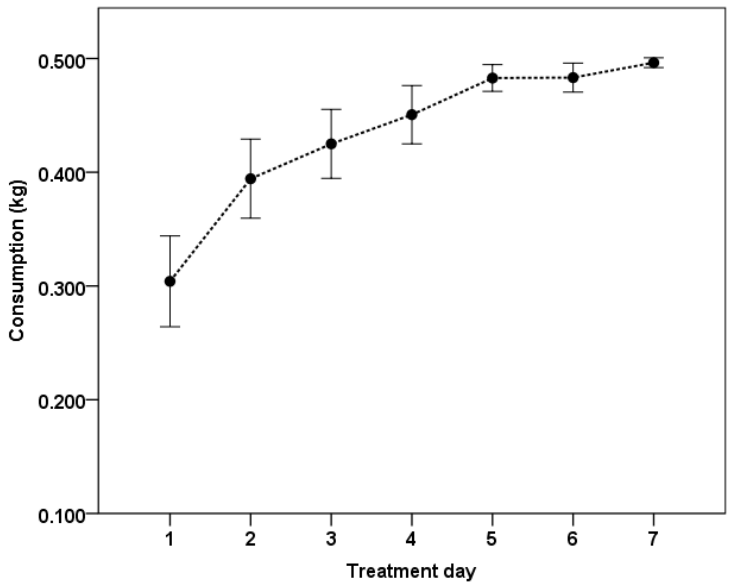
	Px*	**Control***	**P value**
Body weight d1 (kg ± SE)	1.41 ± 0.04	1.37 ± 0.04	NS
Body weight d8 (kg ± SE)	2.29 ± 0.05	2.23 ± 0.05	P < 0.1
Body weight d19 (kg ± SE)	**4.25 ± 0.11**	**4.01 ± 0.11**	**P < 0.05**
ADG d1 – d8 (kg/d)	0.123 ± 0.007	0.114 ± 0.007	P < 0.1
ADG d1 – d19 (kg/d)	**0.158 ± 0.006**	**0.145 ± 0.006**	**P < 0.05**
Mortality d8 (%)	3.7	4.5	P = 0.424
Mortality d19 (%)	**5.2**	**6.7**	**P < 0.001**

* Values are least-squares means ± standard error.

NS = not significantly different **BOLD indicates statistically significant P value.**

Consumption of Px increased steadily during the week. By day 8, virtually all litters were consuming all 500 mL of Px that they were offered. Litters contained an average of 14 piglets, equating to an average consumption of 36 mL/pig after day 3.

Figure 1. Average Daily Consumption of Px by Litters (n = 58)



Conclusions

This study demonstrated that Tonisity Px had a beneficial effect on suckling piglets when given during the first week of life, and that these benefits were measurable at the time of weaning. Contrary to accepted practice, piglets less than one week old will drink significant volumes of Px.

Statistically significant differences that are meaningful to actual production were seen in body weight, average daily gain and pre-weaning mortality (PWM). The control group's pre-weaning mortality in this study (6.7%) was lower than normal due to the extra care and attention being given to the piglets by the study personnel. Nevertheless, the pre-weaning mortality in the Px group was still significantly lower (5.2%) than the control group ($P < 0.001$). This is a 22% reduction in PWM during a trial that provided extra staff to monitor the pigs. In a commercial farm with normal staffing levels, the reduction in PWM is likely to be more pronounced.

Effect of Px Gruel on Feed Intake and Average Daily Gain (ADG) Post-Weaning (16-003-PILOT)

Tonisity Px is a highly palatable liquid that can be mixed with dry feed. Pigs at weaning often have reduced feed intake in the first few days after weaning.

The aim of this pilot study was to see if a gruel made with Px and creep feed would result in increased feed intake and weight gain in the immediate post-weaning period.

Materials and Methods

At weaning, 150 pigs were individually weighed and then randomly allocated to six pens, each containing 25 pigs. Three pens received Px-gruel and three pens received water-gruel for five days after weaning. The gruel was mixed with the farm's usual creep feed, using 1.5 L of either 3% Px solution or water to 1 kg of feed and poured into extra creep feeders. Dry creep feed was also available in each pen. The quantity of gruel and dry creep feed consumed was weighed and calculated daily.

On day 5 post-weaning, pigs were again individually weighed and ADG was calculated. The percentage of pigs achieving a positive ADG was also calculated. Gruel and dry feed consumption per pen was used to calculate gruel and feed intake per pig and per kg body weight (BW).

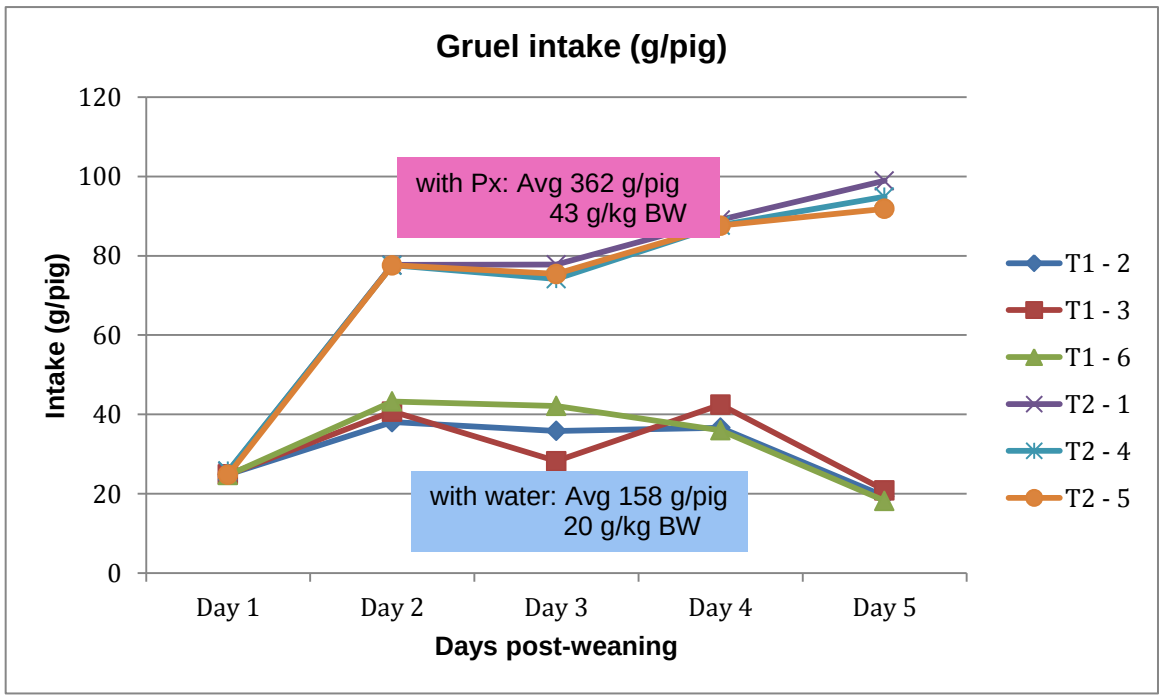
Results

Fifty of the 75 pigs (66%) in the Px-gruel group had a positive ADG over the five days, compared to 18 of 75 pigs (25%) in the water-gruel group. The Px-gruel pens consumed their gruel at an average of 362 g/pig (43 g/kg BW) compared to the water-gruel pens that consumed an average of 158 g/pig (20 g/kg BW). Dry feed consumption in the Px-gruel pens averaged 9 g/pig compared to 20.6 g/pig in the water-gruel pens.

Table 2. Gruel and Feed Intake

Pens	Water 1	Water 2	Water 3	Px 1	Px 2	Px 3
Gruel intake, g/pig	155	157	164	369	360	357
Feed intake, g/pig	12	20	30	9	7	11
Pigs with positive daily gain (%)	18 (25%)			50 (66%)		

Figure 2. Gruel Intake Comparison



Conclusions

Gruel made with creep feed and a 3% solution of Px is highly palatable. The consumption of gruel made with Px was twice that of water-gruel. Using Px-gruel resulted in increased average daily gain and a higher percentage of pigs that achieved positive ADG in the 5-day post-weaning period. A corresponding decrease in dry feed consumption was seen, but was offset by the increased consumption of gruel.

Tonisity Px in Piglets with Scour (T20)

Piglets suffering from diarrhoea may become dehydrated. Px is an isotonic solution containing balanced electrolytes and protein, and may be used for rehydration and support in such situations.

The aim of this study was to determine the effect of Px on suckling pigs with scours.

Materials and Methods

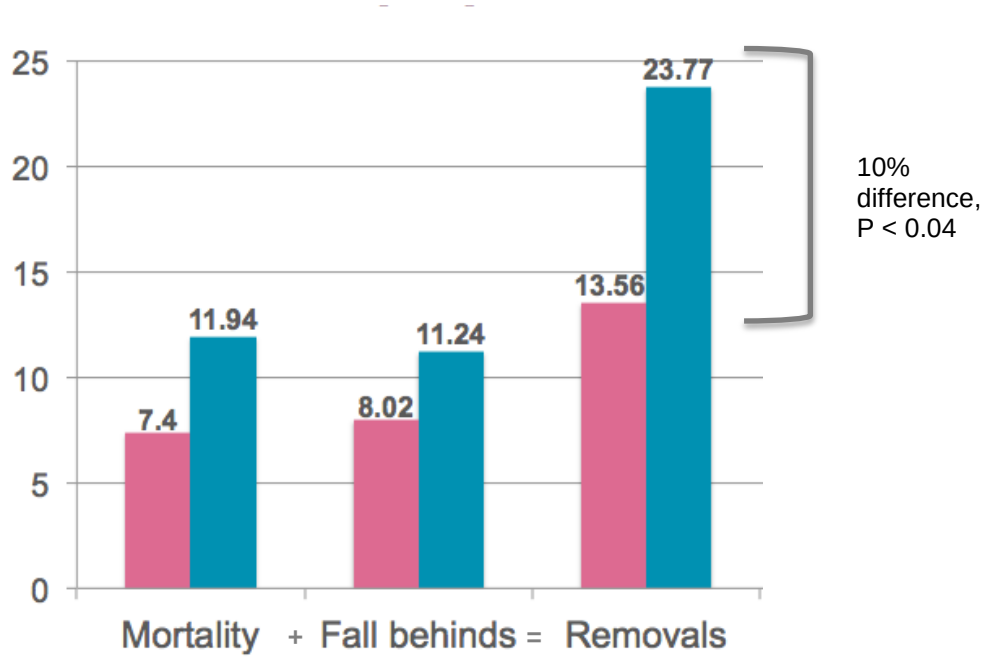
In a farm located in the Midwestern USA, with historically-documented *E. coli* and rotavirus, 20 litters (268 pigs) were prospectively enrolled in the study if they developed scour between 2-4 days of age. Once enrolled, piglets were individually ear-tagged. Odd-numbered piglets within a litter were given 2 mL of Px by mouth twice daily. Even-numbered piglets were given 2 mL of water by mouth twice daily. All piglets received standard farm treatment to control secondary pathogens. All pigs were individually weighed when enrolled, and again at day 18.

Any pigs that died or were removed to a nurse sow were recorded. Data were analyzed as a randomized complete block design using the PROC MIXED procedure of SAS with piglet as the experimental unit and treatment as a fixed effect. Results were considered significant at $P \leq 0.05$ and considered a trend at $P > 0.05$ and $P \leq 0.10$.

Results

Pre-weaning mortality for the Px group was 7.40%, compared to the control group which had a mortality of 11.94% ($P = 0.21$). Similarly, the percentage of pigs that were removed as fall-behinds was lower in the Px group (8.02%) compared to the control group (11.24%) ($P = 0.38$). When mortality and fall-behinds are combined, the total percentage was significantly lower in the Px group (13.56%) compared to the water group (23.7%) ($P = 0.04$).

Figure 3. Comparison of Px v Control in Scouring Piglets



Conclusions

These results show that even small amounts of Px are helpful in the support of piglets with scour, and can have a significant impact upon removals.

Palatability of Water-Soluble Antibiotic in Nursery Pigs (16-002)

Tonisity Px is a novel isotonic solution that provides both rehydration and protein. Pilot studies have shown that it is highly palatable to both suckling and weaned pigs. Pigs are often given oral medications such as antibiotics in water, but many of those medications are poorly accepted.

The aim of this study by Tonisity was to assess whether or not Px could be used to increase the palatability of medication in weaned pigs.

Materials and Methods

198 healthy piglets of approximately 21 days of age were housed in six pens at weaning. Piglets were grouped by size in each pen. Each pen had an automatic drinker. Each pen was also provided with a bowl drinker that was connected to a 20 L carbuoy. The carbuoys were filled each day with a solution of antibiotic in water or antibiotic in a 3% solution of Px. The antibiotic used was Coliphur®, which is a mixture of neomycin and polymyxin B.

Five pigs were randomly chosen from each pen to establish an average body weight. This average body weight was then used to calculate the dose of Coliphur® required (0.1 mL/kg BW/day) and the volume of water required (10% of body weight/day) for each pen.

Starting at three days after weaning, pens were allocated to receive either antibiotic in water or antibiotic in Px for two days. After two days, pens were allocated to the opposite treatment in a crossover design (Table 1).

Table 3. Allocation of Treatment Groups

PEN	No. of pigs	TREATMENT DAY			
		1	2	3	4
1	19	antibiotic + water		antibiotic + 3% Px solution	
2	40	antibiotic + water		antibiotic + 3% Px solution	
3	37	antibiotic + water		antibiotic + 3% Px solution	
4	38	antibiotic + 3% Px solution		antibiotic + water	
5	40	antibiotic + 3% Px solution		antibiotic + water	
6	24	antibiotic + 3% Px solution		antibiotic + water	

All medicated solutions were made fresh each morning. The volume of unconsumed solution from the previous day was measured each morning.

Results

Pigs receiving the antibiotic in Px consumed 94% of their calculated intake volume, but the pigs receiving the antibiotic in water consumed only 33% of their calculated intake volume. Pens in the Px+antibiotic group achieved either 0.09 or 0.10 mL/kg BW of medication on 11 of the 12 treatment days, but none of the pens in the water+antibiotic group received the recommended dose of antibiotic on any day.

Table 4. Consumption of Medicated Solutions in Pens

PEN	TREATMENT*	DAY	MEDICATED WATER (L)				NUMBER OF PIGLETS	COLIPHUR®
			ADDED	LEFTOVER	INTAKE			DOSE (mL/kg BW)
1	control	1	9.79	6.09	3.70	*38%*	19	0.04
1	control	2	9.79	6.46	3.33	*34%*	19	0.04
1	Px	3	9.83	0.00	9.83	*100%*	19	0.10
1	Px	4	9.75	0.10	9.65	*99%*	19	0.10
2	control	1	25.22	17.20	8.02	*32%*	40	0.03
2	control	2	25.22	17.85	7.37	*29%*	40	0.03
2	Px	3	25.38	3.00	22.38	*88%*	40	0.09
2	Px	4	25.38	0.00	25.38	*100%*	40	0.10
3	control	1	23.81	22.99	0.82	*3%*	37	0.00
3	control	2	23.81	9.74	14.07	*59%*	37	0.06
3	Px	3	23.64	1.44	22.19	*94%*	37	0.09
3	Px	4	23.17	0.00	23.17	*100%*	37	0.10
4	Px	1	18.01	6.42	11.59	*64%*	38	0.07
4	Px	2	17.76	0.39	17.37	*98%*	37	0.10
4	control	3	17.76	13.25	4.51	*25%*	36	0.03
4	control	4	17.30	14.25	3.05	*18%*	34	0.02
5	Px	1	24.30	2.19	22.11	*91%*	40	0.09
5	Px	2	24.30	0.40	23.90	*98%*	40	0.10
5	control	3	24.30	9.14	15.17	*62%*	40	0.06
5	control	4	23.56	10.77	12.79	*54%*	40	0.05
6	Px	1	8.00	0.18	7.82	*98%*	24	0.10
6	Px	2	8.00	0.05	7.95	*99%*	24	0.10
6	control	3	10.52	8.41	2.11	*20%*	23	0.02
6	control	4	9.47	7.26	2.21	*23%*	18	0.03

Conclusions

Px was effective at increasing the amount of medication consumed to the recommended dosing level of 0.1 mL/kg. While it is important that antibiotics are prescribed only when necessary, it is also important that the required dose be delivered. Further palatability tests using Tonisity Px with other medications are warranted.

Palatability of Water-Soluble Antibiotic in Suckling Pigs (15-013)

Young piglets suffering from scour may benefit from rehydration. Some producers use oral antibiotics in the treatment of scour, but these antibiotics are sometimes unpalatable.

The objective of this study was to determine whether Px would aid the consumption of medication in suckling piglets.

Materials and Methods

40 sows and their litters were randomly allocated to one of four treatment groups based on parity. The treatment groups were water (W), water+Coliphur® (W+C), and Px+Coliphur® (Px+C). The antibiotic used was Coliphur®, which is a mixture of neomycin and polymyxin B. All litters received 500 mL of their designated solution in an open pan, once daily, from day 2–7 of life. All piglets had access to an automatic drinker. The amount of solution consumed was recorded daily for each litter, and an average intake per piglet was calculated daily.

On the day of farrowing, piglets were individually ear-tagged and weighed. Piglets were again weighed at day 7, and average daily gain was calculated.

Mortality was recorded each day.

Results

The control group receiving plain water (W) had the highest average intake of any group, consuming 180 ± 16.8 mL/pig over the five days of treatment. The Px+C group consumed an average of 162 ± 16.9 mL/pig, which was not significantly different from the control Water group. The Water+C group had the lowest intake of any group, averaging 102 ± 17.7 mL/pig.

Table 5. Consumption of Medicated Solutions in Litters

Group	Mean ± SE (mL/pig)
Water	180 ± 16.8
Px+Coliphur®	162 ± 16.9
Water+Coliphur®	102 ± 17.7

Conclusions

Px+Coliphur® was significantly more palatable than Water+Coliphur®. The volume of Px+Coliphur® consumed was not significantly different from plain water, suggesting that piglets find Px a very palatable product which may be used to deliver medications.

Dose Titration Trial (15-002)

Introduction

The purpose of this study was to assess piglets for any negative effect of Px when administered in the first week of life. The study evaluated the effect of Px on weight, scour incidence, gut bacteria populations, haematology and serum biochemistry, when it was administered to suckling piglets at different doses (2.5 mL, 25 mL, 50 mL and 100 mL) and for different durations (1 to 5 days) during first days of life.

Materials and Methods

10 sows and their litters (~140 piglets) from two different farms located in central Spain were enrolled in the study.

- Farm L was a typical farrow-to-nursery farm with 2,500 Danbred sows, weekly farrowing and weaning at 21-26 days. Farm L has a history of scours during lactation with the following aetiology: bacterial aetiology (Clostridium difficile, Clostridium perfringens type C and Escherichia coli) and virus aetiology (Type A Rotavirus).

- Farm A was a farrow-to-finish farm with 400 Landrace x Large White sows, with four weeks farrowing batches (80 sows per batch) and regular weaning at 21 days. The farm has a low incidence of scours during lactation.

In order to minimize environmental effects all sows on each farm were allocated to the same farrowing room. Each litter/sow was assigned to one of the five treatment durations (from one to five days of treatment). Within each litter, piglets were randomly allocated to one of the five treatment groups (Control: 2 piglets; 2.5 mL: 3 piglets; 25 mL: 3 piglets; 3 piglets: 50 mL: 3 piglets; 100 mL: 3 piglets).

Table 6. Allocation of Piglets to Dose and Duration Groups

Litter	Day -2	Day -1	Day0	Day1	Day 2	Day 3	Day 4	Day5
Litter 1	Farrowing	Blood[1] Faeces[1] Weight$_1$	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	Blood[2] Faeces[2]				Weight$_2$
Litter 2	Farrowing	Blood[1] Faeces[1] Weight$_1$	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	Blood[2] Faeces[2]			Weight$_2$
Litter 3	Farrowing	Blood[1] Faeces[1] Weight$_1$	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	Blood[2] Faeces[2]		Weight$_2$
Litter 4	Farrowing	Blood[1] Faeces[1] Weight$_1$	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	Blood[2] Faeces[2]	Weight$_2$
Litter 5	Farrowing	Blood[1] Faeces[1] Weight$_1$	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	(3) 2.5 ml (3) 25 ml (3) 50 ml (3) 100 ml (2) Control	Blood[2] Faeces[2] Weight$_2$

[1]Samples collected before starting treatment.
[2]Samples collected the day after treatment ending.
(x) Number of piglets treated.
Weight$_1$: piglets' weight recorded on Day -1 (before treatment beginning).
Weight$_2$: piglets' weight recorded on Day 5.

Piglets were individually tagged, weighed and blood sampled on the day after farrowing (day 1). Pooled faecal samples were also collected on day 1. The incidence of scour and the severity of scour was recorded daily for each litter. Individual mortality was recorded daily.

Treatment commenced on day 2 after farrowing. The allocated dose of Px was administered to each piglet once daily, orally, using a volumetric pump dispenser.

Blood and faecal samples were taken from each pig on the day after their treatment ended. All blood samples were analysed for routine haematology and biochemistry (see table below) All piglets were individually weighed on day 7.

Table 7. Hematology and Biochemistry Parameters Measured

Hematology Parameters	Biochemistry Parameters
• Hematocrit, • Total white cell count, • % neutrophils, % monocytes, % lymphocytes, % eosinophils	• Total protein, albumin, globulin • Urea, creatinine • ALKP, ALT, AST, cholesterol • Amylase, lipase • Calcium, Chloride, Phosphorus*

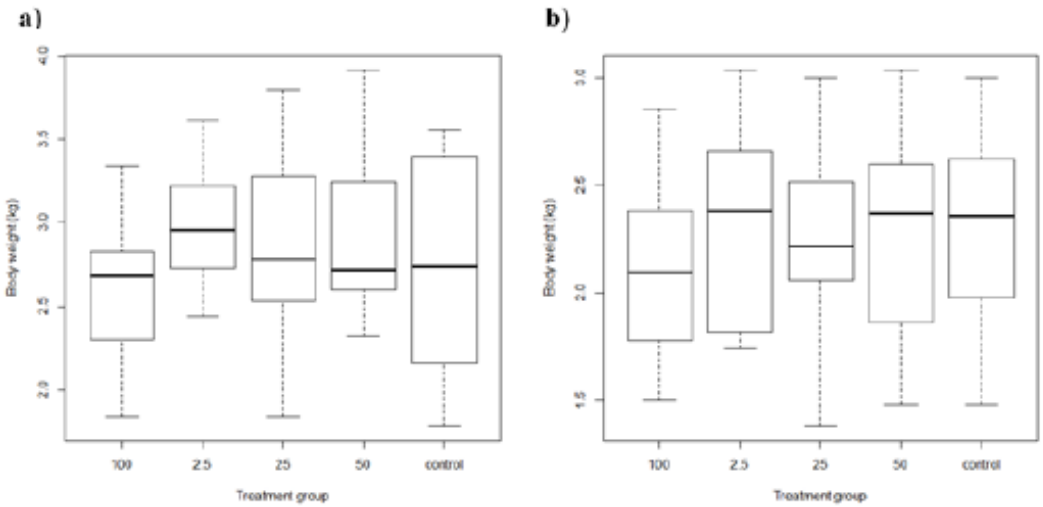
*Sodium results not available due to sample handling issues.

Results

Body Weight and Average Daily Gain at day 7 of age — on both farms, pigs receiving 100 mL/day of Px tended to have decreased body weight and average daily gain. Other groups showed a large degree of variation and overlap in their body weights, with no detectable difference between treatment volume groups or duration of treatment.

Figure 4. Piglets Body Weight (kg) on Day 6

(a) = Farm A, (b) = Farm L



Mortality: only four pigs out of the 140 died. These four pigs were all from the same farm and same litter, and each pig was receiving a different dose of Px.

Incidence and Severity of Scour: No piglets with scour were recorded at Farm A. At Farm L, 17 of the 70 pigs developed scour. There was no association between the incidence of scour and the treatment dose or duration.

Hematology and Biochemistry: There were significant differences between the pigs from Farm A compared to Farm L. However, within each farm, there were no clinically significant differences in the hematology or biochemistry parameters between the treatment volume or treatment duration.

Conclusions

Px showed no deleterious health effects on piglets when given manually at doses that were between 3-5 times the usual intake volume. At high doses (100/pig/day x 5 days), piglets showed decreased weight gain. This was attributed to competition for stomach capacity and milk intake, and would not be expected under normal conditions.

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Detailed information regarding the trials presented in this document may be obtained upon request by email to ava@tonisity.com.