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Research Article

Effect of Tonisity Px™ Administration on Pre-weaning Mortality Under Field Conditions: A Meta-Analysis

Frédéric Vangroenweghe[1,2]*

[1]Elanco Animal Health Elanco Animal Health Benelux, BU Swine & Ruminants, Generaal Lemanstraat 55/3, 2018 Antwerpen, Belgium

[2]Ghent University, Faculty of Veterinary Medicine, Department of Internal Medicine – Reproduction – Population Medicine, Unit of Porcine Health Management, Salisburylaan 133, 9820 Merelbeke, Belgium

Corresponding author: Vangroenweghe F, Elanco Animal Health Elanco Animal Health Benelux, BU Swine & Ruminants, Generaal Lemanstraat 55/3, 2018 Antwerpen, Belgium

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Abstract

Modern sows are characterized by a high prolificacy as indicated by the increased number of total born piglets, which results in a higher pre-weaning mortality. Tonisity Px (TPx) is an isotonic protein drink administered to piglets from d2 to d8 of life during the suckling period to support intestinal health and development. The aim of the present study was to analyze the effects of TPx administration on the pre-weaning mortality under field conditions in 10 sow farms in Belgium and the Netherlands. Therefore, 10 sow farms with a pre-weaning mortality between 3.3 and 13.8% were enrolled in the study. Supplementation of Tonisity Px was compared with standard Control treatment in the same batch. Number of piglets on d2 and the day before weaning was counted and pre-weaning mortality was calculated. Subsequently, reduction in pre-weaning mortality between Control and Tonisity Px group was calculated at farm level. Based on these results, a scatterplot was designed and a trendline formula for the effect of Tonisity Px was calculated. Applying the trendline formula, an economic calculation was run to find the weaned piglets and end-nursery piglet market price for a positive return-on-investment (ROI = or > 1). Supplementation of Tonisity Px resulted in a significant reduction ($P = 0.003$) of pre-weaning mortality from 7.38 to 5.41%, which is a 23.40% reduction in pre-weaning mortality. Economic analysis revealed that Tonisity Px supplementation has a positive economic return-on-investment from 6.0% pre-weaning mortality onwards under the current end-nursery 25 kg piglet market prices. In conclusion, supplementation of Tonisity Px from d2-8 in the suckling period results in a 23.4% reduction in pre-weaning mortality with a positive return-on-investment from 6.0% pre-weaning mortality onwards.

Introduction

Modern sows are characterized by a high prolificacy as indicated by the increased number of total born piglets (TBP). Under Danish conditions, the number of TBP has increased from 12.9 in 2000 to 19.6 piglets per litter in 2020 [1-4]. Modern sows may commonly wean 33-35 piglets per sow per year, but herds with the highest productivity now wean more than 40 piglets per sow per year. The increased litter size is, however, accompanied by a clear decrease in the average piglet birth weight [5-9]. Moreover, due to the limited amount of available colostrum, a decrease in colostrum volume consumed per piglets could be observed [5,12]. This may increase the vulnerability of piglets born from modern high prolific sows [8], which in turn decreases livability from farrowing to weaning. In addition, the small intestine of newborn piglets undergoes major developmental changes during the first 10 days of life. Therefore, this critical period has been identified as a 'window of opportunity' for potential nutritional interventions to support the development of intestinal structure, including digestion, absorption and growth, and the maturation of the immune system resulting in potential lifelong effects [3,6,10,11]. These factors create an opportunity to provide supplemental nutrition in the first days of the piglets' lives to increase livability. Tonisity Px™ (TPx) is a highly palatable isotonic protein solution that provides microenteral nutrition to the intestinal cells. Tonisity Px™ is administered as a 3% solution to neonatal piglets for a 7-day period from day 2 after birth (d2) until day 8 after birth (d8). Tonisity Px™ has been demonstrated to improve intestinal morphology with taller villi (+ 8.3%) and a thicker mucosal layer (+ 9.0%) by d9 in suckling piglets [7]. Furthermore, administration of TPx increased the abundance of beneficial bacterial populations, such as *Lactobacillus* and *Bacteriodes* species, and reduced potentially pathogenic bacterial populations, such as *Escherichia coli* and *Prevotellaceae*, in the pre-weaning period [1,2]. The aim of the present study was to analyze the effects of TPx administration during the suckling period from d2 to d8 on the pre-weaning mortality under field conditions in 10 sow farms in Belgium and the Netherlands.

Materials and Methods

Test Ingredient

The test ingredient consisted of an isotonic protein solution (Tonisity Px™; Tonisity Ltd, Dublin, Ireland), which provides easily-absorbable nutrients (glucose, amino acids, and peptides) and electrolytes that can be used directly by the enterocytes.

Study Population

Ten farrow-to-wean sow farms in Belgium and the Netherlands

with an average number of 733 ± 182 productive sows (min. 200, max. 2000) were enrolled in the field study (Table 1).

The sow herds were run according to different batch-management systems (BMS), such as 1-week BMS (n = 2), 3-week BMS (n = 1), 4-week BMS (n = 6), and 5-week BMS (n = 1). The piglets were weaned at an average age of 23 ± 0.82 days of age (min. 21, max. 26). The average pre-weaning mortality was 7.4 ± 1.1% (min. 3.3, max. 13.8). All sow herds were high prolific with 15.5 live born piglets (LBP) and 32.1 piglets weaned per sow per year.

Experimental Design

Litters within the same farrowing batch were allocated to one of 2 groups, Control or supplementation with TPx. The allocation was balanced according to sow parity (gilts *vs.* older sows) and number of LBP. In 8 out of 10 sow herds, the piglets in the Control group did not receive any supplementation. However, in farm A, the Control group received a supplementation with a standard electrolyte solution, and in farm E, the Control group was supplemented with water during the study period from d2 to d8. Litters in the TPx group were given 250 mL of 3% TPx solution on d2 of age, and from d3-8 of age TPx litters received 500-600 mL of 3% TPx once daily in a clean waterbowl.

Measurements

The number of piglets per litter was counted at d2, the start of TPx administration, and at the day prior to weaning. Pre-weaning mortality was calculated per litter and per batch as the number of dead pigs pre-weaning divided by the number of piglets at d2.

Meta-Analysis

The PWM results obtained in the Control and TPx group were plotted and a trendline was calculated for both the Control and TPx group. Based on the trendline formula of the TPx group, a simulation was performed on potential PWM reduction within the range of 4 to 15% PWM under field conditions. These data were subsequently applied to run an economic calculation for return-on-investment (ROI) of the test product.

Economic Calculations

Return-on-investment calculations were performed based on the number of extra piglets per 1000 piglets enrolled by TPx administration. The cut-off value of weaned and end-nursery piglet market price was calculated for a ROI value of 1.

Therefore, the following formula was used based on the cost of treatment for 1000 piglets enrolled: **y = 390 / x**, with x = number of extra piglets per 1000 piglets enrolled and y = cut-off value of weaned piglet market price. The cut-off value of end-nursery piglet market price was calculated by adding € 25.00 to the cut-off value of weaned piglet market price.

Statistical Analysis

Data were analyzed using JMP 17.0 and results were significant at $P < 0.05$.

Results

Pre-weaning Mortality

The results on pre-weaning mortality in both Control and TPx groups, including the overall percentage of reduction in pre-weaning mortality in the 10 farms enrolled in the study are given in Table 2.

Table 2: Pre-weaning mortality and overall reduction in pre-weaning mortality in the farms enrolled in the study evaluating Tonisity Px supplementation from day 2 to 8 versus a standard on-farm program for the neonatal piglets.

Farm ID	PWM control (%)	PWM Tonisity Px (%)	% PWM reduction
A	7.4	5.7	23.0
B	3.9	3.7	5.1
C	10.0	5.6	44.5
D	4.9	3.3	32.7
E	13.8	8.6	37.7
F	3.3	2.7	17.2
G	5.3	4.7	10.8
H	5.3	4.0	23,8
I	8.6	8.6	10.9
J	11.3	8.1	28.3

Table 1: Description of the relevant farm characteristics (obtained prior to the study enrollment) of all 10 sow farms included in the trial comparing standard piglet treatment to supplementation of Tonisity Px (Tonisity Ltd, Dublin, Ireland).

Farm ID	# Sows	Breed	BMS[1]	Weaning age	% PWM[2]	LBP[3]	PSY[4]	Standard program
A	800	DanBred	4	21	7.4	15.67	32.60	Electrolyte solution
B	250	Topigs-Norsvin	1	26	3.9	14.83	31.23	No supplementation
C	400	Topigs-Norsvin	4	21	10.0	14.53	29.22	No supplementation
D	200	DanBred	4	21	4.9	16.41	35.17	No supplementation
E	1,150	DanBred	1	26	13.8	16.00	30.38	Water
F	2,000	Topigs-Norsvin	4	21	3.3	15.52	33.72	No supplementation
G	1,000	DanBred	4	21	5.3	16.61	35.47	No supplementation
H	1,000	DanBred	4	21	5.3	14.82	33.17	No supplementation
I	280	Hypor	3	26	8.6	15.01	29.45	No supplementation
J	250	Topigs-Norsvin	5	28	11.3	15.45	30.12	No supplementation

[1]BMS: Batch Management System
[2]PWM: Pre-Weaning Mortality
[3]LBP: Live Born Piglets
[4]PSY: Piglets Weaned per Sow per Year

Supplementation of TPx resulted in a significant (P = 0.003) reduction in PWM as compared to the Control group. In the Control group, PWM was between 3.3 and 13.8%, whereas in the TPx group PWM was between 2.7 and 8.6%. The overall percentage of reduction varied between 5.1% at minimum and 37.7% at maximum.

Pre-weaning Mortality According to Breed, Weaning Age and Number of Live Born Piglets

Further detailed analysis of PWM according to breed, weaning age and number of live born piglets in both Control and TPx group are given in Table 3.

For sow breeds, DanBred sows in the Control group had an average PWM of 7.99% in contrast to other breeds (Topigs-Norsvin, Hypor) had a PWM of 6.47%. In the TPx group, both sow breeds had a lower PWM of 5.73% and 4.92% for DanBred and other breeds, respectively.

Table 3: Detailed analysis of overall percentage of PWM in control and Tonisity Px supplemented group, considering sow breed (DanBred *vs.* other breeds), weaning age (early 21 d *vs.* late 26-28 d), and number of live born piglets (low LBP < 15.5 *vs.* high LBP ≥ 15.5). Significant differences at $P < 0.05$ are indicated with a different letter in supercript.

Parameter	PWM control (%)	PWM Tonisity Px (%)	% PWM reduction
All farms	7.38 ± 1.11	5.41 ± 0.67	23.40 ± 4.01
Sow breed			
DanBred	7.99 ± 1.52	5.73 ± 0.89	26.04 ± 3.79
Other breeds	6.47 ± 1.71	4.92 ± 1.10	19.44 ± 8.71
Weaning age			
21 d	6.03 ± 1.98	4.33 ± 0.50[a]	25.33 ± 4.85
26-28 d	9.41 ± 2.12	7.02 ± 1.12[b]	20.51 ± 7.55
Live born piglets			
LBP < 16	6.92 ± 1.84	5.00 ± 1.04	24.27 ± 4.91
LBP ≥ 16	7.84 ± 1.41	5.82 ± 0.91	22.52 ± 6.92

For weaning age, litters weaned at 21 days of age had a lower PWM (6.03%) as compared to litters weaned at a later age of 26-28 days (9.41%) in the Control group. In the TPx group, PWN decreased to 4.33% and 7.02% for litters weaned at 21 and 26-28 days of age, respectively.

For number of live born piglets, litters with an LBP < 16 piglets had a lower PWM (6.92%) as compared to litters with an LBP ≥ 16 (7.84%) in the Control group. In the TPx group, PWM decreased to 5.00% and 5.82% for litters with an LBP < 16 and an LBP ≥ 16, respectively.

Meta-analysis of Pre-weaning Mortality Data

The scatterplot of percentage PWM in Control and TPx group of the 10 farms enrolled in the study demonstrates the reduction in PWM percentage following supplementation of TPx from d2 to d8 (blue trendline) as compared to the PWM in the Control group (orange line) (Figure 1). The trendline formula obtained based on the results was: y = 0.5581 x + 0.0129 with an R^2 of 0.8561. This trendline formula will be used in the simulations for the economic calculation of ROI following supplementation of TPx in different scenarios of PWM percentages.

Economic Calculations

The simulation of PWM reduction following supplementation of TPx based on the trendline formula obtained in relation to the initial on-farm PWM with calculation of the number of extra pigs per litter and per 1000 born piglets based on the PWM reduction is given in Table 4. Simulation with the obtained trendline formula using an initial PWM ranging from 4.0% to 15% resulted in calculated PWM with TPx application from 3.52% to 9.66%, which was equal to a PWM reduction percentage of 11.9 to 35.6%. Based on these numbers, the number of extra piglets per litter and per 1000 piglets born were calculated. At 4.0% initial PWM, a reduction of 11.9% resulted in 0.08 extra piglets per litter and 5 extra piglets per 1000 piglets born.

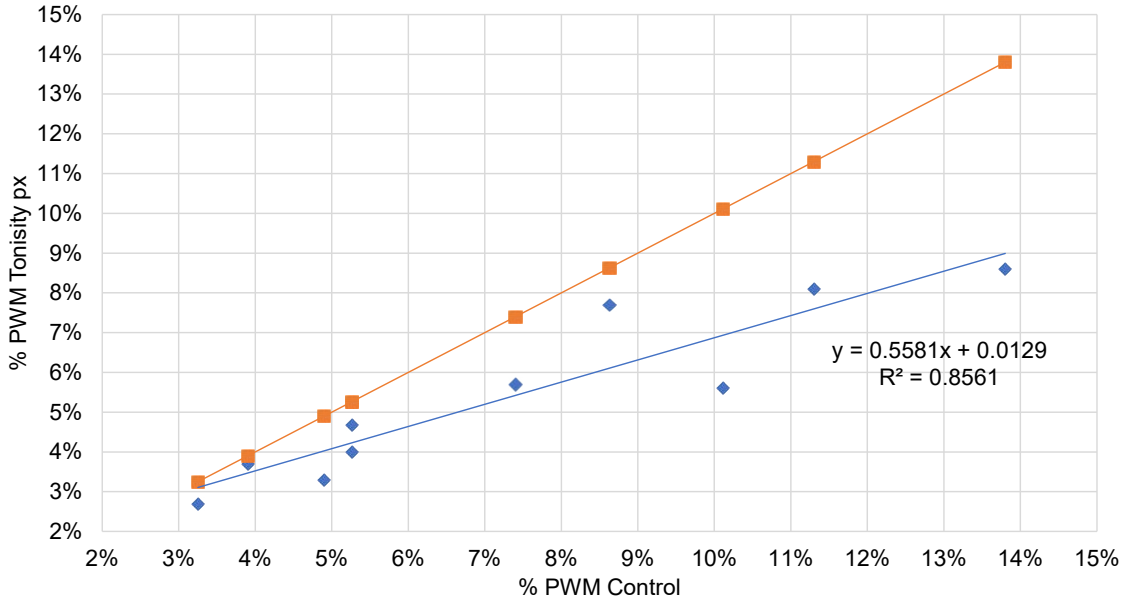

Figure 1: Scatterplot of percentage PWM in Control and Tonisity group of the10 farms enrolled in the study. Orange squares, datapoints of the Control group; blue squares, datapoints of the Tonisity Px supplemented group in relation to their initial percentage of PWM. Trendline shows the correlation between initial percentage of PWM (Control) and the percentage of PWM obtained following supplementation with Tonisity Px.

Table 4: Simulation of PWM reduction following supplementation of Tonisity Px based on the trendline in relation to the initial on-farm PWM with calculation of the number of extra pigs per litter and per 1000 born piglets based on the PWM reduction. Calculation of weaned piglet price and piglet price end-nursery (25 kg) in relation to the return-on-investment breakpoint (ROI = 1.0) based on the average cost of Tonisity Px for 1000 supplemented piglets.

Initial PWM	PWM Tonisity Px	Simulated PWM reduction	Extra piglets/litter	Extra piglets per 1000 piglets born	Weaned piglet price at ROI = 1 breakpoint (€)	Piglet price end-nursery at ROI = 1 breakpoint (€)
4.0%	3.52%	-11.9%	0.08	5	€ 81.66	€ 106.66
5.0%	4.08%	-18.4%	0.15	9	€ 42.41	€ 67.41
6.0%	4.64%	-22.7%	0.22	14	€ 28.65	€ 53.65
7.0%	5.20%	-25.8%	0.29	18	€ 21.63	€ 46.63
8.0%	5.75%	-28.1%	0.36	22	€ 17.37	€ 42.37
9.0%	6.31%	-29.9%	0.43	27	€ 14.51	€ 39.51
10.0%	6.87%	-31.3%	0.50	31	€ 12.46	€ 37.46
11.0%	7.43%	-32.5%	0.57	36	€ 10.92	€ 35.92
12.0%	7.99%	-33.4%	0.64	40	€ 9.72	€ 34.72
13.0%	8.55%	-34.3%	0.71	45	€ 8.75	€ 33.75
14.0%	9.10%	-35.0%	0.78	49	€ 7.96	€ 32.96
15.0%	9.66%	-35.6%	0.85	53	€ 7.31	€ 32.31

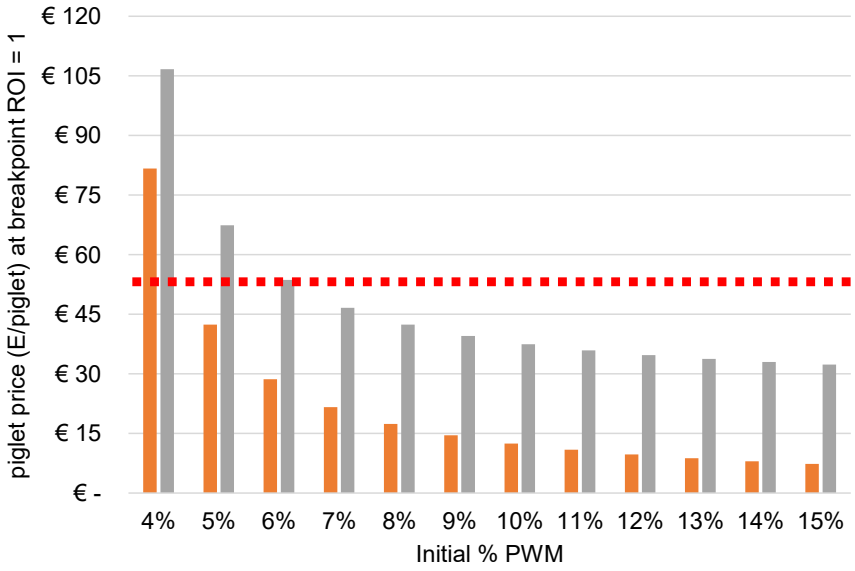

Figure 2: Analysis of return-on-investment breakpoint (ROI = 1) related to market price of weaned piglets (6 kg; orange bars) and piglets at end of nursery (25 kg; green bars). The dashed red line is set at the piglet price (25 kg, end of nursery) of € 56.50 which is the current market price for end-nursery 25 kg piglets (20.09.2024; Flemish piglet price).

Applying the formula y = 390/x, we obtained a weaned piglet price at ROI = 1 breakpoint of € 81.66 and of € 106.66 for end-nursery piglet price. Based on current market prices for weaned piglets and end-nursery piglets (20 September 2024; Flemish piglet price), TPx supplementation has an ROI of 1 or more starting from a PWM percentage of at least 6.0% (indicated by the dotted red line on the figure) (Figure 2).

Discussion

Supplementation of Tonisity Px from d2 to d8 of life resulted in a significant (P = 0.003) reduction of PWM as compared to a simultaneous Control group in 10 farms with difference in management approach under field conditions. This observation is in line with previous studies on the effect of TPx (Carlson et al., 2019). In 8 out of 10 farms, PWM reduction due to TPx was compared to a non-supplemented Control group, whereas in 2 farms a standard supplementation of plain water or electrolyte solution was applied in the Control group. Moreover, the effect of TPx supplementation was evaluated in different sow breeds, such as DanBred (n = 5), Topigs-Norsvin (n =4) and Hypor (n = 1). These breeds are known to be highly prolific which can be confirmed by the high number of LBP (15.01 to 16.41 LBP per litter) and the number of piglets weaned per sow per year (29.22 to 35.47 PSY). As expected, farms with an already low PWM could only observe a mild to moderate further reduction in PWM (5-10%), whereas farms with a rather high PWM had a major reduction in PWM (37-44%).

Detailed analysis on TPx effect related to sow breed, weaning age and number of LBP revealed that in all scenarios, TPx supplementation resulted in a decrease of PWM percentage as compared to the Control. As observed in practice, DanBred sows have a higher PWM as compared to other breeds such as Topigs-Norsvin and Hypor. As expected, TPx supplementation resulted in a higher

PWM reduction (26.04%) in DanBred sows as compared to other sow breeds (19.44%). Litters weaned at 26/28 days of age had a more than 50% higher PWM both in the Control and TPx group as compared to litters already weaned at 21 days of age. There is no clear explanation for this observation. Since most of the PWM occurs in the first 3-5 days of life, length of the lactation period should not further impact PWM. The difference in PWM for litters with more or less than 16 LBP was very limited, as was the reduction in PWM following TPx supplementation. Indeed, all 10 selected farms were highly prolific and therefore the range of LBP was quite limited (15.01 to 16.41 LBP per litter).

Analysis of the scatterplot of PWM percentage in the Control and TPx group resulted in a trendline formule of y = 0.5581 x + 0.0129 with 85.61% of the changes in y (PWM supplementing TPx) that could be explained by changes in x (PWM under standard control situation). Application of this trendline formula in a simulation with control PWM ranging from 4.0 to 15.0% resulted in a presumed PWM supplementing TPx ranging from 3.52 to 9.66%. It could be observed that a gradual increase in PWM reduction was present with higher initial PWM. Based on these data both the number of extra piglets per litter and per 1000 piglets born could be calculated (Table 4). These data were used to calculate the minimal piglet market value for a ROI of 1, both in weaned piglets, which are not regularly sold onto the market under our local Belgian and Dutch conditions, and end-nursery piglets sold at 25 kg standard weight. Further comparison of these end-nursery piglet prices to the current piglet market prices (Flemish pig price, 20.09.2024) demonstrated that TPx supplementation can result in a positive ROI (ROI equal to or higher than 1) from 6.0% PWM onwards.

Conclusions

The administration of TPx from d2 to d8 during lactation resulted in a significant reduction of PWM in 10 farms under field conditions in Belgium and the Netherlands. Supplementation of TPx resulted in a positive ROI (= or > 1) when PWM at farm level was equal to or higher than 6.0% under current end-nursery piglet market prices.

Abbreviations

PWM: Pre-Weaning Mortality; TPx: Tonisity Px™; d2: Day 2 After Birth; d8: Day 8 After Birth; TBP: Total Born Piglets; LBP: Live Born Piglets; ROI: Return-On-Investment

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