TRIAL RESULTS

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WHAT SEVERAL NURSERY PIG TRIALS TELL US ABOUT BACILLUS SUBTILIS C-3102 AND PROFITABILITY

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Improvements in weaned pig body weight gain, feed/gain ratio, and livability (reduction in mortality + removals rate) from dietary inclusion of low cost and efficacious *Bacillus subtilis* C-3102 spores can enhance economic benefits.

Since about the 1980s, our scientific understanding of the application of direct-fed microbials (probiotics) to feed and/or drinking water of pigs has progressed tremendously. *Bacillus subtilis* C-3102, a robust, aerobic beneficial bacteria. was introduced as a feed additive for use in swine production in 1986 (CALSPORIN®, Calpis Co. Ltd, Tokyo, Japan). More than 30 years of experience in partnering with swine producers, has lead to reliable, consistent outcomes with this GRAS-listed direct-fed microbial. Its use has become more widespread globally over this time, and this product is considered to be one of the most widely used bacillus probiotics in animal agriculture in the world. At QTI, Inc. we have conducted and continue to conduct controlled pen trials and field trials to meet the ever-changing needs of the swine Industry. In this article, some relevant research is presented to help you evaluate the use and profitability of this product in your company.

SCIENCE-BASED PRODUCT

Despite modern facilities with their cleanliness, ventilation, and feeding and watering capabilities, and best management and biosecurity practices, weaned pigs are still exposed to some extent to excreta and urine, and pathogens that may be in air, feed or water, or carried from the farrowing facilities to nursery barns. These pathogens include a vast array of bacteria, such as clostridia and E. coli, and viruses with disease causing potential. It has become evident in recent years that gut health is extremely important for absorption of nutrients, immune responses, stress responses, repair of injuries to the intestinal mucosa caused by pathogens, and morbidity and mortality. *Bacillus subtilis* C-3102 was selected from 300 different beneficial bacteria, including bacillus strains, for survivability during steam pelleting, reduction in clostridia counts, better gut health, and improved live performance.

Based on academic research, some of the modes of action of dietary *Bacillus subtilis* C-3102 spores (CALSPORIN®) are known and include vegetating within the digesta of the intestinal tract, consuming oxygen thus making the digesta more anaerobic and favoring the proliferation of native Lactobacillus and Bifidobacteria species, synthesizing and releasing a number of important enzymes, improving calcium dynamics in bone (osteoblasts and osteoclasts), and enhancing the immune response of the host for better disease resistance.

In practical terms, these modes of action often translate into more nursery pig weight gain, better feed/gain ratios, better livability (lower mortality), and greater carcass and lean muscle yields, Interestingly, as a general rule, the more stressful the conditions under which testing has been done typically the greater will be the response (difference or improvement) in measured parameters for pigs on *Bacillus subtilis* C-3102 supplemented diets compared to those fed control basal diets. Besides pen trials, field trials under commercial conditions confirm these benefits.

TRIAL RESULTS: NURSERY PIGS

The results of 2 U.S. and 7 foreign pen trials with nursery pigs between 1996-2009 conducted to compare Control feeds with feed supplemented with CALSPORIN® at various levels are shown in Table 1. In the U.S., nursery pig trials were performed in Minnesota and foreign pen trials were carried out in Greece, Italy, Spain, and Japan.

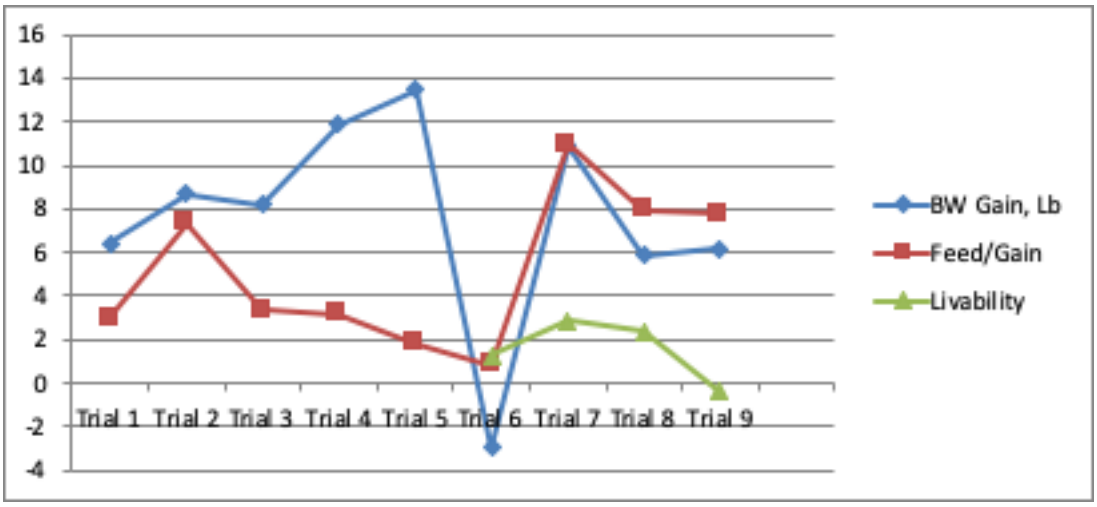
For statistical analysis, paired t-tests were done for body weight gain, feed/gain ratio, and mortality % to compare treatments. Nursery pigs fed the CALSPORIN®-supplemented diets had 1.89 lb greater body weight gain (*P*=0.004; 6.35%), lower feed/gain ratio (*P*=0.093; 5.35%), and less mortality + removals % (*P*=0.122; 26.9% lower than controls). The average initial weights by treatment were just under 17.5 lb per head, and the average feeding period lasted 31.1 days. This indicates that the direct-fed microbial has large positive benefits on weight gain and efficiency of feed utilization during the nursery phase. Consistent with findings of lower mortality during the growing-finishing period, these nursery trials with mortality data from only 4 of 9 studies nevertheless revealed improvement (*P*=0.122) when pigs were fed CALSPORIN®-supplemented diets compared to control basal diets.

Table 1. Nursery pig performance results from 9 comparisons of Control vs. Calsporin® diets (1996-2009)

Trial-Yr	Treatment	Calsporin® cfu/g feed	Initial Wt, lb	Wt Gain, lb	Days Fed	Feed/Grain	Morality, %
Japan96a	Control	0	23.81	33.52	28	1.865	—
Japan96a	Calsporin	1,000,000	23.81	35.68	28	1.809	—
Japan96b	Control	0	23.15	22.92	21	2.050	—
Japan96b	Calsporin	200,000	22.71	24.91	21	1.900	—
Japan96c	Control	0	21.61	20.88	21	1.780	—
Japan96c	Calsporin	200,000	21.38	22.59	21	1.720	—
Minn02a	Control	0	12.13	15.89	28	1.580	—
Minn02a	Calsporin	1,000,000	12.13	17.78	28	1.530	—
Minn02b	Control	0	12.13	14.86	28	1.630	—
Minn02b	Calsporin	1,000,000	12.13	16.86	28	1.600	—
Spain07	Control	0	12.50	36.35	42	1.408	4.20
Spain07	Calsporin	300,000	12.54	35.27	42	1.396	3.00
Greece08	Control	0	16.58	39.75	42	1.926	7.75
Greece08	Calsporin	300,000	16.58	44.07	42	1.715	5.13
Italy08	Control	0	17.42	45.57	28	1.508	3.00
Italy08	Calsporin	300,000	17.46	48.24	28	1.394	0.70
Greece0809	Control	0	17.55	38.18	42	1.882	6.48
Greece0809	Calsporin	300,000	17.53	40.54	42	1.736	6.84
Avg All 9	**Control**	**0**	**17.43**	**29.77**	**31.1**	**1.737**	**5.36**
Avg All 9	**Calsporin**	**511,111**	**17.36**	**31.66**	**31.1**	**1.644**	**3.92**
Difference			-0.07	+1.89	0	-0.093	-1.44
Rel. Diff, %			-0.40	+6.35	0	-5.35	-26.9
P value; Paired t-test			**0.244**	**0.004**	**—**	**0.003**	0.122

Note: The final body weight for Control pigs was 47.20 lb and for CALSPORIN® pigs was 49.02 lb.

Figure 1. Nursery pig % improvements in live performance parameters in 9 trials.



Average:
7.62%
5.09%
1.52%

Looking at economics, the benefit:cost ratio and return on the investment (or pure profit after deducting the cost of the additive) varies according to live performance, feed cost/ton, and live value of 12 lb. weaners and 40 lb. feeder pigs. The cost of the CALSPORIN® may vary as well due to pricing changes, quantity purchased, and delivery charges. Also, feed formulas, genetics, levels of inclusion of the supplement, and so on can cause variability in economics as well.

Historical data over about 3 year periods and provided by Iowa State University online was used as the economic basis for the profitability calculations (Table 2). The actual sales prices for 12 lb. weaner pigs and 40 lb. feeder pigs for the ~ 3-year periods and feed expense per lb. weight gain were used. The projected CALSPORIN® supplementation responses base on the 9 trial meta-analysis results provided the basis for performance improvements.

Table 2. Theoretical benefit:cost ratios and returns on investment in U.S. dollars using live performance meta-analysis results from 9 nursery pig trials (starter phase; 12 lb. weaner to 40 lb feeder; 28 lb. weight gain), Iowa State pig returns website (December, 2003-July, 2017) feed expense, total production expense, and weaner and feeder pig prices, and assumed CALSPORIN® cost (at inclusion rates providing on average 511,111 cfu/g feed).

Iowa State Website Values:						
Purchase date (12/2003 - 7/2017)	2003-2005	2006-2008	2009-2011	2012-2014	2015-2017	Average
Live sales price, $/lb. @12lb	2.9408	2.9342	3.1183	3.9142	3.1250	3.2267
Feed expense, $/lb. BW Gain	0.25107	0.28107	0.32571	0.42321	0.35214	0.33107
Total prod cost, $/lb. BW Gain	0.44214	0.51536	0.59893	0.72679	0.68250	0.60071
Live sales price, $/lb. @40lb	1.6838	1.4435	1.6495	1.8358	1.3545	1.5948
CALSPORIN® Supplementation:						
Benefit: cost ratio, $	47.0:1	38.0:1	43.4:1	46.4:1	32.6:1	41.4:1
Return on investment, $	46.0:1	37.0:1	42.4:11	45.4:1	31.6:1	40.4:1

Note: These economic returns are due to live performance improvement benefits in body weight gain, feed/gain ratio, and livability with CALSPORIN®-supplemented feeds as well as the relatively low cost of this direct-fed microbial product ($2.164 extra cost per ton providing 511,111 cfu/g. feed assumed based on $1.27 for 300,000 cfu/g. feed), and actual weaner and feeder pig prices. An Excel spreadsheet model was used to facilitate the calculations.

This economic analysis (exercise) revealed that with the live performance improvements (9-trial meta-analysis), large benefit:cost ratios and returns on investment occurred when using Iowa State pig returns data from 2003-2017. This was partly due also to the relatively low cost of *Bacillus subtilis* C-3102 (CALSPORIN®) per ton of feed. The bottom line is -- the product works consistently well and is very profitable during the weaner to feeder pig phase. Contact your QTI, Inc. representative for more information, pricing, or for a demonstration trial.

Nursery Pig 9-Trial Meta-Analysis Performance and Economics by Treatment (Spreadsheet Model)

Control basal feeds (0) versus CALSPORIN® 511,111 cfu/g feed

Parameters	Negative Control	CALSPORIN®	
Head Placed Per Week	1,500	1,500	(Final pig weights 47.20 and 49.02 lb, respectively; 31.1 days)
Body Weight Gain, lb	29.77	31.66	
Livability, %	94.64	96.08	
Feed/Gain Ratio	1.737	1.644	
Total BW Gain, lb	44,655	47,490	$2.164 extra cost per ton for CALSPORIN® (511,111 cfu/g)
Total Feed, lb	77,566	78,074	
Feed Expenses, $/lb BW Gain	0.33107	0.33295	
Total Feed Expenses, $	14,784	15,812	
Estimated Feed Cost, $/ton	381.20	383.36	
Live Value @40lb, $/lb	1.5948	1.5948	
Total Live Value, $	71,216	75,737	
Net: Live Value - Feed, $	56,432	59,925	
Diff. from Neg Control, $	0	3,493	
Total Cost of Additive, $	0	84	
Benefit: Cost Ratio		41.4:1	
Return on Investment (ROI)		40.4:1	
Note: Return on investment (ROI) is calculated by reducing benefit side by 1.00 to account for the cost of the additive at 1x dose, meaning the inclusion rate used.			

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