Patent-Pending ADM Energy Burst™ has Beneficial Impact on Nursery Performance

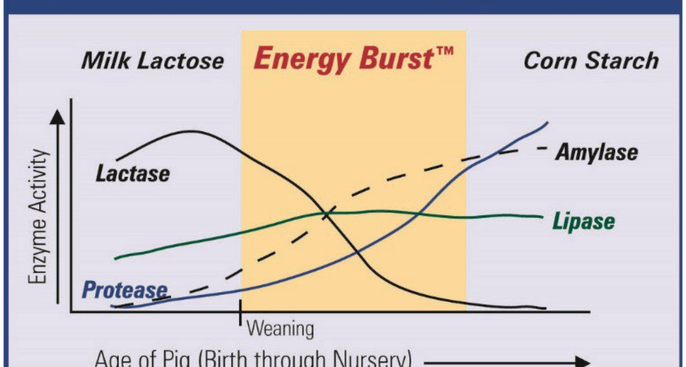
A successful nursery feeding program is designed to optimize performance and maximize profitability of nursery pigs and subsequent grow-finish production. Since digestive systems of weanling pigs are not well developed, these pigs need a complex diet comprised of highly digestible energy and protein ingredients. Milk ingredients and crystalline lactose are often used as highly digestible energy (lactose) sources in early nursery diets. The ADM Animal Nutrition™ research team has shown modified starches can be successfully used as alternative energy sources in nursery diets. The result of ADM research has led to the commercialization of several modified starches in a patent-pending product – Energy Burst™. Application of this use patent to include these modified starches in livestock and poultry feeds is the result of ADM's on-going innovative research.

Carbohydrate Digestion

The newly-weaned pig obtains energy from dietary carbohydrates which are broken down by specific enzymes in the gastro-intestinal tract. The enzymes involved in digestion of carbohydrates are lactase, amylase, trehalase, maltases (sucrase, isomaltase, maltase II and maltase III), and possibly dextrinase (if it exists in animals).

After weaning enzyme secretion changes dramatically in the young pig (see Figure 1). Activity of enzymes involved in digestion of starch and other carbohydrates (amylase, maltases, trehalase and dextrinase) is lower before and shortly after weaning than that of lactase (the lactose enzyme). As weanling pigs mature, lactase activity decreases whereas other carbohydrases increase. As a result, diets provided to early-weaned pigs typically contain a source of lactose (either through milk products or crystalline lactose). Since milk ingredients are expensive, researchers have sought other carbohydrates which would still provide satisfactory performance in early-weaned pigs. Some alternative carbohydrate sources may not be quite as digestible as lactose, yet are more digestible than the starch contained in corn, oats, or other feed ingredients.

Figure 1 Enzyme Development in Young Pigs



Osmolarity and Water Absorption

Osmolarity is defined as the concentration of osmotically active particles in solution, which may be quantitatively expressed in osmoles of solute per liter of solution. Osmolarity is one of many factors that affect water movement in the gastro-intestinal tract. Osmolarity is negatively correlated with water absorption. As osmolarity of gut digesta fluid increases, less water is absorbed into the body. When osmolarity of gut digesta fluid is higher than that for plasma, the body does not absorb any water. Instead water is drawn into the gastro-intestinal tract, resulting in animal dehydration. When water intake is inadequate, osmolarity of gut digesta fluid increases and, in many situations, may be higher than that for plasma. As a consequence, dehydration in the pig occurs. This may partially explain why it is common to observe dehydration when pigs experience heat stress or when pigs (especially weaning pigs) are transported a long distance.

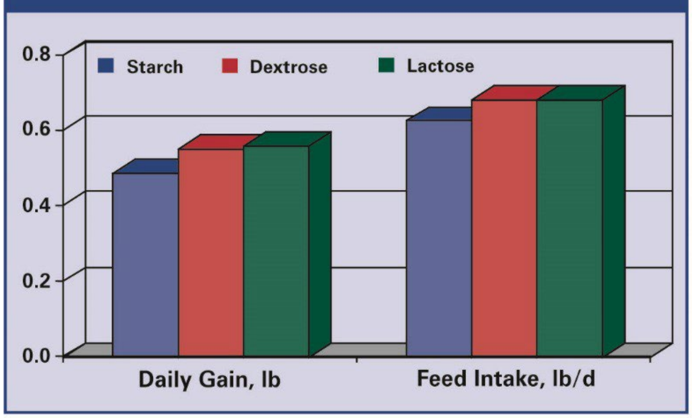
To reduce osmolarity and the accompanying dehydration, a combination of modified starches is beneficial in comparison with the use of dextrose as the sole carbohydrate source. Dextrose is the generic term for glucose monohydrate, which in essence is pure glucose with one molecule of water. Osmolarity is dependent on the number of particles in a solution. The shorter chain a carbohydrate has, the higher it raises the solution's osmolarity. Therefore, it is no surprise that a pure dextrose solution has a higher osmolarity than a solution with several modified starches when the same amount (on a weight basis) of total carbohydrates is dissolved in the solutions.

Swine Research Performance Data

Dextrose Effect on Nursery Performance

The Ohio State University evaluated efficacy of three carbohydrate sources (corn starch, corn dextrose, and crystalline lactose) in a nursery trial. The study used 504 pigs (weaning age of 23 days and weight of 12.8 lb) with 24 replicate pens per treatment. The three carbohydrates were tested at 12% dietary inclusion level in the first two-weeks post-weaning. After 14 days on test, all pigs were fed a common diet. The first 14-day basal diets contained 45% dried skim milk, which provided 22.5% lactose. During the first two-weeks post-weaning, adding 12% dextrose or 12% lactose to the basal diet significantly improved daily gain and feed intake ($P < 0.05$) in comparison to adding 12% corn starch (see Figure 2). No performance differences were observed between pigs fed dextrose and lactose supplemented diets. This suggested that both dextrose and lactose were highly available energy sources for newly-weaned pigs, while corn starch was not.

Figure 2 Effect of Carbohydrate Sources on Daily Gain and Feed Intake of Pigs During the First Two-weeks Post-weaning



Effect of Three Modified Starches on Nursery Performance

Modified Starch A (MS-A)

ADM Animal Nutrition conducted two nursery trials to evaluate whether modified starch A (MS-A) could be used to replace dietary lactose. In the first study (Exp. 5732), replacing 50% lactose by MS-A did not have any negative effects on performance in Phase 1 (15 to 25 lb weight range; see Table 1). However, complete replacement of dietary lactose by MS-A decreased daily gain in Phase 1, but had no negative effect on any performance measurements in Phase 2 (25 to 45 lb weight range). In the second ADM study (S03114), 48 Newsham[†*] weaning pigs (weighing 11.6 lb) were assigned to one of two dietary treatments:

1) Control with whey as the only lactose source
2) MS-A replacing lactose 50% in the diet

There were six pens per treatment with four pigs per pen. The trial consisted of three phases, with 13, 13, and 10 days, respectively. In Phase 3, all pigs were fed a common meal diet containing no lactose or MS-A. Replacing lactose 50% with MS-A did not affect daily gain or feed intake in Phase 1 and overall ($P > 0.10$; see Table 2), but it had a negative effect on feed efficiency in Phase 1. Overall feed efficiency (Phase 1 to 3) and body weight throughout the study were not affected by dietary treatments ($P > 0.10$). Collectively, results from the two ADM studies suggested that without compromising performance, MS-A could be used to replace lactose up to 50% in diets fed to pigs from weaning to 25 lb body weight and could be used to replace lactose 100% in diets fed to pigs heavier than 25 lb.

Modified Starch B (MS-B)

In ADM nursery study S07113, 120 weaning pigs (Newsham Choice Genetics, EB x GP37; initial weight of 11.4 lb) were housed in 24 pens with five pigs per pen. All pigs were transported four hours before the start of the trial at weaning. Pigs were assigned to one of four dietary treatments:

1) Positive control (PC)
2) Negative control (NC)
3) NC + MS-B at low inclusion level
4) NC + MS-B at high inclusion levels.

Positive control diets contained 8% and 6% units higher lactose than those for NC diets in Phase 1 and 2, respectively. Modified starch B inclusion levels were 4.3% vs. 8.6% for low and high level treatments in Phase 1 and 3.2% vs. 6.4% in Phase 2. Phases 1, 2, and 3 were 7, 14 and 11 days, respectively. In Phase 3, all pigs were fed a common diet containing no lactose or modified starches. Diets were offered in pellet form in Phase 1 and meal thereafter.

Daily gain and feed efficiency were similar for pigs fed PC and NC diets in Phase 1 and overall ($P > 0.10$; see Table 3). This suggested a limited positive effect on nursery performance when dietary lactose was increased by 8% units in the first week post-weaning and 6% units in the second and third weeks post-weaning. Increasing dietary MS-B levels tended to have a quadratic effect on overall daily gain ($P = 0.09$). Compared with pigs fed NC diets, pigs fed low levels of MS-B had a greater overall daily gain while pigs fed high levels of MS-B had similar daily gain. As a consequence, pigs fed MS-B at low inclusion levels weighed 1.5 lb more than pigs fed NC diets. These data provided evidence to show efficacy of MS-B as an energy source in nursery diets to improve performance.

Modified Starch C (MS-C)

Modified starch C was used to replace dietary lactose at five different levels: 0, 15, 30, 45, and 60%. Each of the five treatment diets were fed to 35 pigs, which were housed in seven pens. The study (S02108) had three phases (6, 19, and 11 days). Experimental diets were fed during the first two phases and a common meal diet was fed to all pigs in the last phase. Substituting MS-C for lactose up to 60% did not have any negative effect on daily gain in Phase 1 and overall (see

Table 4). Increasing substitution rates did not affect Phase 1 feed efficiency, but had negative effect on overall feed efficiency. Negative effect on feed efficiency seemed to occur at the highest substitution rate (60%). This data indicated MS-C may partially substitute for dietary lactose without compromising performance and can be used in swine nursery diets if it is more cost-effective.

Energy Burst Effect on Nursery Performance

ADM Animal Nutrition evaluated Energy Burst using two different pig genetic lines at two Swine Research Facilities. In ADM nursery study S06119, 175 weaning pigs (Newsham Choice Genetics, EB x GP37; initial weight of 10.8 lb) were used to determine whether increasing dietary Energy Burst inclusion levels improved nursery performance. All pigs were transported four hours before the start of the trial at weaning. This study had seven pens with 35 pigs per treatment. The five dietary treatments were:

1) Positive control (PC)
2) Negative control (NC)
3) Energy Burst at low level
4) Energy Burst at medium level
5) Energy Burst at high level

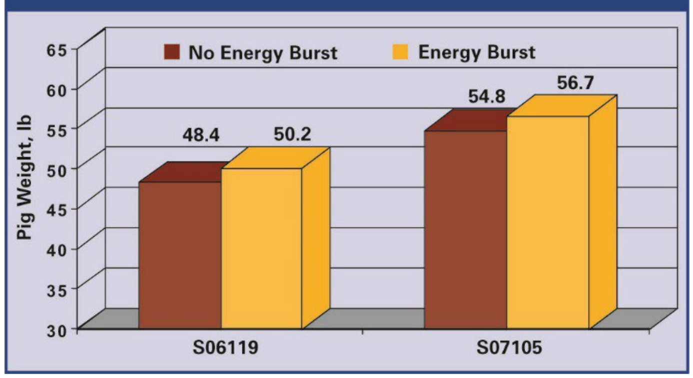
Lactose differences between PC and NC diets were 3% and 1.9% units in Phase 1 and 2. Phases 1, 2, and 3 were 6, 15 and 15 days, respectively. All pigs were fed a common diet containing no lactose or Energy Burst in Phase 3. Diets were offered in pellet form in Phase 1 and meal thereafter.

Adding proper levels of Energy Burst in the diets were beneficial to daily gain and feed efficiency for the first six days post-weaning (see Table 5). Pigs fed medium and high levels of Energy Burst improved Phase 1 daily gain by 25% and 20.8% in comparison with pigs fed the NC diet. The daily gain improvements were greater than that (16.7%) achieved by increasing lactose level by 3% units from the NC diet in Phase 1. Feed efficiency improvement (16.2%) from feeding medium level of Energy Burst was greater than that (8.3%) obtained through increasing lactose level in Phase 1, although the feed efficiency improvement from feeding high level of Energy Burst and from increasing dietary lactose was similar. Collectively, these data demonstrated that Energy Burst was a highly available energy source and improved performance of nursery pigs in Phase 1. Daily gain and feed efficiency improvement was greater in this study than that observed in the other study S07115 (see Table 3). A major difference between the two studies was: More than one modified starch was included in the diets of this study. Therefore, it is suggested that including more than one modified starch may be more beneficial than only using one modified starch in swine nursery diets.

Overall daily gain was greater by 3% to 6% for pigs fed either one of the three Energy Burst treatments than for pigs fed the NC diets. At the end of the 36-day study, pigs fed low, medium, and high levels of Energy Burst were 1.4, 1.1, and 1.8 lb heavier, respectively, than pigs fed the NC diets. On the other hand, overall daily gain and feed efficiency were numerically poorer for pigs fed PC diets than for pigs fed NC diets. These data indicated a positive performance response to dietary addition of Energy Burst even when dietary lactose increase did not generate overall positive responses.

This study (S06119) was repeated as S07105 at ADM Animal Nutrition's research facility at Mendon, IL, using 140 PIC pigs (C22 x 327) with an average weaning age of 17 days and weaning weight of 10.2 lb. There were six pens with 24 pigs per treatment in trial S07105. The same five treatments and experimental diets as S06119 were adopted. Increasing dietary lactose did not improve daily gain throughout the study, but improved feed efficiency by 5.3% in Phase 1 (6 days) and by 4.4% for the overall 42-day period. Compared with pigs fed NC diets, pigs fed low level of Energy Burst improved overall daily gain by 5.6% and overall feed efficiency by 5.5%. Greater daily gain resulted in 1.9 lb heavier exit weight for pigs fed low level of Energy Burst (see Figure 3). These data confirmed the findings from the previous study that proper level of Energy Burst improved daily gain and feed efficiency of nursery pigs, and these positive effects were observed even when pigs had a limited positive response to increased dietary lactose levels. This implies that Energy Burst may have other modes of action which help improve nursery performance beyond serving as a rapidly available energy source.

Figure 3 Effect of Feeding Energy Burst on Final Weight of Nursery Pigs



Based on human research findings, two additional modes of action are theorized. First, diets containing modified starch A (MS-A) and B (MS-B) cause lower osmolarity increase in gut digesta fluid than diets containing MS-A but no MS-B, resulting in more water absorption into the body's blood stream. Second, diets containing more sugar substrates (lactose, MS-A, MS-B, and other modified starches) may stimulate more carbohydrate transporters in the gastro-intestinal tract than diets containing just lactose, leading to greater absorption of different sugars into the body to serve as energy. Furthermore, it has been shown that feeding MS-A and MS-B together improved digestibility of gross energy and ash of the complete diets fed to nursery pigs.

Conclusion and Implication

Energy Burst is an ADM patent-pending product containing several modified starches. Major individual components of Energy Burst have been shown to be readily available energy sources. Swine nursery studies conducted by ADM Animal Nutrition have shown that Energy Burst improved growth performance and feed efficiency of nursery pigs. Based on two ADM studies, average nursery exit weight was up to 1.8 lb heavier for pigs fed Energy Burst, in comparison to pigs fed no Energy Burst. Feeding Energy Burst can offer benefits beyond feeding individual components in swine nursery diets. The performance improvement from feeding Energy Burst may be independent of dietary lactose levels.

Table 1. Performance of Pigs Fed Modified Starch A (MS-A) as a Partial or Complete Substitute for Lactose in Nursery Diets

	MS-A Substitution for Lactose (%)			SE	P value	
	0%	50%	100%		Linear	Quadratic
Daily Gain, lb						
Phase 1	0.88	0.89	0.84	0.04	0.03	0.16
Phase 2	1.12	1.12	1.09	0.05	0.91	0.67
Feed/Gain						
Phase 1	1.26	1.26	1.26	0.02	0.89	0.90
Phase 2	1.45	1.45	1.48	0.01	0.18	0.55

Initial weight: 15.3 lb, 12 pens per treatment, and 5 pigs per pen. Phase 1 – 15 to 25 lb weight. Phase 2 – 25 to 45 lb weight.
Source: ADM Animal Nutrition Research Exp 5732.

Table 2. Performance of Pigs Fed Modified Starch A (MS-A) as a Partial Substitute for Lactose in Nursery diets

	MS-A Substitution for Lactose (%)		SE
	0%	50%	
Daily Gain, lb			
Phase 1, 13 days	0.48	0.44	0.02
Phase 1 to 3, 36 days	1.03	1.02	0.03
Feed Intake, lb/d			
Phase 1, 13 days	0.53	0.57	0.02
Phase 1 to 3, 36 days	1.37	1.34	0.03
Feed/Gain			
Phase 1, 13 days	1.09^{A}	1.27^{B}	0.03
Phase 1 to 3, 36 days	1.33	1.37	0.02

Initial weight: 11.6 lb, 6 pens per treatment, and 4 pigs per pen.
AB: $P < 0.05$.
Source: ADM Animal Nutrition Research S03114.

Table 3. Effect of Modified Starch B (MS-B) Levels on Nursery Performance							
	PC*	NC*	MS-B @ 4.3/3.2%	MS-B @ 8.6/6.4%	SE	P value for MS-B Linear	P value for MS-B Quadratic
Daily Gain, lb							
Phase 1, 7 days	0.50	0.51	0.50	0.50	0.04	0.82	0.86
Overall, 32 days	1.08	1.04	1.11	1.06	0.03	0.64	0.09
Feed/Gain							
Phase 1, 7 days	0.98	0.97	1.00	0.96	0.05	0.93	0.59
Overall, 32 days	1.28	1.30	1.27	1.27	0.02	0.26	0.63

*PC stands for positive control and NC for negative control. Numbers after MS-B were inclusion levels of MS-B in Phase 1 and 2.
Initial weight: 11.4 lb, 6 pens per treatment, and 5 pigs per pen
Source: ADM Animal Nutrition Research S07113

Table 4. Performance of Pigs Fed Modified Starch C (MS-C) as a Partial Substitute for Lactose in Nursery Diets							
	MS-C Substitution for Lactose (%)						
	0%	15%	30%	45%	60%	SE	P value
Daily Gain, lb							
Phase 1, 6 days	0.32	0.33	0.29	0.33	0.31	0.02	
Overall, 36 days	1.09	1.08	1.08	1.08	1.08	0.03	
Feed:Gain							
Phase 1, 6 days	0.98	0.97	1.00	0.98	1.04	0.05	
Overall, 36 days	1.29	1.31	1.30	1.29	1.32	0.01	A

A = MS-C cubic effect, $P < 0.10$.
Source: ADM Animal Nutrition Research S02108

Table 5. Effect of Energy Burst Levels on Performance of Nursery Pigs									
			Energy Burst				P value for Energy Burst		
	PC*	NC*	Low	Medium	High	SE	Linear	Quadratic	Cubic
Daily Gain, lb									
Phase 1, 6 days	0.28	0.24	0.22	0.30	0.29	0.03	0.12	0.97	0.21
Overall, 36 days	1.03	1.04	1.08	1.07	1.10	0.03	0.25	0.81	0.58
Feed/Gain									
Phase 1, 6 days	1.33	1.45	1.78	1.21	1.33	0.19	0.31	0.59	0.08
Overall, 36 days	1.36	1.34	1.32	1.35	1.31	0.02	0.57	0.55	0.33

* PC stands for positive control and NC for negative control.
Initial weight: 10.8 lb, 7 pens per treatment, and 5 pigs per pen
Source: ADM Animal Nutrition Research S06119

References available upon request.

†Not a trademark of ADM.

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