Effect of the water acidifier BIO SAVOR™ on postweaning pig performance

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Summary: *In two sequential trials, a total of 192 3-week-old pigs, each weighing approximately 6 kg (13.23 lb), were allocated within a randomized complete block design to a drinking water treatment of either 0 mL per L (control), 1.95 mL per L, 3.91 mL per L, or 5.86 mL per L BIO SAVOR™. On days 0, 7, 14, 21 and 31 (or 32) of the trial, bodyweights were recorded, uneaten feed was weighed and credited to the pen, and water disappearance for each treatment was recorded. Adding 1.95 mL per L BIO SAVOR™ to the drinking water of weaned pigs increased daily feed intake 73 g per day (13.25%) (P=.002) and daily gain 51 g per day (14.78%) (P=.003), but not gain:feed (P=.695).*

Adding organic acids to starter diets improves pigs' performance.[1–7] Burnell, et al.,[4] demonstrated that a 2:1 mixture of citric acid and sodium citrate improved the growth rate to a greater extent in pigs fed a simple corn-soybean meal-based ration than in those fed a diet based on corn-soybean meal with 15% edible grade dried whey added. This improved growth rate may result from the lowered pH of the gut contents of pigs consuming organic acids. The reduction in stomach pH may enhance the proteolytic activity of pepsin,[8] change the enteric bacterial population,[9] and/or improve the pig's response to commonly used growth promoters. To date, organic acids have most commonly been incorporated in feed. However, by providing the flavoring agents and fatty acids in the water with the organic acids, pigs are consuming a readily available energy source as soon as they are weaned. An additional benefit of having organic acids in the drinking water may ensue from the bacteriocidal or bacteriostatic effects of the low pH.

BIO SAVOR™ is a pH-adjusting solution consisting of a proprietary mixture of lactic acid, acetic acid, sorbic acid, benzoic acid, mono- and diesters of fats and fatty acids, saccharin, propylparaben, methylparaben, and phosphoric acid. The objectives of this research were to determine:

- the growth efficiency of pigs fed three levels of BIO SAVOR™ in the water, and
- whether the expected improved growth efficiency of BIO SAVOR™ is associated with water bacterial counts.

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Materials and methods

Experimental design

In late 1993 and early 1994, we conducted two trials sequentially, the first for 31 days and the second for 32 days. Each time, we allocated 96 crossbred (white line sows × PIC Line 326 boars) pigs, 3 weeks old and weighing approximately 6 kg (13.23 lb), to one of four treatment groups:

- 0 mL per L BIO SAVOR™ added to water (control);
- 1.95 mL per L (.25 oz per gal) BIO SAVOR™ added to water;
- 3.91 mL per L (.5 oz per gal) BIO SAVOR™ added to water; or,
- 5.86 mL per L (.75 oz per gal) BIO SAVOR™ added to water.

Pigs were stratified by weight and gender within six weight blocks, assigned to one of the four treatment groups, and housed in groups of four. Thus, within blocks, pens were balanced for weight and gender. The trial occupied one nursery room for a total of 48 pens, 12 replicates. Nursery pens were 0.92m × 1.83m (3ft × 6ft) with woven wire floors. Maximum and minimum ambient temperatures were recorded daily at pig level in both trials.

Water sampling

The water was continuously delivered, first through water meters, then through proportioners. On days 0, 7, 14, 21, and 31 (or 32), water was aseptically sampled (Total Count sampler paddles, Millipore Corp, Bedford, Massachusetts) at the drinking nipple. Colonies were isolated from the paddles and streaked on trypticase soy agar and incubated for 24 hours. The last two samples of the second trial were processed at another laboratory where 1 mL of water was mixed into agar, then poured into a plate that was incubated for 24 hours and heterotrophic plate counts reported.

For the first and second trials, pigs were fed first a total of 226.8 kg (500 lb) of a commercial ration (McNess Pig Ignitor-AP, code

6301, Furst-McNess Company/Miracle Feeds, Inc., Freeport, Illinois), lysine 1.5%; then 226.8 kg (500 lb) of a lower lysine, 1.29% commercial ration (McNess Pig Pre-Launcher Pellets-AP, code 6305, Furst-McNess Company/Miracle Feeds, Inc., Freeport, Illinois); and finally a 1.2% lysine commercial ration (Southern States 655-510, Southern States Cooperative, Richmond, Virginia) (Table 1).

Table 1

Ration ingredients

Ration:	6301	6305	655-510
Cereal grain	34.1%	45.7	50.0
Soy protein	10.6	26.3	12.5
Lactose	25.5	11.0	11.0
Added fat	5.2	5.0	2.0
Fishmeal	5.0	2.5	0.0
Added lysine	0.16	0.12	0.12
Total lysine	1.5	1.29	1.2
Copper sulfate	0.1	0.1	0.1
Apralan	0.1	0.1	0.0
Mecadox	0.0	0.0	0.25

On days 0, 7, 14, 21, and 31 (or 32) of the trial, bodyweights were recorded, uneaten feed was weighed and credited to the pen, and the water disappearance for each treatment was measured from the water meter and recorded. We did not record water disappearance by pen, only by treatment. Also, feed conversion and growth rate were calculated on a per-pen basis.

Analysis

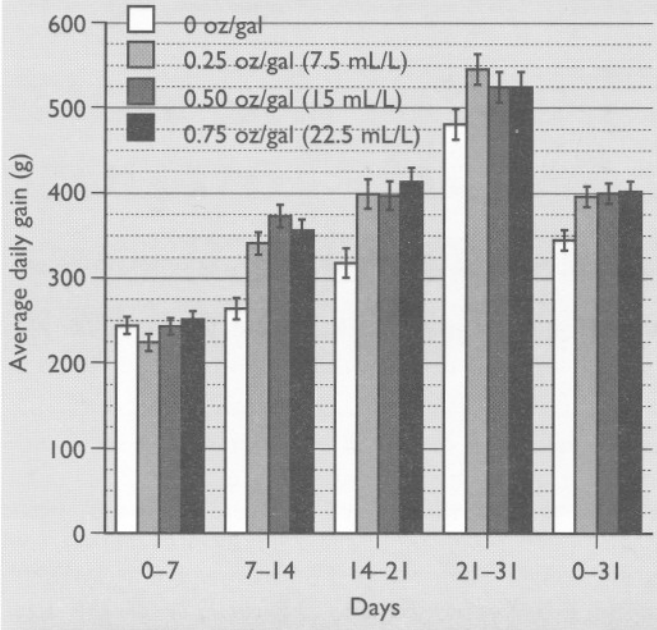
Results were analyzed using the GLM procedure of SAS.[10] The effects of treatment, trial, and replicate were included in the model. To test dose response, a contrast statement was included to determine the appropriateness of a linear, quadratic, or cubic polynomial model. Means were calculated for

- average daily gain (ADG) (g per day),
- average daily feed intake (ADFI) (g per day), and
- gain:feed (GFR) (g per kg).

Results and discussion

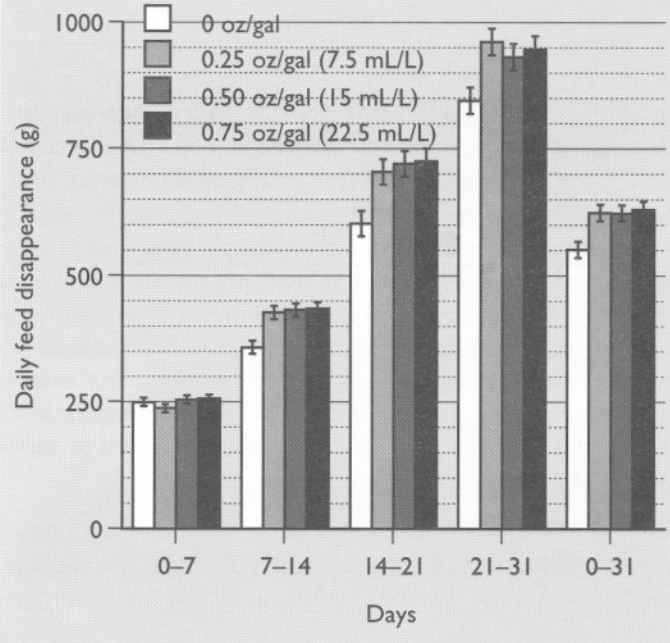
Adding BIO SAVOR™ to the water of pigs in the first month postweaning increased ADFI (P=.002) (Figure 1) and ADG (P=.003) (Figure 2). In the first week, the treatments increased neither ADFI (P=.297) nor ADG (P=.274). The increased ADG in the second (P=.000) and third (P=.005) week was associated with the increased ADFI in the second (P=000) and third (P=.005) week. However, ADFI also increased in the fourth week without increasing ADG (P=.107). These data suggest that BIO SAVOR™ may need to be added only in the second and third week postweaning. Overall, including BIO SAVOR™ did not increase the GFR (Figure 3). However, during the second week, adding 3.91 mL per L (0.5 oz per gal) BIO SAVOR™ increased the GFR (122 g per kg) compared to the control.

Figure 1



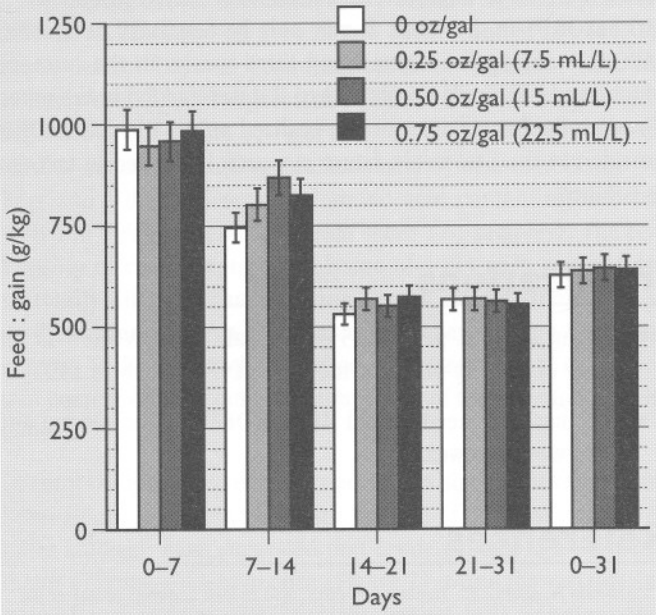
Impact of BIO SAVOR™ on average daily gain (g/d) for the combined trials. Values are means of 12 pens (six pens each in two separate trials) each containing four pigs and averaging 6.36 kg initially. BIO SAVOR™ was applied through a water proportioning system to provide the designated concentrations.

Figure 2



Impact of BIO SAVOR™ on average daily feed disappearance (g/d) for the combined trials. Values are means of 12 pens (six pens each in two separate trials) each containing four pigs and averaging 6.36 kg initially. BIO SAVOR™ was applied through a water proportioning system to provide the designated concentrations.

Figure 3



Impact of BIO SAVOR™ on gain:feed (g/kg) for the combined trials. Values are means of 12 pens (six pens each in two separate trials) each containing four pigs and averaging 6.36 kg initially. BIO SAVOR™ was applied through a water proportioning system to provide the designated concentrations.

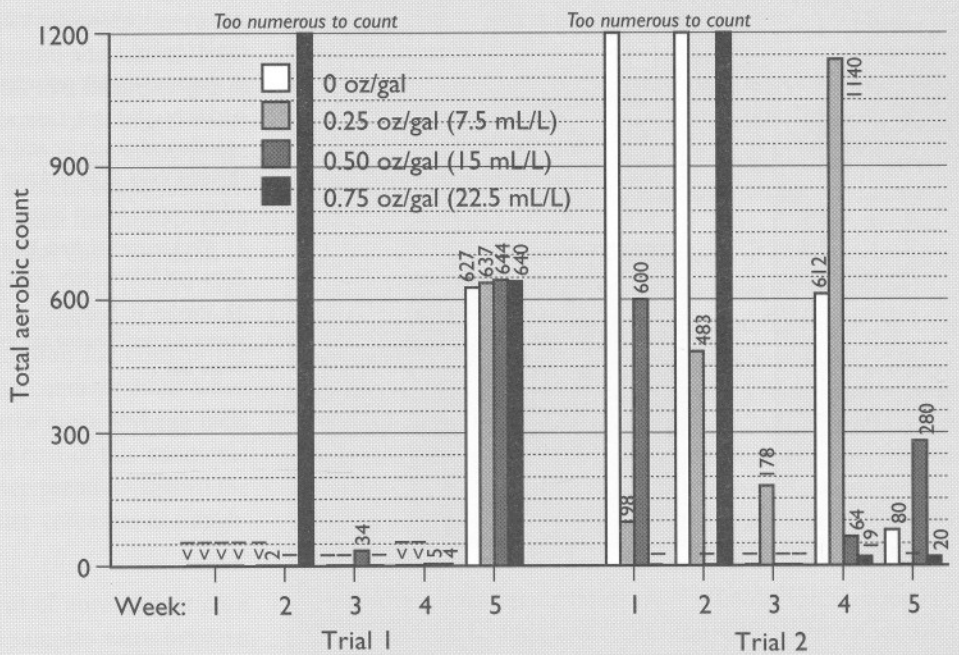
Although the dose responses for ADFI and ADG were significant ($P<.05$) for both linear and quadratic models, the data indicate that a quadratic response is more appropriate. Overall, the only increase in ADFI (73 g per day, 13.25%) and ADG (51 g per day, 14.78%) resulted from adding 1.95 mL per L (0.25oz per gal) BIO SAVOR™. Thereafter, increasing BIO SAVOR™ concentration to 3.91 mL per L (0.5 oz per gal) or 5.86 mL per L (0.75 oz per gal) improved neither ADFI nor ADG.

The mode of action for organic acids to improve growth rate and efficiency is poorly understood. Kirchgessner and Roth,[11] reviewing fumaric acid as a feed additive, suggested that energy metabolism was little effected but nitrogen balance was improved 5%–7%. They suggested that fumaric acid probably assists the immature digestive process of young piglets by decreasing the pH of the stomach, thus promoting peptic activity and, hence, protein digestion. In our study, the improvement in ADG is consistent with Giesting and Easter,[3] who demonstrated a 13.4% improvement in ADG when 3% fumaric acid is added to a corn-soybean meal diet. However, in some studies, the response to adding organic acids depends on the complexity of the base diet. Weeden, et al.,[12] demonstrated that the digestibility of diets high in milk products did not benefit from adding organic acids to the diet. In contrast, Giesting, et al.,[6] demonstrated that adding 3% fumaric acid to soy-based diets yielded a 4.4% improvement in ADG, whereas adding 3% fumaric acid to casein-based diets yielded a 13% improvement in ADG.

The 14.78% improvement in ADG reported here is greater than the responses demonstrated by other researchers. Burnell, et al.,[4] demonstrated a 9.4% increase in ADG only with a basic corn-soybean meal diet. Falkowski and Aherne[1] recorded only small and nonsignificant increases in ADG (4% after adding fumaric acid and 7% after adding citric acid to a complex diet including dried skim milk). Edmonds, et al.,[2] noted an improved feed conversion but no improvement in ADG from complex diets supplemented with both copper sulfate and ASP (110 mg per kg chlortetracycline, 55 mg per kg penicillin, and 110 mg per kg sulfamethazine). Interestingly, all three of the research groups cited above weaned piglets at the 4 weeks. Although we did not record an improvement in ADG until the second week after pigs were weaned at 3 weeks, it may be necessary for them to drink the BIO SAVOR™ in the fourth week of age to ensure a subsequent response. Finally, Giesting and Easter,[3] Burnell, et al.,[4] Falkowski and Aherne,[1] and Edmonds, et al.,[2] all demonstrated an improvement in GFR from feeding organic acids that was not observed in the present study.

BIO SAVOR™ contains no fumaric acid but a mixture of chemicals that should decrease stomach pH and provide a source of readily digestible nutrients. The combination of chemicals BIO

Figure 4



Microbial data from trials 1 and 2.

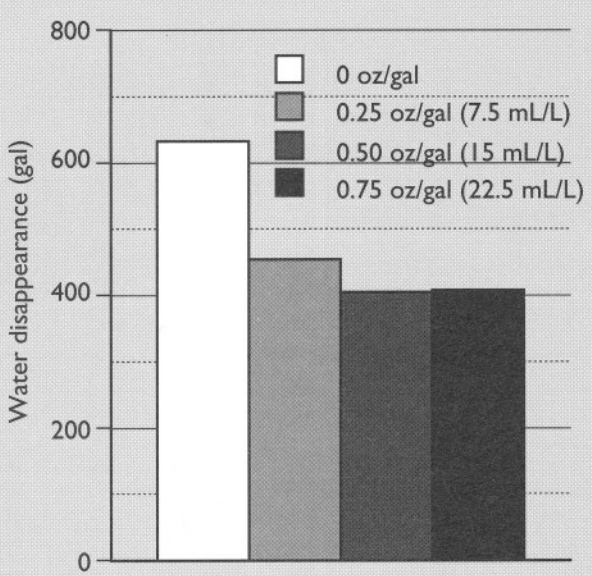
SAVOR™ provided in addition to the basal diet could explain some of the improvement in ADG with the complex diet we fed (the control diet was not decreased in energy to compensate for the energy available from BIO SAVOR™). Also, diet acidification may have other metabolic effects not accounted for by changes in nutrient digestibility. Giesting, et al.,[6] demonstrated that adding sodium bicarbonate to an acidified, casein-based diet improved gain and GFR, though adding acid alone had little effect. Also, Krause, et al.,[5] demonstrated a 13.3% improvement in ADG from adding 2.5% fumaric acid and 2.3% $NaHCO_3$ to a simple corn-soy-based diet.

The effect of BIO SAVOR™ treatments on water bacterial counts was highly variable. We could not determine a trend and therefore assume that BIO SAVOR™ had no bacteriostatic/bacteriocidal effects (Figure 4). Hence, the increase in ADFI and ADG does not appear to be due to differences in water bacterial concentrations among the treatments. However, Cole, et al.,[9] demonstrated that a 0.8% lactic acid solution, applied for 4 weeks to the diet of pigs weaned at about 8 weeks of age, eliminated hemolytic *Escherichia coli* and reduced the count of organisms in the intestinal contents compared with nontreated controls. Thus, the differences in ADG may still be due to a bacteriostatic/bacteriocidal effect of BIO SAVOR™ in the gastrointestinal tract but, in this trial, not in the drinking water.

Water disappearance averaged over the two trials was variable (Figure 5). These differences may be due either to increased water wastage or consumption by the control pigs, or to decreased wastage or consumption by BIO SAVOR™-treated pigs.

These data indicate that ADG for nursery pigs can be increased 51 g per day in the first month postweaning by adding 1.95 mL per L (0.25 oz per gal) BIO SAVOR™. This response did not appear to be attributable to any bacteriostatic/bacteriocidal properties of BIO SAVOR™ in the water. It may only be necessary to add BIO SAVOR™ during the second and third weeks in the nursery, which would be easily accomplished if it were added to the water. However, the benefits may not be realized unless BIO SAVOR™ is provided in the first week; future research is needed to test this possibility.

Figure 5



Impact of BIO SAVOR™ on water disappearance for the combined trials. BIO SAVOR™ was applied through a water proportioning system to provide the designated concentrations.

Implications

- Adding 1.95 mL per L (.25 oz per gal) BIO SAVOR™ to the water of nursery pigs may increase ADG as much as 15%.
- You may only need to add BIO SAVOR™ in the second and third week postweaning.

References

1. Falkowski JF, Aherne FX. Fumaric and citric acid as feed additives in starter pig nutrition. *J Anim Sci.* 1984; 58:935-938.

2. Edmonds MS, Izquierdo OA, Baker DH. Feed additive studies with newly weaned pigs: Efficacy of supplemental copper, antibiotics and organic acids. *J Anim Sci.* 1985; 60:462-469.

3. Giesting DW, Easter RA. Response of starter pigs to supplementation of corn-soybean meal diets with organic acids. *J Anim Sci.* 1985; 60:1288-1294.

4. Burnell TW, Cromwell GL, Stahly TS. Effect of dried whey and copper sulfate on the growth responses to organic acid in diets for weanling pigs. *J Anim Sci.* 1988; 66:1100-1108.

5. Krause DO, Harrison PC, Easter RA. Characterization of the nutritional interactions between organic acids and inorganic bases in the pig and chick. *J Anim Sci.* 1994; 72:1257-1262.

6. Giesting WD, Roos MA, Easter RA. Evaluation of the effect of fumaric acid and sodium bicarbonate addition on performance of starter pigs fed diets of different types. *J Anim Sci.* 1991; 69:2489-2496.

7. Giesting WD, Easter RA. Effect of protein source and fumaric acid supplementation on apparent ileal digestibility of nutrients by young pigs. *J Anim Sci.* 1991; 69:2497-2503.

8. Manners MJ. Milk replacers for piglets. *J. Sci. Food Agric.* 1970; 21:333

9. Cole DJA, Beal RM, Luscombe JR. The effect on performance and bacterial flora of lactic acid, propionic acid, calcium propionate and calcium acrylate in the drinking water of weaned pigs. *Vet. Rec.* 1968; 83:459-464.

10. SAS *User's Guide:* Statistics. SAS Inst. Inc., Cary, NC. 1985.

11. Kirchgessner M, Roth FX. Fumaric acid as a feed additive in pig nutrition. *Pig News and Information.* 1982 3:259-264.

12. Weeden TL, Nelssen JL, Hansen JA, Richardson KL. Effect of acidification on starter pig performance and nutrient digestability. Kansas State University, 1990 Swine Day.