Benzoic acid – a ne
additive for swine

by J. Broz and C. Paulus, DSM Nutritional Products Ltd, Animal N

Benzoic acid and its salts have been used for many years as preservative agents by the food industry, but in some countries also as silage additives, mainly due to their strong efficacy against various fungi and yeasts.

In 2003, benzoic acid has been approved in the European Union as a feed additive for growing-finishing pigs at the inclusion levels of 0.5-1.0% and included into group M, acidity regulators.

Previous and current research revealed some surprising and very useful properties of this organic acid, which may result in its application for multiple purposes. The objective of this contribution is to describe key properties of benzoic acid and to review some recent experimental findings.

Dissociation of benzoic acid is strongly pH dependent and in its undissociated form it exhibits various antibacterial and antifungal activities. Rahn and Conn (1944) reported that the antimicrobial effect of benzoic acid was nearly 100 times as efficient in strongly acid solutions as in neutral ones.

The spectrum of activity includes mainly enterobacteria, Bacillus spp. and micrococci, but also various fungi and yeasts. Its inhibitory action on yeasts and fungi is the background for a long term use of benzoic acid as the food preservative. In vitro antibacterial activity of benzoic acid is shown in Table 1.

Recently, Knarreborg et al. (2002) compared the antimicrobial effects of six different organic acids (formic, propionic, butyric, lactic, benzoic and fumaric acid) in swine stomach content (pH 4.5) and in small intestinal content (pH 5.5), using a specially developed in vitro methodology (see Table 2 and Table 3).

Benzoic acid revealed a strong bactericidal effect on both coliform and lactic acid bacteria in the swine stomach content and in the digesta from the small intestine. Addition of benzoic acid to the culture medium resulted in a dose dependent decrease in the rate of population change. All the doses tested fully controlled coliform bacteria.

Table 1. Antibacterial activity of benzoic acid in vitro (adapted from Lueck, 1980).

Micro-organism	pH	MIC (ppm)
Pseudomonas	6.0	200-480
Micrococcus	5.5-5.6	50-100
Streptococcus	5.2-5.6	200-400
Lactobacillus	4.3-6.0	300-1800
E. coli	5.2-5.6	50-120
Bacillus cereus	6.3	500

This study clearly confirmed that benzoic acid was superior to the other organic acids when considering the bactericidal effect in both stomach and small intestinal contents.

These results are confirming the results found in vivo by Maribo et al. (2000) – a study in piglets revealed a marked reduction in the density and activity of the gastro-intestinal bacteria. Due to its limited solubility in water, absorption of benzoic acid is much delayed when compared to other organic acids. After the absorption, benzoic acid is metabolised in the liver and converted into hippuric acid via conjugation with the amino acid glycine.

Organic acid (100 mM)	Coliform bacteria (h^{-1})	Lactic acid bacteria (h^{-1})
Control	1.16	0.23
Fumaric acid	1.39	-0.19
Lactic acid	0.69	0.06
Propionic acid	0.07	0.18
Butyric acid	-0.06	0.08
Formic acid	-0.13	0.11
Benzoic acid	-0.69	-0.19

Table 2. Specific bacterial growth or death rate in response to various organic acids in swine small intestinal content at pH 5.5 (according to Knarreborg et al., 2002).

Increased excretion of hippuric acid results in the direct acidification of swine urine, which seems to be dose dependent.

Some years ago, den Brok et al. (1999) monitored urinary pH, ammonia emission and performance of growing-finishing pigs after dietary addition of a mixture of organic acids and salts, consisting mainly of benzoic acid. The study was conducted during three fattening periods, involving two identical housing compartments (six pens per compartment, containing 66 pigs).

All pigs per compartment were fed either control or acidified feed and after each experimental period the treatments were changed over. The experimental grower and finisher diets were supplemented with 0.7 and 1.4% of benzoic

w feed

utrition and Health, CH-4002 Basel, Switzerland.

acid in grower and finisher. The mean urinary pH in pigs during the growing period was significantly reduced from 7.50 to 5.69. In the finishing period, the feeding of acidified diets resulted again in a significant decrease of the mean urinary pH from 7.48 to 5.02.

These acidification effects were also visible in the pig slurry. During the finishing period, the mean pH of the top layer of slurry was significantly reduced by 0.78, from 7.82 to 7.04.

Dose (mM)	Coliform bacteria (h^{-1})	Lactic acid bacteria (h^{-1})
0	-0.25	0.69
12.5	-0.33	0.53
25	-0.58	0.37
50	-0.99	-0.05
100	-1.73	-0.18
200	<-7.00	<-7.00

Table 3. Specific bacterial growth or death rate at various doses of benzoic acid in swine stomach content at pH 4.5 (according to Knarreborg et al., 2002).

It is well known that a reduction in the pH value of swine slurry results in a reduced ammonia emission. This phenomenon was confirmed by the experimental data, but the effects on NH3 emission were more variable among the experimental periods, being mainly affected by season. The mean reduction of calculated ammonia emission (kg/pig/year) reached 28, 50 and 13%, in periods 1, 2 and 3, respectively.

In parallel to their study evaluating the effect of acidified diets on ammonia emission, den Brok et al. (1999) also carried out a growth trial with growing-finishing pigs in a separate compartment in order to investigate possible influence on performance. The used grower and finisher diets were formulated to contain 17 and 15% crude protein, respectively.

Table 4. Performance of growing-finishing pigs fed with control and acidified diets (adapted from den Brok et al., 1999).

Treatment	Control diets	Acidified diets[a]
Number of pigs	99	99
Initial weight (kg)	26.1	26.2
Final weight (kg)	107.4	108.2
Daily wt. gain (g)	723	737
Daily feed int. (kg)	1.97	1.95
FCR	2.72	2.64*

[a] Grower and finisher diets contained 0.7 and 1.4% benzoic acid, respectively
** Significant difference versus control (P<0.05)*

This trial consisted of three subsequent periods, each involving both treatments (control and acidified diets), assigned to a total of nine replicates with 11 pigs each.

The results indicated some beneficial effects of experimental diets on growth performance, which were reflected in a numerically increased daily weight gain (+1.9%) and a significant improvement of feed conversion from 2.72 to 2.64 (see Table 4). In 2004, a comparative growth trial was conducted at the Catholic University Leuven in order to evaluate the effects of dietary addition of benzoic acid (VevoVitall) on performance of growing-finishing pigs.

A three phase feeding system was used and the diets were formulated to contain 18.0, 16.3 and 15.0% crude protein, respectively. The results of this growth trial are summarised in Table 5.

Dietary addition of benzoic acid (0.5%) resulted in a numerical increase of mean daily weight gain (+5.5%) and a remarkable and significant improvement of feed conversion from 2.82 to 2.59.

The results of both growth trials clearly confirmed that dietary addition of benzoic acid has a potential to enhance the performance of pigs, in particular the efficiency of feed conversion.

Treatment	A	B
Benzoic acid (%)	0	0.5
Number of pigs	46	47
Initial weight (kg)	24.8	22.8
Final weight (kg)	103.8	105.5
Daily wt. gain (g)	693	731
Daily feed int. (kg)	1.96	1.89
FCR	2.82	2.59*

**Significant difference versus control (P<0.05)*

Table 5. Effects of benzoic acid (VevoVitall) at 0.5% on performance of growing-finishing pigs (adapted from Paulus et al., 2004).

Benzoic acid has been approved as a new feed additive for growing-finishing pigs. Due to its antibacterial activity in the gut and specific metabolism, this organic acid reveals multiple beneficial effects. Dietary supplementation results in a decrease of urinary pH, accompanied by a reduction in ammonia emission and improved growth performance, in particular with regard to feed conversion efficiency.

Therefore, benzoic acid appears to be an easy and cost effective mean to reduce ammonia emission in pig houses and in the environment. ■

References are available from the authors on request.