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The influence of drinking water acidification in broilers under Indonesian conditions

Christian Lückstädt*, Stevan Petrovic and Kevin Teh

ADDCON, Bitterfeld, Germany
*christian.lueckstaedt@addcon.com

Abstract

Organic acids, and in particular formic acid and its salts, are well known to improve productivity in animal nutrition. By acting against pathogens, they help to decrease pressure on the animal's immune system, thus more nutrients will be available for productive functions such as growth. The use of acidifiers via the drinking water will therefore not only create hygienic conditions in the water itself but will also lead to improved performance parameters in poultry. This is especially needed during the rainy season, when conditions are severe, and mortality is rising. A recent trial, conducted at a broiler farm under such conditions in Indonesia, tested drinking water acidification with a liquid acidifier consisting of formic acid and sodium formate (ADDCON XL2.0) at a dosage of 0.6 ml/1000 ml drinking water for 8 h a day from day 14 onwards till slaughter, against a negative control. 55,000 birds were randomly selected and divided equally into 2 groups with 27,500 broilers each. Feed and water were available ad libitum. The effects of the acidifier on performance (daily weight gain, feed conversion) as well as productivity index and mortality were examined at slaughter on day 35. The results are given as mean and a confidence level of 95% was defined for these analyses. Although the water acidification was carried out for 3 weeks only, average daily weight gain and feed conversion were improved significantly ($p<0.05$) across the whole cycle. Mortality, calculated from the start of the treatment till slaughter, tended to be reduced by almost 25% ($p<0.1$). The resulting overall productivity index of the broilers increased by 4.3% ($p=0.012$). It can therefore be concluded that drinking water acidification for broilers has beneficial effects on the performance of the birds and may be considered as a low-cost option to improve production parameters. Especially under tropical conditions, this could play a vital role in providing hygienic drinking water and reducing pathogen load, thus having enormous potential as an integral component of a successful biosecurity programme.

Keywords: drinking water acidification, broiler, formic acid, sodium formate

Introduction

The potential for organic acids to preserve feed and water quality lies in their ability to protect against microbial and fungal contamination and/or degradation. The free hydrogen proton of a dissociated organic acid lowers pH, thereby creating unfavourable conditions for bacterial pathogens. On the other hand, the undissociated form of organic acids directly penetrates the lipid membrane of Gram-negative bacterial cells. After entering cell cytoplasm at neutral pH, organic acids inhibit the bacteria's growth by inhibiting oxidative phosphorylation and causing increased energy expenditure (H^+-ATPase pump) (Lückstädt and Theobald, 2011).

Organic acids have been used in animal production for almost 60 years, mainly as additives in pig diet. In poultry, their application is more recent, with the earliest reports stemming from the early 1980's. One of the first reports of improved broiler performance with organic acid supplementation was from Vogt et al. (1981), who used formic acid. From that time onwards, organic acids became more popular, whether to improve bird performance or to preserve feed from microbial degradation.

The presence of pathogenic bacteria in animal products such as poultry meat and eggs pose a serious threat to consumers. Salmonella for instance, ranks among the world's biggest threats to health. According to the WHO (2018), Salmonella is one of the 4 key global causes diarrhoeal diseases. In the United States alone, the reported cases are responsible for around 580 deaths and an estimated 15,000 hospitalisations each year (WHO, 2005). It is estimated that cases of human salmonellosis in the USA, may vary from 2 to 4 million cases (Jones, 2011). A study reported by *World Poultry* in 2009, found that 79% of poultry drinking water samples were contaminated with Salmonella. Zimmerman (1998) reported a widespread occurrence of coliform bacteria in drinking water in the East and West coasts of the United States. Maes et al. (2019) described that drinking water for broiler can be contaminated with microbiological components, for instance through the source or through the animals via the drinking cups. The same author group obtained that *Campylobacter jejuni, E. coli*, Pseudomonas spp. and Salmonella spp. are among the microorganisms which are frequently found in drinking water for broilers. As such, clear guidelines for safe drinking water are needed. Such recommendations for poultry drinking water, according to Böhm (2000) are shown in Table 1.

Table 1: Drinking water guidelines for poultry – modified after Böhm (2000)

	Pathogen count (CFU)
Salmonella	0 CFU in 100ml
Campylobacter	0 CFU in 100ml
E. coli	0 CFU in 10ml
Total bacteria (37ºC)	<1,000/ml
Total bacteria (20ºC)	<10,000/ml

Those guidelines had been reviewed rather recently by Tabler et al. (2019). The authors commented that the maximum acceptable level for the total bacteria count shall be 1,000 CFU/ml, while the faecal coliform count shall be 0 CFU per ml, regardless of the size of the sample. Environmental conditions play an important role in the recommendations, as bacterial growth can accelerate rapidly with increasing water temperature. In tropical poultry production systems, this can play an important role in determining whether a low level of bacterial contamination in the drinking water or feed can escalate quickly to impaired productivity in the poultry house.

Using organic acids in drinking water rather than feed has several advantages (Wales et al., 2010). The ability to apply acids through water during feed withdrawal periods is especially important during preslaughter, when birds' susceptibility to infection with bacterial pathogens may be increased (Ramirez et al., 1997; Byrd et al., 1998; Corrier et al., 1999). Organic acids in drinking water may also destroy or reduce any vegetative pathogens in the water. Acidifiers used via water can also be used strategically or throughout rearing, to suppress bacterial infections. Birds' water intake is roughly 1.5 to 2 times that of feed intake, so a lower dosage of acid via

water can be used compared to feed to achieve the same dose within the bird. Acidifiers, however, are rapidly metabolised, so without the protection of the feed matrix, their efficacy only reaches the foregut, including crop, proventriculus and gizzard.
Organic acids, and in particular formic acid and its salts (e.g. sodium formate) are well known to improve productivity in animal nutrition. By acting against pathogens, they help to decrease pressure on the animal's immune system, thus more nutrients will be available for productive functions such as growth. Furthermore, securing a low pH in the gizzard and proventriculus, may improve protein digestibility. The use via the drinking water will therefore not only create hygienic conditions in the water itself, but also lead to improved performance parameters in the bird.

Material and Methods

A recent trial, conducted at a broiler farm during the rainy season (29-30°C; ~85% RH) in Indonesia, tested drinking water acidification with a liquid acidifier consisting of formic acid and sodium formate (ADDCON XL2.0) at a dosage of 0.6 ml/1000 ml drinking water for 8 h a day from day 14 onwards till slaughter, against a negative control. 55,000 birds were randomly selected and divided equally into 2 groups with 27,500 broilers each. Feed and water were available ad libitum. The effects of the acidifier on performance (final weight, daily weight gain, feed conversion) as well as productivity index (EBI) and mortality were examined at slaughter on day 35. The EBI was calculated as: EBI = ADG [g] × Survival [%] / (10 × FCR), thus using the three most important parameters in animal production. The results are given as mean and a confidence level of 95% was defined for these analyses.

Results and Discussion

Despite the short inclusion of the drinking water acidifier, average daily weight gain and feed conversion were improved significantly ($p<0.05$), as shown in Table 2, while the final weight tended to be increased by 5.1% ($p=0.09$). Average daily gain (ADG) was improved significantly by 1.5%. Feed conversion ratio (FCR) was also significantly improved by the acidification of the water (1.44 with 8h.d^{-1} acidification, compared to 1.47 in controls), thus reaching an increased feed efficiency by more than 2%. Mortality tended to be reduced by almost 25% ($p<0.1$), reaching only 2.0% in the acidifier group. The EBI was significantly increased by 4.3% ($p=0.012$), proving the economical usage of the water acidifier ADDCON XL2.0.

Table 2: Comparison of broiler performance with or without access to acidified (ADDCON XL2.0) drinking water (0.6 ml per litre) from day 14 till day 35

	Negative Control	**Acidified drinking water (XL2.0)**
35-d BW (kg)	1.97±0.05	2.07±0.11
ADG (g.d^{-1})	61±2^{a}	62±2^{b}
FCR	1.47±0.01^{a}	1.44±0.02^{b}
Mortality (%)	2.7±0.9	2.0±0.4
EBI	398±11^{a}	415±7^{b}

Row means with different letter superscripts are significantly different at $p<0.05$

Acidification of the drinking water has previously been shown to have a positive effect on water quality and growth performance in broilers. Allen (1997) found that the addition of a minimum of 0.15% formic acid containing blend reduced Salmonella counts in drinking water to undetectable levels within 4 hours. Formic acid (0.5%) added to drinking water during a Salmonella challenge (10^8 CFU), significantly reduced levels of the pathogen in the crop of broilers (during feed

withdrawal), highlighting the value of use of an acidifier in drinking water during preslaughter, where feed withdrawal is a critical period for recontamination (Byrd et al., 2001).
The results of this study show improved productivity parameters (ADG, FCR, mortality and EBI) in broilers given acidified drinking water for 8 hours per day. In a previous study (Parker et al., 2006), water acidification (0.08%) led to a significant improvement in FCR in broilers, a finding which is in full agreement with the present study. This was recently reconfirmed by Ali et al. (2020) for acidified mixtures containing formic acid. The authors reported improved growth performance and feed efficiency, as well as gut health.

Conclusions and Outlook

The use of acidifiers in drinking water is a relatively recent development in poultry production. In tropical production systems, this may play a vital role in providing hygienic drinking water and reducing pathogen load, thus having enormous potential as an integral component of a successful biosecurity programme. The authors have used such additives under a wide variety of conditions in Southeast Asia as well as Latin America. This study, carried out in Indonesia, demonstrates that including water acidification in broiler production has beneficial effects on the performance of broilers and may be considered as a low-cost sustainable option to improve production parameters in general, as well as saving resources due to the improved feed efficiency.

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