The efficacy of micro-encapsulated, gastro-resistant blends of essential oils and/or organic acids in broiler diets

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As antibiotic growth promoters are currently banned in the E.U. in meat poultry production, a constant search has been going on to look for efficient alternatives. One of the most recent new technologies is using microencapsulated blends of organic acids and/or essential oils. The double coating process makes the active components gastric resistant with a subsequent slow release throughout the intestinal tract.

A trial was conducted to test different microencapsulated blends of organic acids and/or essential oils as possible alternatives for the antibiotic growth promoters. It consisted of 5 treatments : (A) negative control, (B) positive control supplemented with 10 ppm avilamycin (Maxus 200 at 50 mg/kg diet), (C) negative control + RepaXol (blend of essential oils at 100 g/ton), (D) negative control + AciXol (blend of organic acids and essential oils at 500 g/ton) and (E) negative control + blend of coated Na butyrate and citric acid at 500 g/ton (produced on purpose by SODA Feed Ingredients). Each treatment consisted of 6 replicates with 36 Ross 308 male broilers each. Final body weight was significantly affected by dietary supplementation (P=0.036) with significantly higher values for the treatments with the microencapsulated additives (2654 g, 2665 g and 2654 for C, D and E, resp.) compared to both the negative (2560 g) and the positive control (2569 g). Differences were not significant (1) among the diets supplemented with the microencapsulated additives and (2) among both control diets.

The efficacy of the microencapsulated additives was shown also in terms of F.C.R. In fact, during 1-28 days of age feed conversion was significantly better on diets supplemented with microencapsulated additives compared to the negative control (1.645; 1.574; 1.589 and 1.586 for A, C, D and E, respectively.) with an intermediate value for the positive control (1.606). Overall feed conversion (1-42 days of age) was numerically influenced by treatments (1.752; 1.740; 1.725; 1.740; 1.732 for A, B, C, D and E, respectively).

The performance was less improved by a supplementation with avilamycin compared to the microencapsulated alternatives, which stresses the fact that the mechanism of avilamycin must be partly different from that of the microencapsulated additives.

Keywords : broilers; essential oils; organic acids; microencapsulated

Introduction

Antimicrobial growth promoters (AGP's) are currently banned in the E.U. in meat poultry production due to the fear that their intensive use in the feed of livestock would lead to the formation of resistant pathogenic bacteria in humans. Due to this ban, intensive research has been running looking for safe and efficient alternatives.

Plant extracts, more commonly known as essential oils, have been used for centuries in Chinese herbal medicine. Plant extracts have a positive effect on feed intake (mainly due to their appetizing flavour or aroma), endogenous enzyme production, the immune system as well as bacteriostatic and fungistatic effects (Kamel, 2000; Mellor, 2000). The kind of bioactive compounds and their concentration varies significantly with the source (Kamel, 2000) and supports the fact that mixtures of different plant extracts are supposed to induce greater effects than single plant extracts.

The effect of a homogeneous blend of natural and nature identical plant extracts, evenly distributed into micro-granules and protected by a double coating process, named RepaXol™, was tested in the present trial. The plant extracts used in this product originated from oregano, cinnamon, thyme, capsicum and citrus extracts with the main active components being carvacrol, cinnamic aldehyde, thymol, capsaicin, eugenol and citrus extracts. Carvacrol is known to inhibit the metabolism of the microbial cell wall (Smink, 2000). Cinnamic aldehyde and eugenol stimulate appetite and digestion and are antiseptic (Kamel, 2000). An antioxidant activity is linked to cinnamon and thymol and capsaicin is found to work anti-inflammatory (Kamel, 2000). Citrus extracts (rich in terpenes) are also strong antiseptics. Due to their small molecular structure (C_5H_{10}) diffuse quickly and because they are unsaturated oxidize rapidly.

Also organic acids have been postulated to be valuable alternatives for AGP's with possible positive effects linked to different mechanisms. The influence of acids on the growth of bacteria can be in two ways: first by decreasing the pH of the gastrointestinal tract which induces less favourable conditions for bacterial growth and secondly, certain acids have a direct action against specific micro-organisms. The key principle of this direct mode of action of organic acids against bacteria is that non-dissociated short chain organic acids (C1-C7) are lipophillic and are able to penetrate the cell wall of bacteria. Once inside the cell, the acids dissociate to produce H^+-ions resulting in a reduction of the intracellular pH and anion accumulation, which disrupts normal physiology of the bacterial cell. Furthermore, organic acids can improve digestibility of nutrients and can be metabolized representing an energy source.

There are many results available describing the positive effects of the use of organic acids on the zootechnical performances of broilers (Langhout, 2000; Van Campenhout et al., 2001; Huyghebaert, 2002; Kenyon and Ten Doeschate, 2002; Meeusen et al., 2002), however, only few results are published where a combination of plant extracts and organic acids are described (Langhout, 2000; Lippens et al., 2005). As mode of actions are different, it might be postulated that synergistic or additive effects are possible. AciXol™ is a blend of organic and inorganic acids (citric, fumaric, malic and ortophosphoric) along with the protected essential oils of RepaXol encapsulated in the same MICROPEARLS®.

A trial was conducted to look at the effect of double coated mixtures of essential oils and/or organic acids in broiler diets. The double coating process makes the active components gastric resistant and to be released throughout the gastro-intestinal tract. Moreover, it avoids acid tolerance of bacteria and is safe with other active ingredients (fat soluble vitamins, tryp., Ca salts). It makes them easier to handle and lower inclusion rates of the acids can be used.

Materials and methods

A block experiment was set up which consisted of 5 treatments. Treatment A consisted of a negative control (without any growth promoter nor alternative additives). Treatment B was a positive control supplemented with Maxus 200 at 50 mg/kg diet (10 ppm avilamycin). For treatment C, the negative control was supplemented with RepaXol, a blend of essential oils at 100 g/ton. Treatment D was the negative control supplemented with AciXol which is a blend of organic acids and essential oils at 500 g/ton. Treatment E consisted of the negative control supplemented with a coated blend of Na butyrate and citric acid at 500 g/ton produced on purpose by SODA Feed Ingredients. Each treatment consisted of 6 replicates with 36 Ross 308 male broilers.

Broilers were kept on floor pens on a mixture of cutted straw and peat at a stocking density of 17 animals per m². A convential lighting schedule (23L/1D) and temperature schedule was used. Water and feed were freely available. Table 1 shows the ingredient and chemical composition of the diets used.

Results and discussion

Table 2 summarises the results of the starter period (1-14 days of age). The dietary supplementation with avilamycine did however not result in any positive effects during the starter period which was in fact not in line with most literature findings showing the main benefit of AGP's during the early development phase of the intestinal flora. Growth rate, feed conversion (FC) and daily feed intake (DFI) were not significantly different between the negative and the positive control (treatment A and B). However, supplementation with RepaXol and the Na-butyrate+citric acid increased 14-day-body weight with 1.9 and 3.6 %, respectively (not statistically significantly different compared to the negative control, but significantly better compared to the positive control). The supplementation of AciXol, on the other hand, showed no effect on growth and body weight in this first period of the trial. DFI and FC were not changed significantly by supplementation of the additives, but still a trend of improved FC was found (an improvement of 3.7 % was found for the Na-butyrate+citric acid-treatment).

In the subsequent grower period (15-28 days of age; Table 3), similar effects were found. Again, no effect of the supplementation with avilamycin on the performances was found (treatment B compared to treatment A). Only a tendency of an improved FC was found (3.3 %). Growth of the RepaXol groups was significantly higher compared to the negative control (+ 5.7 %). Increased but not statistically different growth rates were found for the other supplementations with encapsulated additives compared to the negative control (treatments D and E against treatment A). Body weights at 28 days of age of the RepaXol- and Na-butyrate+citric acid-treatments were significantly higher compared to the negative and the positive control. For treatment C (supplementation with RepaXol) this was correlated with a significant improvement of the feed conversion (-5.3 % compared to the negative control). For treatment E (supplementation with Na-butyrate+citric acid), a (non-significant) increase in feed intake (+1.2 %) and a (non-significant) improvement in feed conversion (-3.3 %) was found. Also for treatment D (supplementation with AciXol) a near to significant improvement in feed conversion against the negative control was found (-3.9 %). During 1-28 days of age feed conversion was significantly better on diets supplemented with microencapsulated additives compared to the negative control (improvement of 4.3; 3.4 and 3.6 % against treatment A, respectively) with an intermediate value for the positive control (2.4 % against the negative control). During this period, growth rate was significant better compared to the negative and the positive control for the RepaXol and the Na-butyrate+citric acid supplemented diets (+ 4.6 % and 4.3 % against the negative control, respectively).

In the finishing period (Table 4), growth rates were not significantly influenced by treatments (p=0.145). However, growth rate of treatment D (supplementation with AciXol) was significantly higher compared to the negative control (5.4 %) and the positive control (5.0 %). This was linked with a significant higher feed intake compared to the negative control (6.0%) and the positive control (5.8 %). The other two microencapsulated supplementations (treatment C and E) showed intermediary growth rates. Feed conversions were similar for all treatments during this period. Treatments had a significant effect on final body weights. Final body weights of the diets supplemented with the micro-encapsulated additives (treatment C-E) were all significantly higher compared to the negative and the positive control. The RepaXol supplemented diet showed a 3.7 % higher final body weight compared to the negative control. The AciXol and the Na-butyrate+citric acid showed an improvement of respectively 4.1 and 3.7 %. Overall feed conversion (1-42 days of age) was only numerically influenced by treatments. Mortality rate was not changed significanlty by treatments (results not shown).

According to literature, the average benefit of AGP's on feed conversion to be expected is about 3% (Pfirter, 1998 cited by Wenk, 2003; Bedford, 2000) which was not the case in the current trial. Especially in the starter period, a positive effect is expected as intestinal flora is at that moment still developing and birds are very sensitive for disturbances. Also in previous trials (Lippens et al., 2005), no positive effects of an AGP was found during the starter phase. Probably, there was only a low challenge by some pathogenic microbial species during the entire trial. Although no effects of the AGP was found, still positive effects of the microencapsulated additives were found, which is in line with previous results (Lippens et al., 2005). This confirms the hypothesis that the mode of action of essential oils and/or organic acids is partly different compared to the mode of action of the AGP's. Under the present experimental conditions, it can be concluded that all investigated microencapsulated additives, are valuable alternatives for AGP's thereby improving not only feed conversion but also stimulating feed intake. Further research is needed to investigate the effect of these alternatives in more challenging circumstances.

Table 1 Composition of the respective experimental diets.

	Starter (1-14 d)[2,5]	Grower (15-28 d)[3, 5]	Withdrawal (29-42d)[5]
Feedstuffs			
Wheat	54.49	58.65	58.65
Soybean meal-48	28.89	20.51	20.51
Full fat soybeans	5.14	9.21	9.21
Soya oil	4.00	2.03	2.03
Tapioca			
R. animal fat	3.91	6.47	6.47
Ca-carbonate	0.362	0.328	0.328
Di-Ca phosphate	1.535	1.024	1.024
Sodium bicarb	0.100		
L-lys. HCl	0.056	0.188	0.188
DL-methionine	0.172	0.192	0.192
Threonine		0.052	0.052
NaCl	0.346	0.338	0.338
Vit. & Tr. El. Premix[1]	1.000	1.000	1.000
Nutrients			
MEn, MJ/kg	12.30	12.60	12.60
Cprotein, %	21.84	19.94	19.94
Isoleucine$_{ad}$[4], %	0.88	0.79	0.79
Leucine$_{ac}$, %	1.41	1.27	1.27
Lys.$_{ad}$, %	1.08	1.05	1.05
S amino acids$_{ad}$,%	0.79	0.76	0.76
Fenyl+tyr$_{ad}$, %	1.58	1.42	1.42
Thr.$_{ad}$, %	0.71	0.68	0.68
Trypt.$_{ad}$, %	0.24	0.21	0.21
Val.$_{ad}$, %	0.93	0.84	0.84
Arg.$_{ad}$, %	1.27	1.13	1.13
Hist.$_{ad}$, %	0.47	0.42	0.42
C18:2, %	3.50	3.08	3.08
Ca, %	0.88	0.73	0.73
Pav., %	0.42	0.33	0.33
Na, %	0.18	0.15	0.15
K, %	0.97	0.88	0.88
Cl, %	0.25	0.27	0.27
Na+K-Cl, meq/kg	256	214	214

[1] provided (mg/kg of diet): retinol, 4.05; cholecalciferol, 0.05; tocopherol, 13.5; menadione, 2.25; thiamin, 1; choline, 375; riboflavin, 5.4; panthothenic acid, 13.5; pyridoxine, 1.1, cyanocobalamin, 0.01; nicotonic acid, 40; biotin, 0.15; I, 2.1; Co, 1.4; Se, 0.43; Cu, 7.2; Mn, 86; Zn, 57; Fe, 65; Mg, 110.
[2] containing 500 g/ton Cycostat 6.6% (33 ppm Robenidine)
[3] containing 200 g/ton Clinacox 0.5% (1 ppm Diclazuril)
[4] ad = apparent digestible
[5] no NSP-enzymes are supplemented to the diets

Table 2 Effect of the different additives on the zootechnical performances of the broilers in the starter period (1-14 days of age)

	BW-1d g	BW-14 d g	Daily feed intake (g/a/d)	Growth (g/a/d)	FC
Anova					
Diet (n=5)	0.889	0.039	0.570	0.034	0.357
LSD m.r. test					
A	45.7	360[ab1]	33.7	22.5[ab]	1.503
B	45.8	349[b]	33.1	21.7[b]	1.525
C	45.8	367[a]	33.8	22.9[a]	1.475
D	45.9	361[ab]	33.4	22.5[ab]	1.488
E	45.5	373[a]	33.9	23.4[a]	1.448
SEM	0.1	3	0.2	0.2	0.012

[1] averages with the same subscript are not significantly different from each other at p=0.05

Table 3 Effect of the different additives on the zootechnical performances of the broilers in the grower period (15-28 days of age) and the period 1-28 days of age.

	BW-28 d g	Daily feed intake (g/a/d) 15-28 d	Growth (g/a/d) 15-28 d	FC 15-28 d	Daily feed intake (g/a/d) 1-28 d	Growth (g/a/d) 1-28 d	FC 1-28 d
Anova							
Diet (n=5)	0.038	0.270	0.143	0.105	0.184	0.037	0.033
LSD m.r. test							
A	1274[b]	111.5[ab]	65.2[b]	1.712[b]	72.1[ab]	43.9[b]	1.645[b]
B	1270[b]	108.7[b]	65.7[ab]	1.655[ab]	70.2[b]	43.7[b]	1.606[ab]
C	1331[a]	111.6[ab]	68.9[a]	1.621[a]	72.2[ab]	45.9[a]	1.574[a]
D	1302[ab]	110.6[ab]	67.3[ab]	1.645[ab]	71.3[ab]	44.9[ab]	1.589[a]
E	1327[a]	112.8[a]	68.1[ab]	1.656[ab]	72.6[a]	45.8[a]	1.586[a]
SEM	8	0.6	0.5	0.011	0.3	0.3	0.008

[1] averages with the same subscript are not significantly different from each other at p=0.05

Table 4 Effect of the different additives on the zootechnical performances of the broilers in the finisher period (29-42 days of age)[2] and the period 1-42 days of age

	BW-42 d g	Daily feed intake (g/a/d) 29-42 d	Growth (g/a/d) 29-42 d	FC 29-42 d	Daily feed intake (g/a/d) 1-42 d	Growth (g/a/d) 1-42 d	FC 1-42 d
Anova							
Diet (n=5)	0.036	0.020	0.145	0.963	0.068	0.036	0.826
LSD m.r. test							
A	2560[b]	175.9[b]	92.4[b]	1.905	104.9[b]	59.9[b]	1.752
B	2569[b]	176.2[b]	92.8[b]	1.900	104.5[b]	60.1[b]	1.740
C	2654[a]	181.4[ab]	94.5[ab]	1.921	107.1[ab]	62.1[a]	1.725
D	2665[a]	186.4[a]	97.4[a]	1.917	108.5[a]	62.4[a]	1.740
E	2654[a]	180.4[ab]	94.7[ab]	1.904	107.5[ab]	62.1[a]	1.732
SEM	15	1.2	0.7	0.007	0.5	0.3	0.007

[1] averages with the same subscript are not significantly different from each other at p=0.05

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