Effects of dietary organic acids and essential oils on growth performance and carcass characteristics of broiler chickens

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Primary Audience: Nutritionists, Researchers, Veterinarians

SUMMARY

A study was conducted to investigate the effects of organic acid salts (calcium propionate and calcium formate) and plant extracts (a blend of clove and cinnamon essential oils) on growth performance and carcass quality characteristics in broilers. Four experimental diets were fed from 1 to 46 d of age: diet C (control) without any added compounds, diet A with organic acid salts (5,120 ppm of formic acid and 2,080 ppm of propionic acid), diet O with essential oils (clove and cinnamon) in the amount of 100 ppm, and diet AO with a blend of organic acid salts (5,120 ppm of formic acid and 2,080 ppm of propionic acid) and plant extracts (containing a blend of clove and cinnamon essential oils in the amount of 100 ppm). A total of 1,320 Ross chicks were distributed into 24 groups with 55 broilers in each, giving 6 replicates per treatment. Growth performance parameters (BW, ADG, and FCR) were evaluated at 15, 21, and 46 d. The tested supplements had no influence on BW or ADG, but the FCR were significantly worse for birds receiving diets A or AO for the whole experimental period compared with those given diets C or O. Carcass weight was not influenced by the supplements. However, breast weight (% of carcass) was higher in diet O than in diets C, A, or AO. It was concluded from this experiment that clove and cinnamon essential oils showed a potential advantage over calcium propionate and calcium formate for improving FCR and percentage of breast weight.

Key words: broiler, clove, essential oil, cinnamon, organic acid

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DESCRIPTION OF PROBLEM

The use of antibiotic growth promoters (**AGP**) to improve animal performance has been a usual practice for more than half a century [1, 2]. After 2005 in the European Union [3], the use of all such antibiotics was banned by regulatory measures, and for this reason, it is important to research AGP replacements [4]. There is a huge variety of products for replacing AGP, and organic acids and plant extracts (essential oils) are among the candidates for their replacement [5].

In poultry production, the main effects of essential oils are focused on the intestinal tract [6]. Essential oils have been studied as a tool to reduce unwanted bacteria on the basis of their demonstrated in vitro antimicrobial activity [4, 7, 8].

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The use of essential oils in broiler diets is a new issue and there is an enormous variety of these products. This study was conducted to assess the potential of formic and propionic acids (salt form), plant extracts (essential oils), and the combination of organic acid salts with essential oils as possible alternatives to improve broiler chicken growth performance, FCR, and meat yield.

MATERIALS AND METHODS

Four experimental treatments included diet **C**, a control diet without additive supplementation; diet **A** with 5,120 ppm of formic acid and 2,080 ppm of propionic acid in salt form [9]; diet **O** with 100 ppm of plant extract based on a blend of *Syzigium aromathicum* (clove) and *Cinnamon ceylanensis* and *Cinnamon camphora* (cinnamon) [10]; and diet **AO** containing a blend of 5,120 ppm of formic acid, 2,080 ppm of propionic acid in salt form and 100 ppm of essential oils (clove and cinnamon). The diets were prepared consecutively using the same batch of ingredients, and the different additives used were added together with the microingredients.

All birds received a starter diet in crumble form from 1 to 15 d, a second diet from 16 to 21 d, a third diet from 22 to 39 d, and a finisher diet from 40 to 46 d in pelleted form (4-mm die and 72°C). The ingredient composition, estimated nutrient content, and analyzed chemical values [11] of diets are shown in Table 1.

A total of 1,320 broilers (male and female, 1-d-old, straight-run Ross 308 chicks) [12] were allotted to groups of 55 birds each of 24 pens, giving 6 pens per treatment (3 pens of males and 3 pens of females). Pens were located in a building on a commercial farm so that experimental animals were reared with their contemporaries on the farm.

Birds and feeds were weighed at d 15, 21, and 46 on a pen basis. The BW, feed intake, and FCR were determined. At 46 d of age, all birds were transported to a commercial slaughterhouse. Feed was removed 12 h before processing. Experimental procedures followed the principles for care of animals in experimentation [13]. Measurements of breast yield and abdominal fat (% of carcass weight) were performed.

The effects of diet were analyzed using the GLM procedure of SAS [14]. Data are presented as the means of each group and root mean square error, together with the significance levels of the treatment. Sex was included in the model. When differences among diets were significant, means were separated using Duncan's multiple range test, and significance was set at $P < 0.05$.

RESULTS AND DISCUSSION

A higher BW ($P < 0.01$) was observed in male than in female chickens. The effects of dietary treatment of BW, FCR, and mortality are shown in Table 2. Type of diet significantly influenced FCR at d 15 ($P = 0.0073$), 21 ($P = 0.0003$), and 46 ($P = 0.0195$), and birds fed the C and O diets had better FCR than those fed diets A and AO. Cave [15] showed that dietary organic acids influence both appetite and palatability when added to poultry feed. However, differences in consumption were not significant in the present study. No interactions were found between sex and treatment diet.

The beneficial effect of growth promoter substances, such as antibiotics, on performance is related to a more efficient use of nutrients, which in turn results in an improved FCR [16]. Essential oils have shown this FCR-improving effect [17, 18]. Other authors have shown similar results [19], indicating that, although the dietary addition of organic acids did not affect BW of broilers, it did improve FCR. Hernández et al. [20] failed to observe any effect on the performance of chickens when formic and propionic acids (5,000 or 10,000 ppm) were added to the feeds.

In a recent study, Ulrich [21] showed that liquid organic acids were more effective than salts of these compounds (3,600 ppm of formic acid and 1,600 ppm of propionic acid) at decreasing intestinal pH and *Salmonella* Typhimurium populations. Moreover, different concentrations of organic acids and essential oils elicited different results on BW and FCR. Effects on the growth parameters by organic acids were not consistent [22].

The main results of carcass traits are set out in Table 3. Breast weight as a percentage of carcass was significantly greater ($P \leq 0.001$) in birds fed supplements of 100 ppm of clove and cinnamon

Table 1. Composition of the experimental diets

Item	Prestarter (1 to 15 d)	Starter (15 to 21 d)	Grower (21 to 39 d)	Finisher (39 to 46 d)
Ingredient, % (as-is basis)				
Wheat	3.72	36.35	12.00	22.07
Barley	24.74	5.49	40.63	46.66
Maize	31.42	20.00	10.00	—
Soybean meal (47% CP)	32.55	29.35	29.35	20.84
Soybean oil	3.00	3.00	3.00	—
Animal fat	—	2.00	2.00	6.70
Calcium carbonate	1.36	1.19	1.19	1.02
Monocalcium phosphate	1.46	1.34	1.34	1.19
Sodium bicarbonate	0.20	0.20	0.20	0.20
Sodium chloride	0.40	0.21	0.21	0.21
DL-Met (free base)	0.32	0.24	0.24	0.31
L-Lys·HCl (56%)	0.47	0.24	0.24	0.40
L-Thr (free base)	0.023	0.025	0.025	0.038
Choline chloride	0.05	0.05	0.05	0.05
Vitamin and mineral premix[1]	0.30	0.30	0.30	0.30
Endofeed W DC[2] (xylanase)	0.01	0.01	0.01	0.01
Natuphos[3] (phytase)	0.01	0.01	0.01	0.01
Calculated composition[4]				
AME, kcal/kg	3,000	3,020	3,100	3,200
Lys	13.63	11.53	1.12	1.01
Met + Cys	0.93	0.85	0.85	0.80
Thr	0.85	0.74	0.71	0.64
Linoleic acid	28.70	27.65	11.23	15.52
Analyzed composition, % of DM				
Ash	6.31	5.56	5.63	4.84
CP	21.50	20.00	19.00	17.01
Starch	33.21	37.27	34.51	37.22
Ether extract	7.10	6.87	9.10	9.51

[1]The following was supplied per kilogram of diet: 12,000 IU of vitamin A; 3,500 IU of vitamin D_3; 40 mg of vitamin E; 3 mg of vitamin K; 3 mg of thiamine; 10 mg of riboflavin; 5 mg of pyridoxine; 0.02 mg of vitamin B_{12}; 60 mg of niacin; 1 mg of folic acid; 0.4 mg of biotin; 15 mg of pantothenic acid, 100 mg of manganese; 100 mg of zinc; 40 mg of iron; 15 mg of copper; 1 mg of iodine; 0.3 mg of selenium; and 0.2 mg of cobalt.

[2]Endofeed W DC (product no. 981350, GNC-Bioferm, Bradwell, Saskatchewan, Canada).

[3]Natuphos (product no. JEA8085632/1-29, BASF Group, Tarragona, Spain).

[4]According to de Blas et al. [25]

Table 2. Effect of organic acid salts and plant extracts on growth performance of broilers

	Dietary treatment[1]					
Growth performance	C	A	AO	O	RMSE[2]	*P*-value
BW, d 15	0.464	0.443	0.444	0.454	0.019	0.226
BW, d 21	0.825	0.790	0.768	0.806	0.046	0.190
BW, d 46	2.957	2.784	2.932	2.913	0.267	0.688
FCR, 0 to 15 d	1.301[b]	1.332[a]	1.335[a]	1.307[b]	0.017	0.007
FCR, 0 to 21 d	1.349[b]	1.428[a]	1.425[a]	1.397[b]	0.171	0.0003
FCR, 0 to 46 d	1.847[b]	1.907[a]	1.889[ab]	1.856[b]	0.034	0.019
Mortality, 0 to 46 d	3.940	2.420	2.730	2.730	1.870	0.518

[a,b]Means with different superscripts in the same row differ ($P < 0.05$).

[1]Treatments: control without additive (C); 5,120 ppm of propionic acid (calcium propionate) and 2,080 ppm of formic acid (calcium formate; A), mixed diet with diet A and essential oils (AO); 100 ppm of plant extract based on essential oils (O). Means represent 6 pens per treatment.

[2]RMSE = root mean square error.

Table 3. Effect of organic acid salts and plant extracts on slaughterhouse parameters of broiler at 46 d of age

	Dietary treatment[2]					
Slaughterhouse parameter[1]	C	A	AO	O	RMSE[3]	*P*-value
Breast weight,[4] g	465.10[a]	418.02[ab]	405.00[b]	468.00[a]	44.61	0.050
Breast weight,[5] %	18.89[b]	18.47[c]	18.19[d]	19.42[a]	0.23	<0.001
Abdominal fat,[4] g	48.25	43.75	42.75	44.77	5.52	0.362
Abdominal fat,[5] %	1.95	1.92	1.94	1.87	0.17	0.855

[a–d]Means with different superscripts in the same row differ ($P < 0.05$).

[1]Results in breast weight and abdominal fat are data from males and females together.

[2]Treatments: control without additive (C); 5,120 ppm of propionic acid (calcium propionate) and 2,080 ppm of formic acid (calcium formate; A), mixed diet with diet A and essential oils (AO); 100 ppm of plant extract based on essential oils (O).

[3]RMSE = root mean square error.

[4]Absolute weight in grams.

[5]Percentage of carcass weight.

oils than in all other treatments. However, on an absolute breast weight basis, they were significantly ($P \leq 0.05$) greater than only the AO treatment. These results agree with observations published from previous research on essential oils [23, 24] at this facility.

Although effects on carcass traits in the present study suggest that dietary essential oils appear to have a beneficial effect on breast weight, the interactions between organic acid salts and essential oils remain unclear. A detailed study is required to clarify the mechanisms that regulate digestibility of feed by organic acid salts and essential oil supplements.

CONCLUSIONS AND APPLICATIONS

1. Birds fed the C and O diets had significantly ($P < 0.02$) better FCR at d 15, 21, and 46 than birds fed the A or AO diets.
2. Dietary supplementation with a blend of clove and cinnamon essential oils (diet O) showed the most positive effect on breast weight. The C group had better results than the A or AO diets.
3. Diet AO resulted in less breast weight and worse FCR than the other dietary treatments.

REFERENCES AND NOTES

1. Kamphues, J., and D. Hebeler. 1999. Performance enhancers—The status quo from the view of animal feeding. Overviews Anim. Feed. 27:1–28.

2. Gollnisch, K., C. Wald, and A. Berk. 2001. The use of different essential oils in the breeding of piglets. Pages 259–262 in in Proc. 6th German Soc. Quality Res. Conf., Jena, Germany.

3. Reglamento (CE) no. 183/2005 del Parlamento Europeo y del Consejo, de 12 de enero de 2005.

4. Griggs, J. P., and J. P. Jacob. 2005. Alternatives to antibiotics for organic poultry production. J. Appl. Poult. Res. 14:750–756.

5. Beford, M. 2000. Removal of antibiotic growth promoters from poultry diets: Implications and strategies to minimise subsequent problems. Worlds Poult. Sci. J. 56:347–365.

6. Wenk, C. 2002. Herbs, spices and botanicals: "Old fashioned" or the new feed additives for tomorrow's feed formulations? Concepts for their successful use. Pages 79–97 in Biotechnology in the Feed Industry. T. P. Lyons and K. A. Jacques, ed. Nottingham University Press, Nottingham, UK.

7. Cai, L., and C. D. Wu. 1996. Compounds from *Syzygium aromaticum* possessing growth inhibitory activity against oral pathogens. J. Nat. Prod. 59:987–990.

8. Cowan, M. M. 1999. Plant products as antimicrobial agents. Clin. Microbiol. Rev. 12:564–582.

9. Luprocid Dry NC, Product Number 50134383, BASF, Tarragona, Spain.

10. Essempro, Laboratorios Calier S.A., Barcelona, Spain.

11. AOAC. 2000. Official Methods of Analysis. 17th ed. Assoc. Off. Anal. Chem., Arlington, VA.

12. Ross 308, Ross Breeders AVICU S.A., Guadalajara, Spain.

13. Boletín Oficial del Estado. 2005. Real Decreto Español 1201/2005, de 10 de octubre, sobre protección de animales utilizados para experimentación y otros fines científicos. Bol. Ofic. Estado 252:34367–34391.

14. SAS Institute. 2007. SAS User's Guide. Version 9.1 ed. SAS Inst. Inc., Cary, NC.

15. Cave, N. A. G. 1982. Effect of dietary short-and medium chain fatty acids on feed intake by chicks. Poult. Sci. 61:1147–1153.

16. Devriese, L. A., G. Daube, J. Hommez, and F. Haesebrouck. 1993. In vitro susceptibility of *Clostridium perfringens* isolated from farm animals to growth-enhancing antibiotics. J. Appl. Bacteriol. 75:55–57.

17. Kluth, H., E. Schulz, I. Halle, and M. Rodehutscord. 2002. About the efficiency of herbs and essentials oils in pigs and poultry. Pages 66–74 in Proc. 7th Pig and Poultry Feed Conv. M. Rodehutscord, ed. Martin-Luther-University, Halle Wittenberg, Germany.

18. Tedesco, D. 2001. The potentially of herbs and plant extracts as feed additives in livestock production. Zootec. Nutr. Anim. 27:111–133.

19. Runho, R. C., N. K. Sakomura, S. Kuana, D. Banzatto, and O. M. Junqueira. 1997. Uso de ácido-orgánico (ácido fumárico) nas raçoes de frangos de corte. Rev. Bras Zootec. 26:1183–1191.

20. Hernández, F., V. García, J. Madrid, J. Orengo, and P. Catalá. 2006. Effect of formic acid on performance, digestibility, intestinal histomorphology and plasma metabolite levels of broiler chickens. Br. Poult. Sci. 47:50–56.

21. Ulrich, R. 2006. Info-Service Animal Nutrition 82. BASF, Ludwigshafen, Germany. http://www.animal-nutrition.basf.de/ Accessed June 2008.

22. Skinner, J. T., A. L. Izat, and P. W. Waldroup. 1991. Fumaric acid enhances performance of broilers chicken. Poult. Sci. 70:1444–1447.

23. Perdok, H., P. Langhout, and P. van Vugt. 2003. Stimulating appetite. Feed Mix 11:10–13.

24. Wald, C. 2003. Gewürze and Co.—Eine Übersicht. Lohmann Inf. 3:1–5.

25. de Blas, C., G. G. Mateos, and P. G. Rebollar. 2003. Tablas Fedna de composición y valor nutritivo de alimentos para la fabricación de piensos compuestos. 2nd ed. Fundación Española para el Desarrollo de la Nutrición Animal, Madrid, Spain.

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