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Evaluation of Hops (*Humulus iupulus*) as an Antimicrobial in Broiler Diets[1]

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Abstract: A study was conducted to evaluate the use of hops (*Humulus iupulus*) in broiler diets as a potential replacement for antibiotics. Broiler diets were prepared based on nutrient specifications of top broiler companies and supplemented with either 50 g/ton penicillin or hops at 0.5, 1.0, 1.5, and 2.0 lbs/ton of feed and compared to an unsupplemented control group. Each treatment was assigned to eight replicate groups of 45 male chicks of a commercial broiler strain. The diets were fed in pelleted form with starter diets fed as crumbles. Addition of 50 g/ton of penicillin resulted in significant improvements in body weight, feed conversion, and feed efficiency at all ages, as compared to those fed the negative control. The addition of hops at 0.5 lbs per ton also resulted in significant improvements in feed conversion and feed efficiency at all ages when compared to the negative control, and also significantly improved body weight at 14 d as compared to those fed the negative control diet. At 42 d, the body weight of chicks fed 0.5 lbs of hops per ton was greater (P = 0.09) than that of chicks fed the negative control. Higher levels of hops feeding resulted in some improvements as compared to those fed the negative control; including 14 d body weight for those fed 1.0 lb per ton, and improved 1 to 42 d feed conversion and feed efficiency for those fed 1.5 lbs per ton. Results of this study suggests that inclusion of hops into diets at the rate of 0.5 lbs per ton for broiler chickens may result in improved growth rate and feed utilization in the absence of growth promoting antibiotics.

Key words: Hops, broilers, antibiotics, antimicrobials

Introduction

Hops (*Humulus lupulus*) have been used for centuries as an antimicrobial in the brewing of beer. Hops have a long history in herbal medicine where they have been used to treat a variety of complaints (Batchvarov and Marinova, 2001). A number of studies have demonstrated antimicrobial activity from hops in various types of situations (Stavri *et al.,* 2004). Many U.S. patents have been issued regarding the antimicrobial effects of hops in food processing (Barney *et al.,* 1995; Millis and Schendel, 1994). As there is growing concern regarding the use of growth promoting antibiotics with total bans imposed in the European Union, the search for products that can replace antibiotics continues. The objective of the present study was to evaluate hops as an antimicrobial in diets for growing broilers.

Materials and Methods

Diets were mixed for starter (0-14 d), grower (14-35 d) and finisher (35-42 d) periods using nutrient specifications for the top five producing broiler companies in a leading agricultural survey[3]. Total and digestible amino acid values for corn and soybean meal were from a leading amino acid producer[4]. Composition and nutrient content of diets is shown in Table 1.

Six dietary treatments were compared. Test diets were prepared by taking aliquots of a common basal diet. One treatment was considered as the negative control with no additives. One treatment was supplemented with 50 g/ton penicillin[5]. Four additional treatments included hops at 0.5, 1.0, 1.5, and 2.0 lbs/ton of feed. Whole hops of the variety Teamaker, analyzed[6] to contain 0.6% alpha acids and 9.3% beta acids, were ground through a hammermill with 1/8 inch screen before adding to the diets. This provided approximately 23, 46, 69, and 93 mg/kg of hops beta acid to the diets. Diets were fed as pellets; starter diets were crumbled after pelleting. Each treatment was assigned to eight replicate groups of chicks.

Male chicks of a commercial broiler strain[7] were obtained from a local hatchery where they had been vaccinated *in ovo* for Marek's disease and had received vaccinations for Newcastle Disease and Infectious Bronchitis post hatch via a coarse spray. Forty-five chicks were randomly assigned to each of 48 pens (50 ft^2) in a floor pen house of commercial design. Previously used softwood shavings over concrete floors served as litter. Each pen was equipped with two tube feeders and one Plasson water fount. Supplemental feeder flats and water founts were used during the first seven days. Care and management of the birds followed recommended guidelines (FASS, 1999).

Birds were group weighed by pen at 1, 14, 35, and 42 d of age. Feed consumption was determined at 14, 35, and 42 d of age. Birds were checked twice daily for mortality; any bird that died or was removed to alleviate

Table 1: Composition (g/kg) and calculated nutrient content of basal diets

Ingredient	0-14 d	14-35 d	35-42 d
Yellow corn	547.48	603.49	669.88
Poultry oil	30.43	28.98	27.37
Soybean meal	346.23	300.32	238.72
Ground limestone	13.95	11.73	11.62
Dicalcium phosphate	17.46	15.59	14.79
Sodium chloride	5.66	5.69	5.72
L-Threonine	0.95	0.31	0.46
L-Lysine Hcl	2.19	1.34	1.21
Zoamix 25%[1]	0.75	0.75	0.00
Alimet 10% premix	27.90	24.80	23.23
Broiler premix[2]	5.00	5.00	5.00
Trace mineral mix[3]	1.00	1.00	1.00
Variable[4]	1.00	1.00	1.00
TOTAL	1000.00	1000.00	1000.00
ME, kcal/lb	1400.00	1425.00	1450.00
Crude protein, %	22.40	20.42	17.88
Calcium, %	0.98	0.86	0.82
Nonphytate P, %	0.45	0.40	0.38
Methionine, %	0.60	0.55	0.51
Lysine, %	1.38	1.19	1.01
Threonine, %	0.94	0.81	0.72
TSAA, %	0.99	0.91	0.83
Digestible Met, %	0.58	0.53	0.48
Digestible Lys, %	1.26	1.07	0.90
Digestible Thr, %	0.83	0.70	0.63

[1]Alpharma Inc., Fort Lee NJ 07024.

[2]Provides per kg of diet: vitamin A (from vitamin A acetate) 7714 IU; cholecalciferol 2204 IU; vitamin E (from dl-alpha-tocopheryl acetate) 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; menadione (from menadione dimethylpyrimidinol) 1.5 mg; folic acid 0.9 mg; choline 1040 mg; thiamin (from thiamin mononitrate) 1.54 mg; pyridoxine (from pyridoxine HCl) 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg.

[3]Provides per kg of diet: Mn (from $MnSO_4$•H_20) 100 mg; Zn (from $ZnSO_4$•$7H_2O$) 100 mg; Fe (from $FeSO_4$•7H $_2O$) 50 mg; Cu (from $CuSO_4$•$5H_20$) 10 mg; I from $Ca(IO_3)_2$•H_20), 1 mg.

[4]Variable levels of antibiotic, hops, or washed builders sand.

suffering was weighed and the weight used to adjust feed efficiency.

Pen means were used as the experimental unit for statistical analysis. Mortality data were transformed to $\sqrt{n+1}$. Data was subjected to one-way ANOVA using the General Linear Models procedure of the SAS Institute (1991). Contrast comparisons to the negative control diet were made for all treatments. Statements of statistical significance are based on ($P<0.05$) unless stated otherwise.

Results and Discussion

Results of the study are shown in Table 2. Overall, performance of the birds was good and met the performance guidelines suggested by the breeder. Addition of 50 g/ton of penicillin resulted in significant improvements in body weight, feed conversion, and feed efficiency at all ages, as compared to those fed the negative control. The addition of hops at 0.5 lbs per ton also resulted in significant improvements in feed conversion and feed efficiency at all ages when compared to the negative control, and also significantly improved body weight at 14 d as compared to those fed the negative control diet. At 42 d, the body weight of chicks fed 0.5 lbs of hops per ton was higher than that of those fed the negative control ($P = 0.09$). Higher levels of hops feeding resulted in some improvements as compared to those fed the negative control; including 14 d body weight for those fed 1.0 lb per ton, and improved 1 to 42 d feed conversion and feed efficiency for those fed 1.5 lbs per ton. There were no significant differences in feed intake, indicating that there was no adverse effect of the hops on any sensory factor that might have inhibited feed intake. Overall mortality was low and within normal limits.

Results of this study suggests that inclusion of hops into

Table 2: Effect of hops supplementation on the performance of broiler chickens (means of eight pens of 45 males per treatment)

	Negative Control	Penicillin 50 g/ton	Hops						
			0.5 lb/ ton	1.0 lb/ ton	1.5 lb/ ton	2.0 lb/ ton	P-value	S.E	CV (%)
Body weight (kg)									
14 d	0.404^{c}	**0.438^{a}**	**0.427^{ab}**	**0.422^{b}**	0.414^{bc}	0.416^{bc}	0.0002	0.005	3.12
35 d	2.162^{b}	**2.268^{a}**	2.168^{b}	2.172^{b}	2.184^{b}	2.176^{b}	0.0101	0.021	2.75
42 d	2.778^{b}	**2.892^{a}**	*2.837^{ab}*	2.813^{b}	2.809^{b}	2.817^{b}	0.0377	0.024	2.36
Feed conversion (kg feed per kg gain)									
1 to 14 d	1.266^{a}	**1.210^{b}**	**1.229^{ab}**	1.254^{a}	1.257^{a}	1.258^{a}	0.0121	0.012	2.60
1 to 35 d	1.575^{ab}	**1.486^{c}**	**1.551^{b}**	1.581^{a}	1.555^{b}	1.577^{ab}	<0.0001	0.009	1.55
1 to 42 d	1.716^{a}	**1.614^{d}**	**1.669^{c}**	1.706^{ab}	**1.698^{b}**	1.707^{ab}	<0.0001	0.005	0.79
Feed efficiency (kg gain per kg feed)									
1 to 14 d	0.790^{b}	**0.827^{a}**	**0.814^{ab}**	0.797^{b}	0.796^{b}	0.796^{b}	0.0093	0.008	2.58
1 to 35 d	0.635^{bc}	**0.673^{a}**	**0.645^{b}**	0.632^{c}	0.643^{b}	0.634^{bc}	<0.0001	0.004	1.57
1 to 42 d	0.583^{d}	**0.620^{a}**	**0.599^{b}**	0.586^{cd}	**0.589^{c}**	0.586^{cd}	<0.0001	0.002	0.79
Feed intake (kg)									
1 to 14 d	0.476	0.494	0.488	4.748	4.718	4.757	0.1159	0.040	2.41
Mortality (%)									
1 to 14 d	0.56	1.40	1.11	0.83	1.11	0.83	0.9069	0.53	0.74^{1}
1 to 35 d	1.39	3.64	2.22	3.06	3.33	1.39	0.2917	0.87	1.19^{1}
1 to 42 d	2.50	4.47	3.33	4.17	4.17	2.50	0.7006	1.13	1.54^{1}

^{abcd}Means in row with common superscripts do not differ significantly (P<0.05) based on Duncan's Multiple Range Test. Values in bold face differ significantly (P<0.05) from negative control diet based on single-degree contrasts. Value in italics above differs from negative control diet based on (P<0.10). ^{1}CV of transformed means.

diets at the rate of 0.5 lbs per ton for broiler chickens may result in improved growth rate and feed utilization in the absence of growth promoting antibiotics. Although some patents have been issued regarding the microbial activity of hops in food products (Barney *et al.,* 1995; Millis and Schendel, 1994) we are unable to find any reported studies where fresh hops have been fed to any type of livestock. Further studies are suggested to confirm the results of the present study.

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References

Barney, M.C., L.T. Lusk, P.L. Ting and D.S. Ryder, 1995. Inventors; Miller Brewing Company, assignee. Method of inhibiting listeria. U. S. patent 5,455,038. October 3, 1995.

Batchvarov, V. and G. Marinova, 2001. Healthy ingredients in malt, hops and beer. Khranitelnovkusova-Promishlenost, 50: 15-17.

FASS, 1999. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. 1st rev. ed. Federation of Animal Science Societies, Savoy IL.

Millis, R.R. and M.J. Schendel, 1994. Inventors. Bio-Technical Resources, assignee. Inhibition of food pathogens by hop acids. U.S. Patent, 5, 286, 506.

SAS Institute, 1991. SAS® User's Guide: Statistics. Version 6.03 edition. SAS Institute Inc., Cary, NC.

Stavri, M., R. Schneider, G. O'Donnell, D. Lechner, F. Bucar and S. Gibbons, 2004. The antimycobacterial components of hops (Humulus lupulus) and their dereplication. Phytotherapy Res., 18: 774-776.

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[3]Agri-Stats, Fort Wayne IN.

[4]Ajinomoto Heartland Lysine, Chicago IL

[5]Penicillin G, Alpharma Inc., Fort Lee NJ 07024.

[6]Analysis conducted by the Washington State University Hop Lab, Pullman, WA.

[7]Cobb 500. Cobb-Vantress Inc., Siloam Springs AR.