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Meta-analysis of Broiler Chicken Trials Using Diets With or Without Allzyme® SSF Enzyme Complex

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Abstract: A meta-analysis of body weight and feed conversion ratio results from broiler chicken pen trials plus a few commercial trials (2001-2009) from several countries was conducted to demonstrate effects of a dietary enzyme complex (Allzyme® SSF, Alltech, Inc., Nicholasville, Kentucky USA) versus no supplement (negative control) on live performance. In the statistical meta-analysis, 28 references provided results for 51 comparisons (paired t-test) from which overall averages for body weight and feed conversion ratio were calculated. The final age (days) in each trial or in the experimental feeding period was noted and an estimate of final age was calculated using the ending age in each trial. Broiler chicken final body weight with the dietary enzyme complex product was found to be 0.057 kg or 3.73% greater than unsupplemented chicken body weight whereas feed conversion ratio was lowered by 0.043 or 2.64% with the enzyme product. These changes in live performance exceed those of Fisher and Wilson (1974) and those predicted by linear regression analysis using data from Jackson *et al.* (1982) and Waldroup (1996) for 75 extra kcal ME/kg of diet. Therefore, the 75 kcal ME/kg uplift used in the manufacturer's ingredient matrix appears to be conservative for the enzyme complex product based on results in the cited publications. Base on results presented herein, this enzyme complex product is recommended for use in broiler chicken feeds either by addition on top to take advantage of expected benefits or by reformulating the diets with 75 kcal less ME/kg (along with -0.1% calcium, -0.1% available phosphorus and -1% essential amino acids used in formulation). The usual rate of inclusion is 0.02% or 200 g/tonne.

Key words: Allzyme SSF, broiler, enzymes, meta-analysis, metabolizable energy

INTRODUCTION

An enzyme complex manufactured by solid-substrate fermentation, rather than conventional liquid fermentation, and containing phytase, starch and non-starch polysaccharide enzymes is commercially available (Allzyme® SSF, Alltech, Inc., Nicholasville, KY) for use in broiler chicken feeds. By this method, a naturally selected (non-genetically modified) strain of *Aspergillus niger* produces phytase, xylanase, protease, cellulase, beta-glucanase, amylase (Wu *et al.*, 2003), pentosanase and pectinase (Sundu *et al.*, 2004). This is not a blend or cocktail of enzymes but a natural complex or system of enzymes of fungal origin. According to the manufacturer, the enzyme complex product included in feed at the recommended dose (200 g/tonne or 0.02%) releases 75 kcal ME/kg (34 kcal ME/lb), 0.1% calcium and 0.1% available phosphorus, as well as 1% of the amino acids.

This article presents a meta-analysis of results of broiler chicken pen trials plus a few commercial trials (2001-2009) from several countries to demonstrate effects of the dietary enzyme complex vs. no supplement (negative control) on live performance.

MATERIALS AND METHODS

Research reports, articles and slide presentations (28 references) relating to pen trials and a few commercial field trials (2001-2009; one undated during this time period) were collected from 15 countries including Argentina, Australia, Brazil, Canada, China, Honduras, India, Ireland, Latvia, Maylaysia, Mexico, New Zealand, Switzerland, Taiwan and USA. In order to be included in the statistical meta-analysis, each trial must have reported age, inclusion rate of the enzyme product in the diets, body weight or gain and feed conversion or feed/gain ratio for the 2 treatments (negative control or negative control + Allzyme® SSF). Statistical analysis was performed using 51 pairs of data for each of the parameters and conducting paired t-tests with Statistix 8 (Analytical Software, Tallahassee, Florida; www.statistix.com). The level of probability for statistical significance was $p \leq 0.05$.

RESULTS AND DISCUSSION

In Table 1, data from 28 references (2001-2009) are presented showing broiler chicken body weight and feed conversion ratio values from trials comparing treatment

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Table 1: Meta-analysis of live performance results from broiler chickens given diets unsupplemented (nCON; negative control) or supplemented with the enzyme complex (+SSF, Allzyme® SSF) in trials from several countries[1]

Reference	Age days	Enzyme product % (vs. 0%)	Body wt (or gain), kg[2]		Feed conversion ratio (or feed/gain)[3]	
			nCON	+SSF	nCON	+SSF
Arrieta Acevedo ..., 2008	10-35	0.02	1.709	1.842	2.04	1.87
Azcona *et al*., 2007a	42	0.02	3.045	3.128	1.736	1.681
Azcona *et al*., 2007a	42	0.02	3.019	3.047	1.736	1.707
Azcona *et al*., 2007b	28	0.02	1.378	1.437	1.388	1.375
Chen *et al*., ca. 2002	41	0.02	2.635	2.641	1.721	1.703
Chen *et al*., ca. 2002	42	0.02	2.713	2.671	1.534	1.525
Christodoulou, 2003	42	0.02	2.17	2.21	1.738	1.678
Christodoulou, 2003	42	0.03	2.17	2.23	1.738	1.658
Gernat, 2009	42	0.02	2.309	2.244	1.839	1.780
Gernat, 2009	42	0.02	2.169	2.288	1.853	1.761
Gernat, 2009	42	0.02	1.975	2.192	1.844	1.923
Gernat, 2009	42	0.02	2.043	2.040	1.955	1.932
Gonzales *et al*., 2005	10-36	0.02	1.457	1.592	2.04	1.87
Harter-Dennis ..., 2001	4-18	0.03	0.336	0.362	1.425	1.453
Humphrey *et al*., 2008	43	0.02	2.175	2.164	1.79	1.78
Humphrey *et al*., 2008	43	0.04	2.311	2.323	1.83	1.81
Iglesias *et al*., 2009	28	0.02	1.378	1.437	1.388	1.375
Iglesias *et al*., 2009	28	0.025	1.378	1.408	1.388	1.387
Iglesias *et al*., 2009	28	0.03	1.378	1.396	1.388	1.373
Johnston *et al*., 2001	35	0.05	1.924	2.000	1.717	1.660
Leeson (undated)	17	0.0125	0.463	0.471	1.25	1.25
Leeson (undated)	17	0.025	0.463	0.456	1.25	1.21
Leeson (undated)	17	0.05	0.463	0.495	1.25	1.19
Leeson (undated)	17	0.10	0.463	0.502	1.25	1.19
Perez, 2003	42	0.02	2.156	2.354	1.782	1.736
Perez, 2003	42	0.02	2.277	2.340	1.848	1.844
Perez, 2005	42	0.02	2.61	2.80	1.66	1.66
Perez, 2005	42	0.02	2.63	2.67	1.65	1.65
Peric *et al*., 2008	42	0.02	2.073	2.160	1.96	1.93
Peric *et al*., 2008	42	0.02	2.066	2.105	1.99	1.96
Pierce *et al*., 2007	21	0.02	0.626	0.648	1.727	1.639
Pierce *et al*., 2008	14	0.02	0.383	0.387	1.453	1.460
Pierce *et al*., 2008	14	0.02	0.306	0.336	1.767	1.626
Pierce *et al*., 2009	21	0.04	0.507	0.588	1.502	1.431
Pierce *et al*., 2009	21	0.06	0.507	0.605	1.502	1.383
Qin *et al*., 2003	21	0.02	0.514	0.618	1.47	1.45
Qin *et al*., 2003	21	0.02	0.588	0.623	1.48	1.53
Ramesh and Dev., 2004	42	0.02	2.086	2.165	1.88	1.81
Ribeiro *et al*., 2003	3-15	0.006	0.139	0.221	1.65	1.43
Ribeiro *et al*., 2003	3-15	0.006	0.132	0.218	1.75	1.42
Ribeiro *et al*., 2003	3-15	0.006	0.252	0.301	1.38	1.35
Rutz, 2005	21	0.02	0.860	0.884	1.30	1.35
Schang and Azcona, 2005	42	0.02	2.60	2.73	1.69	1.67
Shan and Feng, 2008	56	0.02	3.079	3.138	1.91	1.83
Silveira *et al*., 2006	21	0.02	0.795	0.794	1.45	1.49
Silveira *et al*., 2006	21	0.02	0.886	0.884	1.35	1.35
Sundu and Dingle, 2003	7-21	0.02	0.543	0.622	1.24	1.19
Sundu and Dingle, 2003	7-21	0.02	0.568	0.573	1.21	1.22
Vitina *et al*., 2007	49	0.015	3.014	3.130	1.91	1.85
Widmer and Hadorn, 2001	41	0.02	2.091	2.153	1.797	1.777
Widmer and Hadorn, 2001	41	0.02	2.066	2.161	1.785	1.795
Overall avg (n = 51)	~ 31.7[4]	0.024	1.527[b]	1.584[a]	1.631[a]	1.588[b]
Difference				+0.057		-0.043
Relative difference, %				+3.73		-2.64
p-value (paired t-test)				<0.001		<0.001

[a-b]Overall means within a parameter and with different superscripts differ at $p \leq 0.05$.

[1]Some negative control diets had lower than standard levels of phosphorus, calcium, metabolizable energy, protein and/or amino acids.

[2]Body weight (preferably) or gain in kg (some values estimated from graphs).

[3]Feed conversion ratio, mortality-adjusted feed conversion ratio, or feed/gain (some values estimated from graphs).

[4]Average age estimated from ending ages in days

groups receiving negative control (nCON) diets or Allzyme® SSF supplemented (+SSF) diets. Final ages or ages during the feeding trials are given in days. An estimate of average age was calculated using the final age for each trial. The amount of enzyme complex product added to the supplemented diets is given in %. Body weight (or gain) is provided by treatment. Feed conversion (or feed/gain) ratio values are shown.

The overall average age was 31.7 days. The overall average amount of enzyme complex product added was 0.024% (240 g/tonne) and this ranged from 0.006-0.10% (6-1,000 g/tonne). Body weight (or gain) averaged 1.527 kg in the nCON treatment versus 1.584 kg in the +SSF treatment, a highly significant difference ($p<0.001$). The actual difference was 0.057 kg or 57 g due to supplementation and this was a 3.73% relative improvement over the nCON result. Feed conversion (or feed/gain) ratio averaged 1.631 in the nCON treatment versus 1.588 in the +SSF treatment, a highly significant difference ($p<0.001$) of 0.043 in favor of SSF treatment which was 2.64% relative improvement.

Fisher and Wilson (1974) reported an effect of dietary ME level on body weight of broiler chickens at 42 days of age. They developed a regression equation: Body weight (relative to body weight at 2.8 kcal ME/g diet) = 0.541 + 0.1639 x ME of diet (kcal/g). At 2.8 kcal ME/g of diet, relative body weight = 1.000. Weight gain (0-42 days) changed by +1.23% for each 0.075 kcal ME/g (75 kcal/kg) increase in the diet. Body weight gain/feed (g/g) changed by +1.98% for each 0.075 kcal ME/g (75 kcal ME/kg) increase in the diet (based on their table values). Their data was drawn from 51 experiments in 22 reports with a variety of different breeds, sexes, ages, nutrient ratios and forms of feed.

Jackson *et al.* (1982) used a 6 x 6 factorial arrangement of treatments with dietary crude protein from 16-36% and ME from 2600-3600 kcal/kg to determine effects on broiler body weight and feed conversion ratio. The main effects of increasing ME levels were a body weight increase from 1.645-1.797 kg at 49 days and a feed conversion ratio decrease from 2.306 to 1.948 from 0-49 days. For an extra 75 kcal ME/kg (using midpoint of ME range as basis; that is, 3,100 vs 3,175 kcal/kg), Jackson *et al.* (1982) data shows +0.0117 kg (+0.67%) body weight change and -0.0273 (-1.29%) feed conversion ratio change by linear regression.

Waldroup (1996; cited by Coon, 2001) fed male broiler chickens diets containing 3,023-3,383 kcal ME/kg (10 levels) to 42 days of age and found that feed conversion ratio linearly decreased with increasing ME content. Results were further analyzed by doing linear regression analysis for this report. The main effects of increasing ME levels were a body weight increase from 2.119-2.200 kg at 42 days and a decrease in feed conversion ratio from 1.823-1.694 from 0-42 days. For an extra 75 kcal ME/kg (using midpoint of ME range as basis; that is, 3203 vs 3,278 kcal/kg), Waldroup (1996) data shows +0.0200 kg body weight change (+0.92%) and -0.0288 feed conversion ratio change (-1.64%) by linear regression.

Meta-analysis results with the enzyme complex product (Table 1) exceed those in the published reports for improvements with 75 extra kcal ME/kg of diet. The meta-analysis overall change of +0.057 kg (+3.73%) in body weight with the enzyme complex product versus negative control appears to exceed 75 kcal ME/kg uplift based on the published broiler ME trial results of Fisher and Wilson (1974), Jackson *et al.* (1982) and Waldroup (1996). This is also true for the meta-analysis overall change of -0.043 (-2.64%) in feed conversion ratio with the enzyme complex supplemented versus negative control diet (Jackson *et al.*, 1982; Waldroup, 1996).

In conclusion, broiler chicken feeding trials from several countries over the period 2001-2009 have been evaluated in a statistical meta-analysis in order to compare negative control (unsupplemented) and Allzyme® SSF supplemented diets with regard to body weight and feed conversion ratio. By averaging results from 51 comparisons, improvement in body weight with the enzyme complex product was found to be 0.057 kg or 3.73% whereas feed conversion ratio decreased by 0.043 or 2.64%. These changes in live performance exceed those of Fisher and Wilson (1974) and those predicted by linear regression analysis using data from Jackson *et al.* (1982) and Waldroup (1996) for 75 extra kcal ME/kg of diet. Therefore, the 75 kcal ME/kg uplift used in the enzyme complex ingredient matrix appears to be conservative based on results in those publications. The enzyme complex product is recommended for use in broiler chicken feeds either by addition on top to take advantage of expected benefits or by reformulating the diets with 75 kcal less ME/kg (along with -0.1% calcium, -0.1% available phosphorus and -1% of the essential amino acids used in formulation). The usual rate of inclusion is 0.02% or 200 g/tonne.

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