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Broiler, *Cinnamomum*, glucose.

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The Effects of Cinnamon Powder Feeding on Some Blood Metabolites in Broiler Chicks

ABSTRACT

The effect of cinnamon powder (CNP) feeding on some blood metabolites in broiler chicks was studied in a 49-day experiment. The feeding program consisted of a starter diet until day 21, a grower diet until day 42 and a finisher diet until day 49. There were five treatments: a negative control diet, without the additive (control: T₁); 250 mg/kg (T₂); 500 mg/kg (T₃); 1000 mg/kg (T₄); and 2000 mg/kg (T₅) of CNP in the diet. A total of 320 one-day-old mixed-sex broilers (Ross 308) were distributed into 16 pens with 20 chickens each, comprising 3 replicates per treatment (except for T₁, which had 4 replicates). Serum glucose was measured weekly and reported periodically. At the end of the experiment serum cholesterol, triglycerides, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activities were determined. There were no significant differences among treatments regarding broiler performance and carcass characteristics, except for the finisher phase, when T₂ resulted in a significant decrease in feed conversion ratio and weight gain ($p < 0.05$). In the lowest level of cinnamon supplementation (T₂), a significant increase in glucose level in starter, finisher and overall rearing period was observed, as well as an increase in triglyceride levels at the finisher phase as compared to T₄ and T₅ ($p < 0.05$). However, cholesterol, AST and ALT levels were not statistically different among treatments. Therefore, it was concluded that the use of cinnamon powder can affect on some blood metabolites and broiler performance.

INTRODUCTION

Phytogenic feed additives are plant-derived products used in animal feeding in order to improve livestock performance. This class of feed additives has recently gained interest, especially for use in swine and poultry, as can be observed by a significant increase in the number of scientific publications since 2000. One of the oldest medicinal plants is cinnamon, belonging to the Lauracea family. The genus *Cinnamomum* comprises approximately 250 species that are widely distributed in China, India and Australia (Jayaparkasha, 2003). The main substance in cinnamon is cinnamaldehyde.

Plasma glucose concentrations in bird species are 150 to 300% higher than in mammals of similar body mass (Umminger, 1975; Pollock, 2002; Braun & Sweazea, 2008). Glucose is utilized by birds for a variety of functions, particularly for energy production through cellular oxidation, glycogen synthesis in the liver and glycolytic muscles, fatty acid synthesis as well as synthesis of nonessential amino acids, vitamin C, and other metabolites. In addition, domestic fowl are known for their insulin resistance, hence requiring doses of insulin which



chickens (Gibson *et al.*, 1989). Moreover, large doses of insulin are required for glucose uptake in insulin responsive tissues in chickens (Gomez-Capilla, 1977).

More than 400 plants that lower glucose levels are known, including cinnamon (Ernst, 1997). Khan (1990) isolated an unidentified factor from cinnamon and called it insulin potentiating factor (IPF). They demonstrated that IPF increased threefold the activity of insulin in glucose metabolism in rat epididymal fat cells. Anderson (2001) characterized this unidentified factor present in cinnamon as methyl hydroxy chalcone polymers (MHCP). Also, Khan (2003) compared fasting serum glucose levels in 60 type-2 diabetic subjects. Cinnamon had a statistically significant effect in decreasing fasting serum glucose level (from a mean of 326 to 175 mg/dl), which was not observed with the placebo.

The effect of ground thyme and cinnamon on performance of broilers was studied by Al-Kassie & Jameel (2009), who found they affected live weight gain and improved bird health, as well as other performance traits, as feed conversion ratio and feed intake.

Although there are some differences in blood glucose level control in mammals and birds, cinnamon had shown hypoglycemic effects in some experiments with mammals. Thus, it was decided to investigate the effect of different levels of cinnamon powder on performance and carcass composition of broilers, as

well as on blood glucose level and on other blood biochemical metabolites.

MATERIALS AND METHODS

Birds and experimental facilities

Three hundred and twenty one-day-old mixed sex broiler chicks (Ross® 308) were used. Birds were housed in a litter floor system. Routine management procedures used in intensive broiler production were followed to ensure disease control and comfort of the experimental birds. Feed and water were provided *ad libitum*. Pens were placed inside a commercial farm so that experimental broilers were reared with other birds at the farm. The initial temperature of 32°C was gradually reduced according to bird age and reached 20°C at the end of the experiment. Chicks were randomly allotted to groups of 20 birds to each of the 16 floor pens (2 × 1 m), with three pens per treatment (except for the control treatment, which had four replicates).

Experimental design and diets

Five experimental diets, with three replicates each (except for T₁, which had four replicates), were fed to broiler chicks for 49 days: a negative control diet, without dietary supplementation (T₁); 250 mg/kg (T₂); 500 mg/kg (T₃); 1000 mg/kg (T₄); and 2000 mg/kg (T₅) of cinnamon powder (CNP). Table 1

Table 1 - Composition of experimental diets of broiler chickens during 7 to 49 days of age.

Ingredients	Starter (7-21 days)					Grower (21-42 days)					Finisher (22-49 days)				
Corn	56.77	56.77	56.77	56.77	56.77	63.81	63.81	63.81	63.81	63.81	71.53	71.53	71.53	71.53	71.53
Soyean meal	32.06	32.06	32.06	32.06	32.06	30.13	30.13	30.13	30.13	30.13	24.33	24.33	24.33	24.33	24.33
Fish meal	4.47	4.47	4.47	4.47	4.47	-	-	-	-	-	-	-	-	-	-
Cinnamon ¹ (CNP)	0.000	0.025	0.05	0.1	0.2	0.000	0.025	0.05	0.1	0.2	0.000	0.025	0.05	0.1	0.2
Wheat bran	0.75	0.725	0.7	0.65	0.55	0.75	0.725	0.7	0.65	0.55	0.75	0.725	0.7	0.65	0.55
Dicalcium phosphate	0.93	0.93	0.93	0.93	0.93	1.03	1.03	1.03	1.03	1.03	0.81	0.81	0.81	0.81	0.81
Limestone	1.09	1.09	1.09	1.09	1.09	1.24	1.24	1.24	1.24	1.24	1.16	1.16	1.16	1.16	1.16
Vit. Min. Permixon ²	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.34	0.34	0.34	0.34	0.34	0.31	0.31	0.31	0.31	0.31	0.23	0.23	0.23	0.23	0.23
Vegetable oil	3.00	3.00	3.00	3.00	3.00	2.20	2.20	2.20	2.20	2.20	0.69	0.69	0.69	0.69	0.59
DL-Methionine	0.09	0.09	0.09	0.09	0.09	0.03	0.03	0.03	0.03	0.03	-	-	-	-	-
Calculated analysis															
E (kcal/kg)	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900
CP (%)	20.48	20.48	20.48	20.48	20.48	18.12	18.12	18.12	18.12	18.12	16.31	16.31	16.31	16.31	16.31
Ca (%)	0.91	0.91	0.91	0.91	0.91	0.82	0.82	0.82	0.82	0.82	0.72	0.72	0.72	0.72	0.72
Avail. P (%)	0.41	0.41	0.41	0.41	0.41	0.32	0.32	0.32	0.32	0.32	0.11	0.11	0.11	0.11	0.11
Arg. (%)	1.40	1.40	1.40	1.40	1.40	1.20	1.20	1.20	1.20	1.20	1.05	1.05	1.05	1.05	1.05
Lys (%)	1.247	1.24	1.24	1.24	1.24	0.98	0.98	0.98	0.98	0.98	0.85	0.85	0.85	0.85	0.85
Met+Cys (%)	0.82	0.82	0.82	0.82	0.82	0.65	0.65	0.65	0.65	0.65	0.57	0.57	0.57	0.57	0.57



shows the composition of the experimental diets. All diets were made up with essential ingredients such that they supplied bird nutritional requirements as recommended by National Research Council (NRC, 1994). An unbalanced completely randomized design was applied. The required amount of cinnamon was purchased from the local market and finely ground. All birds received a starter diet from 1 to 21 d, grower diet from 21 to 42 d and finisher diet from 42 to 49 d. All diets were in mash form.

Sampling and measurements

Bird body weight and feed intake were weekly recorded to calculate weight gain and feed conversion in the different periods. At the end of the experiment, one chicken from each replicate were slaughtered and the relative weight of abdominal fat pad, liver, pancreas and carcass yield to live body weight were measured. Blood glucose level was measured weekly (two birds from each pen) with a glucometer and reported periodically (Rightest™ GM300). A glucometer was used in this experiment because of its high speed determination and low stress for the broilers, too. At the end of the experiment, two birds in each pen were bled from a punctured median metatarsal vein. Ten milliliter of blood were aspirated from each bird then coagulated to sera for blood chemistry measurements. The bottles of coagulated blood were subjected to standard methods of serum separation and the harvested sera used for evaluation of plasma cholesterol, triglyceride, AST and ALT. The measurements were made at 49 days of age, using

appropriate commercial laboratory kits with RA1000 spectrophotometer.

Statistical Analyses

The effect of cinnamon powder on blood chemistry, performance and carcass traits were analyzed statistically by ANOVA with SAS9.1 software (SAS, 2002). Duncan's multiple range test was used to detect the differences ($p < 0.05$) among different group means (Steel, 1980).

RESULTS AND DISCUSSION

Performance and carcass characteristics

The effects of different level of CNP on broiler performance are presented in Table 2. Different level of cinnamon powder had no significant effect on feed intake in all periods. From 42 to 49 days of age (finisher), broilers fed the T_2 diet grew slower than the broilers fed the T_3 diet (510g and 628g, respectively). Results indicated that cinnamon powder at its lowest level during the whole experimental period (T_2) had its lowest feed intake. The highest feed intake happened with the broilers of T_3 ($p > 0.05$). These results could be related to changes that happened in blood metabolites.

The common regulatory mechanisms of feed intake include the glucostatic theory, the thermostatic theory, the lipostatic theory, distention of the gastrointestinal tract, circulating amino acids and protein intake (Gleaves, 1989). The feed intake reduction in T_2 might be due to the glucostatic hypothesis, and/or the increase in glucagon level. Hypoglycemia stimulates a nervous center for intake whereas hyperglycemia stimulates the center for satiety. Shirlock and Forbes (1981) observed that with the injection of glucose in the hepatic portal vein of fasted chickens, food intake decreased at physiological rates, whereas no effect was observed when glucose was injected into the jugular vein. Central administration of glucagon in rats suppressed feed intake (Inokuchi *et al.*, 1984). Increase in glucose level in T_2 may be the responsible to reduce appetite and feed intake in the birds of that treatment.

The results of different levels of cinnamon powder in some aspects

Table 2 - Growth performance in broiler chickens fed the experimental diets.

Parameters	Control(T_1)	T_2	T_3	T_4	T_5	SE (Control)	SE (T_2 ...)
Body weight gain g/day/bird							
Days 7-21	463	478	494	473	469	0.01	0.02
Days 21-42	1386	1397	1320	1374	1386	0.04	0.05
Days 42-49	611ab	510b	628a	570ab	601ab	0.03	0.04
Days 7-49	2461	2377	2443	2419	2456	0.06	0.07
Feed intake, g/day/bird							
Days 7-21	814	858	888	836	835	0.02	0.02
Days 21-42	3068	3004	3094	3084	3064	0.08	0.09
Days 42-49	1482	1453	1559	1479	1465	0.06	0.07
Days 7-49	5365	5316	5543	5400	5346	0.14	0.16
FCR, Feed intake/weight gain							
Days 7-21	1.75	1.80	1.795	1.76	1.79	0.05	0.06
Days 21-42	2.22	2.14	2.30	2.24	2.19	0.07	0.08
Days 42-49	2.44b	2.89a	2.47b	2.6ab	2.45b	0.08	0.10
Days 7-49	2.18	2.23	2.27	2.231	2.17	0.03	0.04

T_1 : basal diet, T_2 : basal diet + 250 mg/kg of cinnamon powder, T_3 : basal diet + 500 mg/kg cinnamon powder, T_4 : basal diet + 1000 mg/kg cinnamon powder and T_5 : basal diet + 2000 mg/kg



at Table 3. Different levels of cinnamon powder had no significant effect ($p>0.05$) on the evaluated carcass traits. T_2 resulted in the lowest abdominal fat content, but this difference was not statistically significant ($p>0.05$). It seems that glucagon increase in T_2 increased lipolysis and reduced abdominal fat.

Blood parameters

The effects of CNP supplementation on blood biochemical parameters (glucose, cholesterol, triglycerides, AST and ALT) of broilers are presented in Table 4. Cinnamon powder supplementation had no significant effect on cholesterol, AST and ALT levels. Cinnamon powder, at its lowest level (T_2), significantly increased average glucose level at 7, 42 and 49 days of age ($p<0.05$). In addition, at 49 days of age, blood plasma triglyceride level of birds in T_2 group was higher than those of birds in T_4 and T_5 ($p<0.05$).

These findings disagree with the results of a study conducted by Kim (2006), in which supplementation of the diet of diabetic mice with 200 mg/kg of cinnamon powder decreased blood glucose, total cholesterol and triglyceride levels, while raised HDL cholesterol levels. Also, Khan (2003) showed that cinnamon had hypoglycemic and hypolipidemic effects in type-2 diabetic subjects. In contrast with mammals, in birds, glucagon plays a major role in directing the distribution of nutrients, and insulin has a secondary role (Sturkie, 1998). In the present study, supplementation of

broilers diet with 250 mg/kg of cinnamon powder significantly increased blood glucose ($p<0.05$). One possibility is that, due to reduced insulin resistance in the tissues and reduced insulin levels, glucagon secretion increased, and therefore, serum glucose level increased. Glucagon inhibits hepatic lipogenesis (Collado *et al.*, 1983; Leclercq *et al.*, 1988; Rosebrough, 1992). The increase in lipolysis may have caused the increase in triglyceride levels in T_2 . Also, it was found that T_2 increased cholesterol level ($p>0.05$) at 49 days of age. This finding agrees with the results of a study conducted by Sambaiah & Srinivasan (1991), and Lee (2004). Sambaiah & Srinivasan (1991) reported that powdered-cinnamon at the level of 500 ppm increased serum cholesterol in rats, which corroborates with the results obtained in this experiment and also Lee's (2004) results. Lee (2004) reported the supplementation of a rye diet with cinnamaldehyde significantly increased plasma cholesterol levels in broiler chicks. In addition, Faix (2009) reported that ALT was significantly reduced in chickens fed diets supplemented with 0.05% and 0.025% of cinnamon oil. The liver plays an important role in metabolic processes, and the metabolic activity of the liver is important for the normal functioning of cellular events. Serum AST and ALT are indicators of normal liver function (Cornellus, 1980). In this study, there was no change in AST and ALT activities in all groups.

Birds appear to be a unique class among vertebrates with respect to the use of glucose as a metabolic substrate. Birds, as a class, maintain relatively high PGLu.

CONCLUSION

The use of hypoglycemic plants may have different effects in mammals and birds. By evaluating the biochemical metabolites of broiler blood, we were able to study their relationship with broiler performance.

More research is needed to clarify the effect of CNP on blood metabolites, carcass characteristics and broiler performance.

Table 3 - Carcass characterized in broiler chickens fed the experimental diets.

Parameters	T1 (Control)	T2	T3	T4	T5	SE (Control)	SE (other treatments)
Carcass yield (%)	71.80	72.79	71.98	72.66	70.47	0.98	1.13
Pancreas (%)	0.16	0.19	0.16	0.18	0.17	0.02	0.02
Liver (%)	1.87	1.90	1.75	1.75	1.84	0.11	0.13
Abdominal fat (%)	3.13	2.57	3.35	2.97	3.05	0.30	0.35

T1: basal diet, T2: basal diet + 250 mg/kg of cinnamon powder, T3: basal diet + 500 mg/kg cinnamon powder, T4: basal diet + 1000 mg/kg cinnamon powder, T5: basal diet + 2000 mg/kg cinnamon powder and SE: standard error. a,b - Means within a trait and row with no common superscript differ significantly ($p < 0.05$).

Table 4 - Blood parameters in broiler chickens fed the experimental diets.

Parameters	T1 (Control)	T2	T3	T4	T5	SE (Control)	SE (other treatments)
Glucose (mg/dl)							
Days 7	273b	341a	266b	276b	271b	18.15	20.9
Days 21	249	257	257	253	256	4.98	5.75
Days 42	243b	269 a	246b	251ab	253ab	5.67	6.50
Days 49	253b	287a	258b	261b	261b	6.39	7.38
Cholesterol (mg/dl)	116	117	104	110	117	4.47	5.17
Triglyceride (mg/dl)	119ab	140a	97ab	90b	80b	12.16	14.05
AST (IU/L)	222	240	209	210	229	11.42	14.70
ALT (IU/L)	3.40	4.16	4.50	4.83	3.83	0.60	0.70

T1: basal diet, T2: basal diet + 250 mg/kg of cinnamon powder, T3: basal diet + 500 mg/kg cinnamon powder, T4: basal diet + 1000 mg/kg cinnamon powder, T5: basal diet + 2000 mg/kg cinnamon powder and SE: standard error. a,b - Means within a trait and row with no common superscript differ significantly ($p < 0.05$).



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