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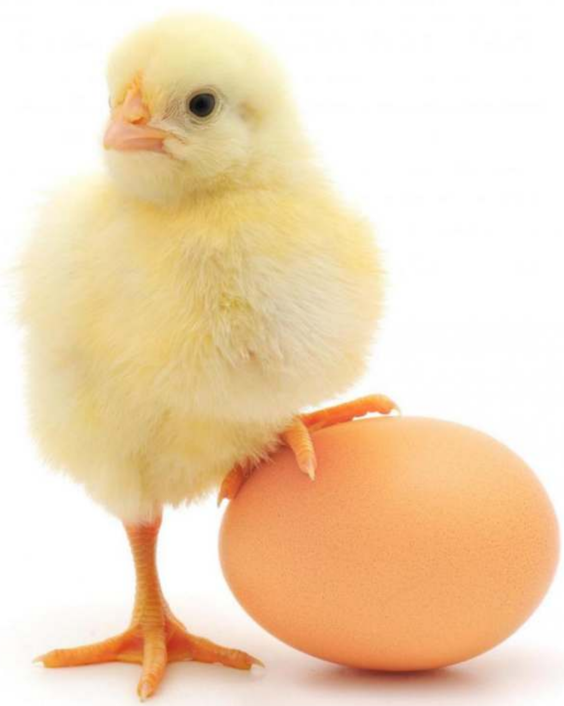

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Effect of Starch and Amino Acid Levels on Growth Performance and Blood Parameters of Broiler Chicks

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Abstract: This study was conducted to investigate the relationship between starch and amino acid levels of broiler diets on growth performance and feed efficiency. In this study, 240 day old chicks were distributed into 6 treatments using a completely randomized design (CRD) with four replications. Three treatments were fed with high starch and three others were fed with low starch. Both type of diets were formulated as isocaloric with three levels of total lysine, varying from 1.34, 1.43 and 1.48% for starter period (0-18 days) and 1.18, 1.3 and 1.35% for finisher period (19-35 days). The result showed that high starch level increased body weight gain ($p<0.01$) and feed intake at 35 days ($p<0.05$). No interaction between starch level and amino acid level was observed for body weight gain, feed intake and feed conversion ratio at 35 days. There was no difference for blood parameter glucose. Uric acid and insulin was affected by starch and amino acid level. Significant interaction between starch level and amino acid was observed for uric acid. Ratio starch and amino acid were positively correlated with weight gain and feed consumption ($r = 0.573$, $p<0.05$). It was concluded that feeding high starch level based on corn soya diet increased body weight gain and feed intake. Starch level has relationship with blood glucose, insulin and utilization of protein and energy in broiler.

Key words: Starch, amino acid, broiler performance

INTRODUCTION

Feed efficiency aims to achieve production results that match genetic potential with low feed costs and reduce the potential environmental pollution caused by excess nutrients which are not digested by livestock, especially proteins. One technique to improve feed efficiency is to use the concept of balance energy and protein in broiler feed formulation. In addition, protein is composed of amino acids with a certain ratio of the amino acid lysine (ideal protein concept model). Starch is a part of carbohydrate as important energy source for broiler chickens. The amount of starch is still not taken into account in predicting the energy content of a material. Starch provides a more than 50% of energy requirement in broiler feed which based on corn and soybean meal. Starch generally has very high digestibility, but the rate of degradation in the intestine varies (Weurding *et al.*, 2001).

Feed with the starch content gradually broken down in the small intestine, will provide continuous glucose into the bloodstream. Glucose in the blood will be responded by the release of insulin which plays an important role in the transport of glucose and protein into muscle during growth (Fox, 1996). Continuous availability of glucose to the posterior part of the small intestine, could prevent the use of amino acids as an energy source for the intestinal wall (Weurding *et al.*, 2003).

This study focused on investigate concept of balance energy-amino acid related to the difference in the speed of starch digestibility in the small intestine Availability of different amounts of starch in the isocaloric feed, is expected to give different growth responses in broilers.

MATERIALS AND METHODS

Animal and housing: In this study, 240 birds (DOC) were placed in to 24 pens. Six types of feed with four replication were used and each replication contained 10 birds. Age 0-18 days used food similar with starter feed. Age 19-35 days used grower feed.

Diets: There were 6 types of feed formulation were used, 2 of starch(high starch 36% and lower starch 32%).which combine with 3 levels of the amino acid Lysine based Total 1.34, 1.43 and 1.48% for the starter phase and 1.18, 1.3 and 1.35% for the grower phase. Other amino acid will follow the ratio of total Lysine according to nutrient requirement ROSS 308. The feed is given in the form of crumble. Temperature process was 80°C conditioner, die size of 3.2 mm, minimum 90% PDI. Composition and nutrient content of research feed as in Table 1 and 2.

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Table 1: Composition and nutrient content of starter feed (0-18 days)

	Treatment					
Raw material	HSLL	HSML	HSHL	LSLL	LSML	LSHL
Corn	57.118	57.449	58.671	46.497	46.075	47.468
Ricebran	3.502	2.838	0.000	13.809	15.000	11.321
Soybean meal 47%	27.764	26.970	27.792	26.966	24.757	27.445
Fish meal 60%	5.000	5.000	5.000	5.000	5.000	5.000
Crude Palm Oil	3.756	3.331	3.195	5.000	4.508	4.638
Meat Bone Meal 50%	0.000	2.300	3.400	0.000	1.050	2.050
Poultry Meat Meal	0.000	0.000	0.000	0.000	1.400	0.000
L-Lysine 78%	0.195	0.270	0.285	0.190	0.290	0.300
L-Threonine 95%	0.062	0.113	0.122	0.063	0.105	0.112
DL-methionine 99%	0.294	0.353	0.370	0.288	0.352	0.370
Tryptophan 100%	0.000	0.000	0.003	0.000	0.000	0.000
Limestone Ca 38%	0.400	0.000	0.000	0.500	0.200	0.000
Dicalcium Phosphate 18%	1.250	0.827	0.629	1.120	0.723	0.748
Salt NaCl	0.145	0.118	0.106	0.135	0.101	0.112
Mineral Premix	0.100	0.100	0.100	0.100	0.100	0.100
Vitamin Premix	0.100	0.100	0.100	0.100	0.100	0.100
Choline chloride 60%	0.100	0.100	0.100	0.101	0.101	0.096
Antimold propionic acid	0.050	0.050	0.050	0.050	0.050	0.050
Antioxidant	0.020	0.020	0.020	0.020	0.020	0.020
Anticoccydium	0.060	0.060	0.060	0.060	0.060	0.060
Nutrient content						
Crude Protein (%)	21.34	22.17	22.88	21.04	22.00	22.60
ME (Kkal/kg)	3100.0	3100.8	3100.1	3100.2	3100.6	3100.0
Ca (%)	0.95	0.95	1.04	0.95	0.95	0.91
P (%)	0.75	0.79	0.78	0.86	0.89	0.87
Crude Fiber (%)	2.51	2.46	2.25	3.29	3.37	3.12
Crude Fat (%)	7.55	7.26	6.94	9.60	9.47	9.19
Starch (%)	36.00	35.98	36.01	32.09	32.13	32.05
Lysine (%)	1.34	1.43	1.48	1.34	1.43	1.48
Cl (%)	0.278	0.289	0.29	0.284	0.284	0.286
Na (%)	0.16	0.16	0.16	0.16	0.16	0.16
Methionine (%)	0.664	0.732	0.757	0.661	0.732	0.755
Methionine+Cystine (%)	1.00	1.07	1.11	1.00	1.07	1.11

HSLL: starch 36%-lysine 1.34% HSML: starch 36%-lysine 1.43% HSHL: starch 36%-lysine 1.48%
LSLL: starch 32%-lysine 1.34% LSML : starch 32%-lysine 1.43% LSHL: starch 32%-lysine 1.48%
HSLL: High starch Low Lysine HSML:High Starch Medium Lysine HSHL:High Starch High Lysine
LSLL: Low starch Low Lysine LSML:Low Starch Medium Lysine LSHL:Low Starch High Lysine

Feed quality and blood parameters analysis

Proximate analysis: Quality feed were analyzed using full proximate AOAC method (1980).

Blood parameters: Blood glucose levels (Glucose Hexokinase Kit, Bayer, USA), levels of the hormone insulin (Coat-A-Kits COUNTA Insulin, DPC, LA, CA) and blood uric acid (Bio-systems kit), was read with a spectrophotometer.

Starch analysis: Polarimeter methods read with a spectrophotometer.

Starch and protein digestibility

Ileal starch digestibility (%): Calculated by subtracting the total amount of starch consumed with remaining starch in the small intestine digesta, divided by the total starch consumed multiplied by 100%.

Total protein digestibility (%): Calculated by subtracting the total protein consumed minus total protein remaining in the feces, divided by the total protein consumed multiplied by 100%.

Chicken growth

Feed intake (g/bird): Measured by weighing the amount of feed consumed during the study.

Average weight gain (g/bird): Calculated by calculating the weight at the end of the study by reduced the initial weight.

Feed conversion ratio: calculated by comparing feed consumption with weight gain.

Statistical analysis

The experimental design used in this study is a completely randomized design (CRD) with 4 replications 2x3 factorial. The data obtained were analyzed using analysis of variance (ANOVA),and the differences among mean treatments were analyzed using Tukey test (Steel and Torrie, 1995a-b).

RESULTS AND DISCUSSION

Weight gain: Based on Table 3, the average weight gain of birds aged 0-35 days in all treatments ranged from 1659.82 to 1891.54 g. Standard of broiler strain ROSS

Table 2: Composition and nutrient content of finisher feed (19-35 days)

	Treatment					
Raw material	HSLL	HSML	HSHL	LSLL	LSML	LSHL
Corn	59.021	54.482	55.154	45.787	45.799	44.655
Ricebran	10.000	10.000	8.407	15.000	15.000	15.000
Soybean meal 47%	18.962	22.121	21.513	17.836	17.195	16.178
Fish meal 60%	5.000	5.000	5.000	5.000	5.000	5.000
Crude Palm Oil	3.226	4.024	3.753	5.000	5.000	6.000
Meat Bone Meal 50%	1.600	2.300	4.450	0.450	4.600	2.400
Poultry Meat Meal	0.000	0.000	0.000	4.500	1.050	0.000
L-Lysine 78%	0.220	0.245	0.275	0.235	0.335	0.240
L-Threonine 95%	0.085	0.110	0.123	0.088	0.140	0.088
DL-methionine 99%	0.285	0.341	0.362	0.328	0.368	0.283
Wheat Pollard	0.000	0.000	0.000	0.000	0.000	4.050
Copra Expeller	0.000	0.000	0.000	5.000	5.000	5.000
Dicalcium Phosphate P 18%	1.014	0.816	0.428	0.265	0.000	0.541
Salt NaCl	0.121	0.111	0.086	0.062	0.063	0.104
Mineral Premix	0.100	0.100	0.100	0.100	0.100	0.100
Vitamin Premix	0.100	0.100	0.100	0.100	0.100	0.100
Choline chloride 60%	0.136	0.120	0.119	0.119	0.120	0.130
Antimold propionic acid	0.050	0.050	0.050	0.050	0.050	0.050
Antioxidant	0.020	0.020	0.020	0.020	0.020	0.020
Anticoccydium	0.060	0.060	0.060	0.060	0.060	0.060
Nutrient Content						
Crude Protein (%)	18.949	20.509	21.182	21.262	21.072	19.205
ME (Kkal/kg)	3200.7	3200.9	3200.0	3200.8	3200.8	3200.6
Ca (%)	0.90	0.94	1.09	0.87	1.06	0.88
P (%)	0.84	0.85	0.88	0.84	0.91	0.89
Crude Fiber (%)	2.90	2.93	2.80	3.78	3.74	4.01
Crude Fat (%)	7.95	8.60	8.40	10.74	10.79	11.54
Starch (%)	36.77	36.00	36.00	31.98	31.99	32.02
Lysine (%)	1.18	1.30	1.35	1.18	1.30	1.35
Cl (%)	0.284	0.284	0.286	0.26	0.284	0.27
Na (%)	0.16	0.16	0.16	0.16	0.16	0.16
Methionine (%)	0.629	0.702	0.730	0.701	0.735	0.629
Methionine+Cystine (%)	0.930	1.020	1.050	1.024	1.05	0.931

HSLL: starch 36%-lysine 1.18% HSML: starch 36%-lysine 1.30% HSHL: starch 36%-lysine 1.35%
LSLL: starch 32%-lysine 1.18% LSML : starch 32%-lysine 1.30% LSHL: starch 32%-lysine 1.35%
HSLL: High starch Low Lysine HSML:High Starch Medium Lysine HSHL:High Starch High Lysine
LSLL: Low starch Low Lysine LSML:Low Starch Medium Lysine LSHL:Low Starch High Lysine

for weight gain in 35 days old is 1979 g. Best result in this study was 95.5% of genetic potential. Ratio starch and amino acid were positively correlated with weight gain and feed consumption (r = 0.573, $p<0.05$) (Table 5).

Different starch content in feed between 36 and 32% gave a significant influence on the weight gain of the chicken 0-35 days ($p<0.01$). Weight gain was not influenced by different levels of amino acids. The results showed no interaction between level of starch and amino acids on chicken weight gain. Feed with starch content of 36% led to higher feed intake than the diet feed containing 32% of starch ($p<0.05$). Difference in feed intake is causing different starches consumption. Starch is part of energy source carbohydrate which is essential for broiler. Starch break down into glucose in small intestines. Pancreatic α-amylase secreted into the lumen of the small intestine, especially in the jejunum to break the bonds α-1,4 starch (Rogel *et al.*, 1987).

Glucose is absorbed through the small intestinal wall, through sodium and potassium pump mechanism. Glucose is needed as a precursor in the citric acid cycle (citric acid cycle) (Klasing, 2000). Oxidation of glucose produces energy which is necessary for the synthesis of glycogen, amino acids, fatty acids and other metabolites (Harper *et al.*, 1984). Feed that containing 36% starch produces more glucose compared with the diet containing 32% starch. This evidenced by the digestibility of starch in the small intestine (ileal Digestibility starch) were significantly different ($p<0.05$), ie 99.46 and 99.26% between diets with a high starch compared with lower starch diet. Glucose produced of feed containing different starches will be determined by the amount of starch entering the small intestine multiplied by its digestibility level.

Feed with adequate starch content, will provide continuous glucose into the bloodstream. Glucose in the blood will be responded by the release of the insulin hormone (Henquin, 2000). Insulin plays an important role in the transport of glucose and deposition protein into muscle during growth (Fox, 1996). Black *et al.* (2005) stated that the unequal rate of starch digestibility and protein affect protein deposition and broiler performance.

Consumption and feed conversion ratio: Based on Table 3, the average feed consumption in chickens aged 0-35 days in all treatments ranged from 2795.76 to 3199.32 gram. Genetic potential of modern broiler strain ROSS for feed consumption to 35 days old is 3248 gram. Average feed intake in this study was 90.9% of genetic potential. Starch content in different feed between 36 and 32% gave significant effect on feed consumption of chicken 0-35 days age ($p<0.05$). Feed consumption is not influenced by differences in the levels of amino acids in the diet. The results showed there is no interaction between level of starch and amino acids on broiler feed consumption. Differences on starch content in the diet cause differences gelatinization process at the pellet-making process heating steam temperature above 80°C, leading to differences resistance pellet. Pellet quality was also influenced by the feed composition. A good quality pellet and not easily destroyed is one of the things that led to increased feed intake (Weurding *et al*., 2001).

Feed conversion 0-35 day old chicks in all treatments ranged between 1.65-1.75. Genetic potential of modern broiler strain ROSS 308 for feed conversion for age 35 days is 1.607. Average feed conversion in this study was 95% of the genetic potential. Starch content in different feed between 36 and 32% had no real effect on 0-35 days age chicken feed conversion ($p>0.05$). Feed conversion is not influenced by differences in the levels of amino acids in the diet. The results showed no interaction between level of starch and amino acids to the broiler feed conversion. Feed containing higher starch tends to provide a better feed conversion ration compared with lower starch content.

Ileal starch absorption: Based on Table 4, the average digestibility of starch in the small intestine 35 days old chicken on all treatments ranged from 99.09-99.48%. Starch content in different feed between 36 and 32% gave significant effect on digestibility of starch in the small intestine of chicken 0-35 days ($p<0.05$). Digestibility of starch in the small intestine is not influenced by differences in the levels of amino acids in the ration. The results showed no interaction between level of starch and level of amino acids for starch digestibility to the small intestine for 35 day old chickens. Feed containing higher starch provides a higher digestibility of starch in the intestine than the lower starch diets.

Total protein absorption: Based on Table 4, the average of total feed protein digestibility of chickens aged 35 days on all treatments ranged from 68.98 to 84.22%. Starch content in different feed between 36 and 32% gave real effect on protein digestibility chicken feed 0-35 ($p<0.05$). Protein digestibility is influenced by differences in the levels of amino acids in the diet (p<0:05). The results showed no interaction between level of starch and level of amino acids for protein digestibility. Feed containing higher starch gives a lower protein digestibility than the diet containing lower starch (75.35 and 84.22%). Results of this study indicate that although feed with low starch content have higher protein digestibility, but did not give weight gain better than the feed that contain more starch. Selle *et al*. (2010) states that the rate of absorption of amino acids associated with the rate of starch digestibility and absorption of glucose that had effect on the growth and deposition protein. Nitrogen Retention not correlated with the rate of nitrogen digestibility.

Content of glucose, uric acid and insulin in chicken blood: The blood parameter profile was provided in Table 6. Blood glucose levels ranged between 200. 14-223.68 mg/dL. Hazelwood (1984) stated that the levels of glucose in broilers is higher compared with other mammals, the range 180-250 mg/dL. Chickens are in a state of hypoglycemia when blood glucose levels 137 mg/dL and hyperglicemia on blood glucose levels 363 mg/dL (Goodwin *et al*., 1994). Results showed no significant differences in all treatments. Feed containing higher starch tend to have higher blood glucose levels compared with a diet containing a low starch content

Table 3: Average weight gain, feed consumption and conversion ratio age 0-35 days

Item	HSLL	HSML	HSHL	LSLL	LSML	LSHL
Gain (g/bird)	1891.54±110.18[a]	1795.36±41.37[a]	1811.02±143.30[a]	1659.30±90.93[b]	1665.82±99.48[b]	1676.43±96.65[b]
Consumption (g/bird)	3199.32±99.06[a]	2971.80±144.8[a]	3003.95±295.25[a]	2829.07±60.98[b]	2795.76±128.3[b]	2931.84±70.02[b]
FCR	1.69±0.1	1.65±0.06	1.657±0.11	1.70±0.06	1.68±0.03	1.75±0.08

Means in the same row with different superscript differ significantly ($p<0.05$)

HSLL: High starch Low Lysine HSML: High Starch Medium Lysine HSHL: High Starch High Lysine

LSLL: Low starch Low Lysine LSML: Low Starch Medium Lysine LSHL: Low Starch High Lysine

Table 4: Average intestine starch digestibility and total protein digestibility age 0-35 days

	Treatment					
Item	HSLL	HSML	HSHL	LSLL	LSML	LSHL
Protein Dig.	68.98±2.93[c]	74.36±4.24[c]	82.70±2.49[b]	77.70±5.13[b]	81.68±5.7[b]	84.22±2.26[a]
Starch Dig.	99.42±0.02[a]	99.48±0.11[a]	99.47±0.11[a]	99.09±0.45[b]	99.39±0.3[b]	99.26±0.29[b]

Means in the same row with different superscript differ significantly ($p<0.05$)

HSLL: High starch Low Lysine HSML:High Starch Medium Lysine HSHL:High Starch High Lysine

LSLL: Low starch Low Lysine LSML:Low Starch Medium Lysine LSHL:Low Starch High Lysine

Table 5: Pearson correlations between Ratio starch amino acid and broiler performance

Item	Ratio Starch Amino acid (r)	p
Weight gain	0.573	0.003*
Feed Intake	0.550	0.005**
FCR	-0.012	NS
Glucose	0.013	NS
Uric Acid	-0.760	0.001**

**significant ($p<0.01$), *significant ($p<0.05$), ns: non significant

Table 6: Average Glucose, Uric Acid and Insulin in blood

	Treatment		
Parameter	Glucose (mg/dL)	Uric Acid (mg/dL)	Insulin (μIU/mL)*
HSLL	223.68±14.17	2.32±0.02	2.52±0.25
HSML	212.14±10.71	2.82±0.26	2.16±0.18[c]
HSHL	209.09±16.90	3.02±0.11	2.72±0.20[a]
LSLL	209.28±7.21	2.92±0.03	2.39±0.20[b]
LSML	209.22±19.31	2.87±0.18	1.73±0.05
LSHL	200.14±14.45	3.12±0.05	2.34±0.20[b]

Means in the same row with different superscript differ significantly ($p<0.05$)

HSLL: High starch Low Lysine HSML: High Starch Medium Lysine
HSHL: High Starch High Lysine LSLL: Low starch Low Lysine
LSML: Low Starch Medium Lysine LSHL: Low Starch High Lysine

(214.97 mg/dL and 206.21 mg/dL). Blood glucose always regulated in relatively constant levels through glucoregulation mechanism which is controlled by several metabolic hormones such as insulin, glucagon, pancreatic polypeptide, corticosterone and thyroxin (Hazelwood, 1984). Levels of insulin in the blood of chickens significantly influenced by the levels of starch and amino acids in the diet ($p<0.05$). Interaction between starch content and amino acids in the diet did not affect the levels of insulin. It showed that glucose results from breakdown of starch in diet stimulating secretion of insulin hormone by the pancreas (Henquin, 2000). Difference in starch content in feed will also result in different amounts of glucose. Grizard *et al.* (1999) stated that insulin plays a role in protein deposition in the body. This is thought to cause better weight gain on diet containing more starch. Adding of the amino acid from Lysine 1:34 to 1:43% did not respond higher insulin levels, both on the high starch and lower starch diet. Uric acid level in the blood can be used as one indicator to the final result nitrogen metabolism (Hartman *et al.*, 2006).

Donsbough (2010) stated levels of uric acid in broilers in the range of 2:02-5:13 mg/dL. The result of this study shows that differences in the levels of starch and amino acids in the diet treatment did not affect the levels of uric acid in the chicken blood. The result of this study similar to that expressed by Donsbough (2010). levels of uric acid had a tendency to increase at each addition of acid amino. Xie *et al.* (2004) suggest that increased levels of uric acid by the addition of amino acids methionine in diet. Uric acid as an antioxidant stated by (Hare and Johnson, 2003), therefore its existence is also associated with a state of oxidative stress (Cutler, 1984). Uric acid levels increase when the nitrogen intake increased (Hevia and Clifford, 1977).

Conclusions: Diet containing the same type starch but with different numbers gives different of weight gain and feed consumption in broilers ages 35 days. Feed containing high starch tends to have more levels of glucose and insulin in the blood. Total digestibility of proteins not directly describe the growth performance of chickens on feed which the starch content distinguished.

Recommendations: Broiler feed formulation needs to pay attention to the content of starch in the ration, because the process of starch digestion and glucose absorption associated with protein deposition.

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