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Effect of L-Dopa on Performance and Carcass Characteristics in Broiler Chickens

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***Abstract*—**Pure form of L-Dopa is used to enhance muscular development, fat breakdown and suppress Parkinson disease in humans. However, the L-Dopa in mucuna seed, when present with other antinutritional factors, causes nutritional disorders in monogastric animals. Information on the utilisation of pure L-Dopa in monogastric animals is scanty. Therefore, effect of L-Dopa on growth performance and carcass characteristics in broiler chickens was investigated. Two hundred and forty one-day-old chicks were allotted to six treatments, which consisted of a positive control (PC) with standard energy (3100Kcal/Kg) and negative control (NC) with high energy (3500Kcal/Kg). The rest 4 diets were NC+0.1, NC+0.2, NC+0.3 and NC+0.4% L-Dopa, respectively. All treatments had 4 replicates in a completely randomized design. Body weight gain, final weight, feed intake, dressed weight and carcass characteristics were determined. Body weight gain and final weight of birds fed PC were 1791.0 and 1830.0g, NC+0.1% L-Dopa were 1827.7 and 1866.7g and NC+0.2% L-Dopa were 1871.9 and 1910.9g respectively, and the feed intake of PC (3231.5g), were better than other treatments. The dressed weight at 1375.0g and 1357.1g of birds fed NC+0.1% and NC+0.2% L-Dopa, respectively, were similar but better than other treatments. Also, the thigh (202.5g and 194.9g) and the breast meat (413.8g and 410.8g) of birds fed NC+0.1% and NC+0.2% L-Dopa, respectively, were similar but better than birds fed other treatments. The drum stick of birds fed NC+0.1% L-Dopa (220.5g) was observed to be better than birds on other diets. Meat to bone ratio and relative organ weights were not affected across treatments. L-Dopa extract, at levels tested, had no detrimental effect on broilers, rather better bird performance and carcass characteristics were observed especially at 0.1% and 0.2% L-Dopa inclusion rates. Therefore, 0.2% inclusion is recommended in diets of broiler chickens for improved performance and carcass characteristics.

***Keywords*—**Broilers, Carcass characteristics, L-Dopa, performance.

I. Introduction

MUCUNA bean (velvet bean), a tropical legume, has a low human preference for food, but has a high potential as an energy and protein source in livestock feed [1]. It is comparable to soybean in terms of amino acid and mineral profile [2], [3]. However, the use of velvet bean as feedstuff for monogastric animals is limited by the presence of antinutritional factors like trypsin inhibitors, haemagglutinin, phytic acids, hydrocyanic acid, tannins and L-3, 4-dihydroxyphenylalanine (L-Dopa) [2], [4]. It has been reported that intake of raw, unprocessed mucuna by growing chickens has several deleterious effects [5]. Growth rate and feed intake were markedly depressed; physiological changes which included decrease in blood plasma levels of triiodothyroxine, cholesterol and creatinine, but an increase in plasma alanine aminotransferase were observed. The authors also reported that anatomical changes included increase in the weights of the pancreas, gizzard and proventiculus, but no change in liver weight while lengths of the small and large intestines and caeca were increased and he concluded that, the toxic principle in mucuna seed was identified to be L-Dopa, (3, 4-dihydroxyphenylalanine), which is said to be a potentially neurotoxic agent which occurs in large amounts [6]. Although L-Dopa (being the toxic principle in mucuna seeds) has a dramatic and negative effect on chicks' growth and feed intake as raw mucuna, most of the other physiological and anatomical effects of feeding raw mucuna, except for a decrease in plasma creatinine, which did not occur when pure L-Dopa was added to chick diets [7]. Thus, the L-Dopa content of raw mucuna alone cannot explain most of their negative effects when fed to chickens, and therefore, such changes must be due to other toxic anti-nutritional factors or combined effects of all the anti-nutritional agents or ordinary component such as fiber. In the research work done by [8], pure L-Dopa (50mg L-Dopa per 15g feed which equivalents 0.3% L-Dopa) was fed to Japanese quail without record of toxicity. This further confirms that L-Dopa is not the only toxic factor in mucuna but the combined activities of other agents.

In animals, L-Dopa is synthesized endogenously by hydroxylation of the amino acid Tyrosine and it is the precursor for the neurotransmitters; dopamine, norepinephrine (noradrenaline), and epinephrine (adrenaline) collectively known as catecholamines.

The hypothalamic monoamines; dopamine, L-Dopa (3, 4-dihydroxyphenylalanine), noradrenalin and serotonin have profound effects on the release of mammalian pituitary hormone, in most cases by modulating release of the hypothalamic hormone [9]. The hypothalamus is of paramount importance as an integration centre for the various influences on pituitary function. The hypothalamus apparently responds to the exteroceptive and interoceptive stimuli by altering secretion of certain neurotransmitters and release hormones. The response of any given pituitary hormone is presumably the sum of all the stimulatory or inhibitory influences.

Epinephrine, that dopamine is a precursor of, increases fat metabolism. Aside from insulin, catecholamines are the primary regulators of fat breakdown in cells by way of stimulation of adrenoceptors on the fat cell membrane. The

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activation of the sympathetic nervous system is involved in diet-induced thermogenesis, exercise and thermogenic supplements. Triglycerides are the stored form of fat used in energy metabolism. Fat cells are located in subcutaneous adipose tissue (under the skin), in the abdominal cavity surrounding organs (visceral fat) and between the cells of muscle and other tissues (intracellular lipids). Catecholamines (epinephrine and norepinephrine) are powerful stimulators of triglycerides from adipose tissue and exert their effect by binding to adrenergic receptors, stimulating fat oxidation. Additionally, catecholamines prevent fat cell formation by blocking the actions of adrenoreceptors on white adipose cells. As stimulation of the adrenoceptors can be thought of as the "on" switch for lipolysis, the adrenoreceptors can be considered the "off" switch.

According to [10], although the balance of these stimulating and inhibiting peptides determine GH release, the balance is affected by many physiological stimulators (e.g., exercise, nutrition, sleep) and inhibitors (e.g., free fatty acids) of GH secretion. One of the stimulators of GH is L-Dopa [11]. It contains natural secretagogues which may support the body's ability to stimulate the natural release of growth hormone. The blood carries the dopamine into the brain, where it naturally increases growth hormone production from the pituitary gland. An optimal hypothalamic dopamine concentration for growth hormone release could be achieved with a considerably lower dose of L-Dopa [12].

The effect of both oral and intravenous administration of L-Dopa on growth hormone (GH) secretion was studied by [13] on group of normal volunteers and a significant rise of serum GH levels was observed in both cases. The findings from that study supported the possibility that dopamine plays a role in the physiological regulation of GH secretion. L-Dopa is the precursor for Dopamine which plays an important role in physiological regulation of the growth hormone. According to [14], 0.5g L-Dopa has been observed to be associated with increasing levels of circulating growth hormone in persons without hypopituitarism, with the maximum time being approximately 60 minutes after ingestion. Hence this study is aimed at investigating the effect of L-Dopa on the performance and Carcass Characteristics in Broiler Chickens. A positive effect of L-Dopa on GH and, by implication, growth performance of broilers will lead to the use of L-Dopa as a growth enhancer then a better carcass accretion.

II. Materials and Methods

A. Management of Experimental Birds

Two hundred and forty one-day-old Abor Acre broiler chicks were obtained from a local hatchery, tagged, weighed and randomly allotted to 6 diets. The diets containing 22.6% (starter) and 20.6% (Finisher) crude protein were formulated as follows; a positive control (PC) with standard energy (3100Kcal/Kg) and negative control (NC) with high energy (3500Kcal/Kg). The rest 4 diets were NC+0.1, NC+0.2, NC+0.3 and NC+0.4% L-Dopa, respectively.

Each diet was replicated 4 times and a group of 4 pens of 10 birds each assigned to each treatment in a completely randomised design. The starter and the finisher diets were offered to the birds from day-old to 21 and from day 22 to 42, respectively. The diets and water were supplied *ad libitum* during each phase. The birds were housed in a well-ventilated standard poultry house.

B. Data Collection

Feed intake was determined deducting the left over from the total quantity of feed supplied to the birds. The birds were weighed weekly. On day 42, two birds of close to group average weight in each replicate were selected and killed by severing the jugular vein for carcass quality. Dressed weight, those of organs and primal cut (shanks, drumstick, breast, thigh, back, wings, neck and head) were also taken and recorded.

C. Statistical Analysis

Data obtained were analysed with ANOVA [15] and differences between treatment means differences were separated using Duncan Multiple Range Test ($P<0.05$).

III. Results

A. Performance of Birds Fed L-Dopa Supplemented Diets

The effect of L-Dopa supplementation on the performance of birds on experimented diets is shown in Table I. At the starter phase, significant ($P<0.05$) differences were observed in final weight, body weight gain, feed intake and dry matter intake of birds on dietary treatments. The feed conversion ratio was not statistically affected. The final weight (718.65g) of birds on Positive Control (PC) + 0.0% L-Dopa diet was similar to those on NC + 0.1% L-Dopa (663.30g) but higher than other diets. The lowest final weight was in birds fed NC + 0.3% (560.23g) and NC + 0.4% (517.40g) L-Dopa, which were similar. The body weight gain and dry matter intake of birds fed PC + 0.0% L-Dopa diet (679.60g and 886.02g) were significantly better than other diets with the least also obtained in birds fed NC + 0.3% (521.20g and 650.19g) and NC + 0.4% (478.30g and 621.14g) L-Dopa which were not significantly different. A similar trend was observed for feed intake where birds fed PC + 0.0% L-Dopa diet (977.60g) had highest value, which was significantly higher than other diets and the lowest values observed in birds fed NC (773.40g), NC + 0.3% (710.80g) and NC + 0.4% (680.90g) L-Dopa.

At the finisher phase, significant ($P<0.05$) differences were observed in final weight and body weight gain of birds on dietary treatments. Feed conversion ratio, feed intake and dry matter intake were not significantly different. The final weight of birds fed PC + 0.0% L-Dopa diet (1829.98g), NC + 0.1% L-Dopa (1866.72g) and NC + 0.2% L-Dopa (1910.88g) were similar but significantly better than the other L-Dopa supplemented diets. Also, the body weight gain of birds fed NC + 0.1% L-Dopa (1203.90g) and NC + 0.2% L-Dopa (1263.90g) were similar but significantly better than other diets. However, the least final Weight (1422.50g) and Body

Weight Gain (905.13g) values were recorded in birds fed NC + 0.4% L-Dopa supplemented diets.

B. Carcass Characteristics of Birds Fed L-Dopa

The effect of L-Dopa supplementation on carcass characteristic of birds on experimental diets is shown on Table II. There were significant (P<0.05) differences observed in the live weight, drum stick, thigh, breast, wings, neck and head of birds on dietary treatments. The live weight, thigh and breast of broiler chickens fed PC + 0.1% (2175.00g, 202.50g and 431.75g) and PC + 0.2% (2124.10g, 194.88g and 410.75g) L-Dopa supplementation were statistically similar but higher than other diets with least observed in birds fed PC + 0.4% (1869.00g, 175.63g and 333.38g) L-Dopa. Similar trend was observed in drumstick, neck and head weight of birds on experimental diets. However, back and shank of birds were not significantly influenced by the dietary treatments.

C. Meat to Bone Ratio of Birds Fed L-Dopa

The effect of L-Dopa supplementation on meat to bone ratio of the broiler chickens fed experimental diets is shown in Table III. Significant (P<0.05) difference was observed for the dressed weight of the experimental birds but other parameters were not significantly affected.

The dressed weight of birds fed NC + 0.1% (1375.0g) and NC + 0.2% (1357.13g) L-Dopa were significantly similar but better than other diets. The lowest value was observed in NC + 0.4% (1150.25g) L-Dopa supplementation.

TABLE I
PERFORMANCE OF BIRDS FED L-DOPA SUPPLEMENTED DIETS

Growth Period	Diet	Final weight	Body Weight Gain (g/chick)	Feed intake (g/chick)	FCR	Dry Matter intake (g/chick)
Starter, 0-21d	PC+0.0% L-Dopa	718.65^{a}	679.6^{a}	977.60^{a}	1.44	886.02^{a}
	NC+0.0% L-Dopa	577.83^{bc}	538.80^{c}	773.40^{cd}	1.44	707.43^{bc}
	NC+0.1% L-Dopa	663.30^{a}	624.30^{ab}	857.60^{b}	1.38	784.92^{b}
	NC+0.2% L-Dopa	644.02^{ab}	605.10^{b}	838.60^{bc}	1.39	765.48^{b}
	NC+0.3% L-Dopa	560.23^{c}	521.20^{c}	710.80^{cd}	1.37	650.19^{c}
	NC+0.4% L-Dopa	517.40^{c}	478.30^{c}	680.90^{e}	1.43	621.14^{c}
	SEM	26.42	20.76	22.64	0.03	29.87
	P-value	0.0004	0.001	0.001	0.309	<.0001
Finisher, 22-42d	PC+0.0% L-Dopa	1829.98^{a}	1107.00	2253.90	2.04	2072.20
	NC+0.0% L-Dopa	1718.82^{b}	1144.00	2278.10	1.99	2031.20
	NC+0.1% L-Dopa	1866.72^{a}	1203.90	2259.60	1.89	2073.20
	NC+0.2% L-Dopa	1910.88^{a}	1263.90	2363.50	1.87	2159.30
	NC+0.3% L-Dopa	1661.76^{b}	1104.10	2093.90	1.90	1921.60
	NC+0.4% L-Dopa	1422.50^{c}	2334.50	2178.10	1.84	1989.00
	SEM	34.22	589.21	117.25	0.21	106.13
	P-value	<.0001	0.57	0.65	0.79	0.71

Values are means of 4 replicates pens of 10 birds each, abc Means in column in each growth period with different superscripts are significantly different at P<0.05.

TABLE II
CARCASS CHARACTERISTICS (G/100G BW) OF BIRDS FED EXPERIMENTAL DIETS

Item	PC+0.0% L-Dopa	NC+0.0% L-Dopa	NC+0.1% L-Dopa	NC+0.2% L-Dopa	NC+0.3% L-Dopa	NC+0.4% L-Dopa	SEM	Pvalue
Live weight	2059.9^{ab}	1937.6^{ab}	2175.0^{a}	2124.1^{a}	1959.3^{ab}	1869.0^{b}	72. 7	0.0453
Drum	196.38^{ab}	191.13^{b}	220.50^{a}	214.00^{ab}	188.38^{b}	188.00^{b}	8.58	0.0087
Drum flesh	127.50^{ab}	121.13^{ab}	141.13^{a}	133.38^{ab}	120.25^{ab}	114.50^{b}	7.26	0.0212
Thigh	189.38^{ab}	186.88^{ab}	202.50^{a}	194.88^{a}	177.00^{ab}	175.63^{b}	8.15	0.0504
Thigh flesh	138.38^{ab}	135.50^{ab}	150.88^{a}	143.63^{ab}	121.88^{b}	126.13^{b}	6.97	0.0218
Breast	405.38^{ab}	376.88^{ab}	431.75^{a}	410.75^{a}	363.38^{ab}	333.38^{b}	22.3	0.0125
Breast flesh	306.13	287.75	314.25	283.50	270.50	243.13	24.9	0.5046
Back	303.75	287.75	333.00	327.38	309.25	288.38	15.4	0.2003
Back flesh	115.75	112.25	125.26	119.50	122.38	98.63	13.5	0.7308
Wing	161.88^{ab}	165.00^{ab}	176.75^{ab}	184.50^{a}	161.75^{ab}	156.38^{b}	7.02	0.0112
Wing flesh	76.25^{b}	74.5^{b}	74.63^{b}	89.25^{a}	74.38^{b}	67.38^{b}	3.69	0.0276
Shank	86.50	78.38	78.00	86.25	78.75	81.25	5.30	0.7868
Neck	90.75^{b}	103.00^{ab}	107.38^{a}	111.25^{a}	104.13^{ab}	97.38^{ab}	4.34	0.0105
Head	48.25^{ab}	45.13^{b}	50.25^{ab}	53.50^{a}	48.63^{ab}	46.00^{b}	1.75	0.0403

Values are means of 4 replicates pens of 10 birds each, abc Means in row with different superscripts are significantly different at P<0.05.

IV. Discussion

A. Performance of Birds on Experimental Diets

It was revealed from the results that L-Dopa supplementation did not elicit any deleterious effect on effect on performance parameters measured in both the starter and finisher phases. Despite the deliberate increase of the energy levels of the diets above NRC requirement using Soya oil, the Feed Conversion Ratio was not significantly affected so also was the Feed intake, especially at the finisher phase. Rather, Final weight and Body Weight Gain of broiler chickens fed high energy diets with L-Dopa inclusion were better without significant fat deposition.

The results obtained in the present study is an indication that L-Dopa extract from *Mucuna pruriens* is not responsible for the intoxication reported by [16] who reported that L-Dopa intoxication associated with the consumption of mucuna beans is related to their L-Dopa content. They postulated that anti-nutritional factors, lectins and L-dopa have been implicated in nutritional disorders in monogastric animals associated with their consumption. With the result of this study, also, L-Dopa content of Mucuna meal may not be responsible for the negative linear relationship on the parameters (feed intake and body weight gain) measured when *Mucuna utilis* beans meal (MBM) was used in a study by [17] and the significant reduction in weight gain of broiler chickens fed 20% inclusion of boiled mucuna seed meal as reported by [18]. However, [19] reported that phenolic non protein amino acid L-Dopa had significant effect on the growth performance and feed conversion ratio of common carp.

The improved weight gain of birds observed L-Dopa supplemented diets is probably due to bioavailability and utilisation of nutrients in L-Dopa supplemented diets. This is in line with the study by [20] and [21] who reported that L-Dopa is not a factor involved in the low feed intake of Mucuna diets, but intake improvement in processed diets was due to the reduction of anti-trypsic factors. These observations were similar to what was observed in the present study confirming the indication that pure L-Dopa extract from *Mucuna pruriens* is not responsible for the deleterious effects previously reported. The meat to bone ratio for the whole carcass and the primal cuts were not significantly affected by the inclusion of L-Dopa to the diets of broiler chickens.

TABLE III
MEAT TO BONE RATIO OF BIRDS FED EXPERIMENTAL DIETS

Item	PC+0.0% L-Dopa	NC+0.0% L-Dopa	NC+0.1% L-Dopa	NC+0.2% L-Dopa	NC+0.3% L-Dopa	NC+0.4% L-Dopa	SEM	P value
Live weight	2059.90^{ab}	1937.60^{ab}	2175.00^{a}	2124.10^{a}	1959.30^{ab}	1869.00^{b}	72.6627	0.0453
Dressed weight	1311.50^{ab}	1216.50^{ab}	1375.00^{a}	1357.13^{a}	1208.88^{ab}	1150.25^{b}	55.8491	0.0485
Meat:Bone	2.00	2.06	1.90	1.85	1.97	1.74	0.14	0.65
Dressing percentage	63.69	62.69	63.15	63.81	61.81	61.56	1.22	0.7
Drum Meat:Bone	2.57	2.59	2.53	2.46	2.74	2.19	0.23	0.67
Thigh Meat:Bone	3.70	4.27	4.53	4.22	3.48	3.94	0.38	0.42
Breast Meat:Bone	4.45	4.77	3.85	3.54	4.39	3.85	0.52	0.57
Back Meat:Bone	0.73	0.77	0.71	0.72	0.79	0.62	0.09	0.82
Wing Meat:Bone	1.19^{ab}	1.11^{ab}	1.02^{b}	1.29^{a}	1.24^{ab}	1.05^{b}	0.07	0.007

Values are means of 4 replicates pens of 10 birds each, PC- Positive Control, NC- Negative Control, abc Means in row in each growth period with different superscripts are significantly different at P<0.05.

B. Carcass Characteristic of Birds on L-Dopa Supplemented Diets

The dressed weight, breast, thigh, drumstick, wings, shank and neck of birds were positively influenced by the inclusion of L-Dopa in the diets. The increased weight of primal cut of broilers on lower levels of L-Dopa supplementation corroborated with the findings of [12] who reported that an optimal hypothalamic dopamine concentration of growth hormone release could be achieved with considerably lower dose of L-Dopa. The present result contradicted the report of [22] who reported that the lowest weight of carcass and cut-parts recorded on raw mucuna seed was due L-Dopa supplement which was considered as the growth depressing antinutritional factor. These reports were supported by [18] and [23].

V. Conclusion

The result from this study showed that L-Dopa supplemented diet improved the performance of broiler as a result of improved feed intake and weight gain of the experimental birds at the starter and finisher phases. Similarly, L-Dopa diet supplementation improved the carcass quality of birds on the experimental diet. It can therefore be concluded that L-Dopa supplementation on the diets of broiler at 0.1 to 0.4% inclusion levels did not elicit any deleterious effect on the overall performance of birds. Therefore, 0.2% L-Dopa inclusion is recommended for of improved feed intake, weight gain and carcass quality. Further research should be carried out to evaluate utilisation of L-Dopa *supplementation* in other poultry species.

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