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Growth Performance and Intestinal Morphology of Growing Pullets Fed Diets Containing Single and Combined Levels of Turmeric and Clove

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ABSTRACT

A total of 432, ISA Brown growing pullets were used to evaluate the effects of feeding diets containing Turmeric, Clove and Turmeric + Clove on growth performance and intestinal morphology. The birds were divided into 36 groups of 12 each weighed and allotted into experimental units. A total of nine experimental diets were formulated such that they contained 0, 1 and 2% turmeric, 0, 1 and 2% clove, and 0, 1 and 2% turmeric + clove combination on a 1:1 basis, respectively, in a 3 × 3 factorial arrangement (turmeric × clove × turmeric + clove: 0 × 1 × 2), replicated four times. The birds were weighed weekly to determine their body weight, weight gain, and feed conversion ratio. At the end of the experiment, 27 birds were sacrificed, and the duodenum, jejunum and ileum segments of the gastro intestinal tract were removed for gut histo-morphometry. Results showed that level of inclusion of feed additives significantly influenced feed intake (FI) and feed conversion ratio (FCR). Birds fed 1 and 2% inclusion of feed additive had reduced feed intake and lower FCR value when compared to higher FI and FCR values recorded in birds fed 0% inclusion of additives. Duodenal, jejunal and ilea morphology were significantly influenced by turmeric, clove, turmeric + clove, inclusion levels and treatment interaction. Birds fed diet containing turmeric + clove have significantly longer duodenal and jejunal villi as well as best duodenal and jejunal villus height: crypt depth ratio. It was concluded that up to 2% turmeric and turmeric + clove can be included in growing pullet's diet for improved performance. Inclusion of turmeric, clove and turmeric + clove improved morphological changes in the duodenum, jejunum and ileum of birds which might influence nutrient absorption and thus, improved FCR.

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Introduction

The risks associated with antibiotic usage and the increased pressure on the poultry industry to encourage organic livestock and poultry production has stimulated increased interest in natural consumer accepted growth promoters. Phytogenics are plant-derived natural bioactive compound which could be incorporated into livestock feed to potentially enhance productivity. Products may comprise the dried form of whole plants or their parts or extracts of some valuable ingredients (Grashorn, 2010). Phytogenics in feed as natural growth promoter has been identified as effective alternative to antibiotics as it has been reported to enhance performance, feed conversion ratio, carcass meat safety and quality in animals (Stanacev et al., 2011; Dhama et al., 2014, 2015). Phytogenic feed additive have also been reported to have beneficial effects on nutrient utilization by stimulating digestive enzymes such as lipase, amylase, or protease (Platel and Srinivasan, 2004), immune enhancement, health protection (Alagawany et al., 2015a and b) and improves gastrointestinal morphology (Upadhaya et al., 2016). However, variation in their bioactive ingredients, influences of location, climatic conditions, harvest or storage conditions (Huyghebaert et al., 2011) and preparation affects their efficacy. Some other factors that influence the efficacy of phytogenic feed additives include the plant parts and their physical properties, the genetic variation of the plant, age of the plant, different dosage used, extraction method, harvest time, and compatibility with other ingredients (Yang et al., 2009).

Turmeric is known to be native to the tropical South Asia, but is also grown in other tropical and sub-tropical Africa including Nigeria since it requires temperature between 20 and 30°C and a considerable amount of annual rainfall for growth (Khan et al., 2012). Clove is one of the major vegetal sources of phenolic compounds and is known to originate from the Maluku islands in east Indonesia (Nurdjannah and Bermawie, 2012). There are variations in the documentations of the effects of turmeric and clove supplementation on poultry performance. Al-Kassie et al., (2011), reported improved body weight gain, feed intake and feed conversion ratio with 0.75% and 1% inclusion of turmeric in the diets of broiler chickens. In another study, he reported that supplementation of turmeric and cumin mixture in the diets of broiler chickens at the rate of 5.0 g/kg resulted in a greater body weight gain and lower feed conversion ratio. Rajput et al., (2012) reported that supplementation of pure curcumin (phytochemical derived from turmeric) in the diets of 42 day old Arbor Acre at the rate of 0.2 g/kg in a corn-soybean based diets increased body weight gain, reduced feed conversion ratio, increased villus length, villus width in the duodenum, jejunum, and caecum. Agostini *et al*. (2012,) reported clove powder (0.1 - 2.5 g/kg diet) had positive effect on growth performance, feed efficiency and changes in the intestine epithelium of broiler chickens. However, some studies found no effect of dietary supplementation of turmeric and clove on poultry performance. Malekizadeh et al. (2012) reported that supplementation of turmeric meal in the diet at the rate of 10.0 or 30.0 g/kg did not influence production performance and external egg qualities of single comb White Leghorn (W-36) laying hens. Mahrous *et al*., 2017 also documented that the inclusion levels of 1.0 and 1.5 g of clove powder/kg diet did not affect growth performance parameters, but improved the health of broiler chickens. Thus, it is important to document the effect of PFA in a geographical location as well as their appropriate inclusion levels. Therefore, this study was aimed at investigating the single and combined effect of turmeric and clove on growth performance and intestinal morphology of growing pullets.

Materials and Methods

Ethical Approval

The study protocol and procedures were carried out in accordance with Babcock University Health Research Ethics Committee guidelines and regulations.

Location of the Study

This trial was conducted at a private farm in Ilorin, Kwara State, Nigeria under the supervision of the Animal Research Unit of the Faculty of Agriculture and Industrial Technology, Babcock University, Ilishan-Remo, Ogun State, Nigeria. The site is located in the middle belt of Nigeria on Longitude 4º35‟E of the Greenwich and Latitude 8º 29‟N of the equator.

Collection and Preparation of Experimental Materials

Fresh turmeric and dried clove buds used in this study were purchased from Mandate market Ilorin, Kwara State. Fresh Turmeric rhizomes were manually cleaned, peeled and cut into thin pieces. Thinly cut turmeric rhizomes were air dried under shade at temperature between 25 – 29°C for 10-15 days until crispy. Dried clove buds were cleaned and air dried for 24 hours prior to milling. Thereafter, they were milled individually in kitchen blender to fine particle sizes and stored in air-tight bags until incorporation into the formulated diet.

Management of Birds and Diets

A total of four hundred and thirty two (432) ISA Brown growing pullets were used for the study. They were randomly allocated on weight equalization basis to nine dietary groups of 48 birds. Each treatment group had four (4) replicates with 12 birds per replicate in a 3×3 factorial experimental arrangement. Dried wood shavings were used as litter materials in pens measuring 1m x 1.5m x 2m. Nine experimental diets were formulated such that the diets contained 0, 1 and 2% Turmeric, 0, 1 and 2% Clove, and 0, 1 and 2% Turmeric + clove on 1:1 ratio, respectively (Table 1).

Table 1. Ingredient Composition of growing pullets Diets containing Turmeric, Clove and their combination (week 8-16)

Ingredients	Turmeric			Clove			Turmeric+Clove		
	0%	1%	2%	0%	1%	2%	0%	1%	2%
Maize	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Soybean meal	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Wheat offal	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Bone meal	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Oyster shell	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Turmeric	-	+	++	-	-	-	-	-	-
Clove	-	-	-	-	+	++	-	-	-
Turmeric + Clove	-	-	-	-	-	-	-	+	++
Total	100	100	100	100	100	100	100	100	100
Analyzed Nutrients									
Crude Protein(%)	16.50	16.43	16.99	16.50	16.30	16.45	16.50	17.09	17.30
Ether Extract(%)	4.40	5.03	5.11	4.40	4.44	4.45	4.40	4.33	4.26
Crude Fibre(%)	4.76	4.37	5.89	4.76	3.12	3.09	4.76	4.61	4.96
Ash(%)	5.0	5.24	5.35	5.0	4.30	4.30	5.0	5.11	5.64
**ME(MJ kg $^{-1}$)	10.42	12.60	12.40	10.42	12.90	12.73	10.42	12.26	12.38

Grower Vit./Min. Premix contains Vit A, 10 000 000 iu; D_3, 2 000 000 iu; E, 12 500iu; K, 1.30; B_1,1.30; B_2, 4.00g; D Calcium-Pantothenate, 1.30g; B_6 1.30g; B_{12}, 0.01g; nicotinic acid, 15.00g; folic acid, 0.05g; biotin, 0.02g; Co, 0.20g; Cu, 5.00g; Fe, 25.00g; I, 0.06g; Mn, 48.00g; Se, o.10g; Zn, 45.00g; choline chloride, 200.00g; BHT, 50.00g, **ME (MJ kg^{-1}) = ME (Kcal kg^{-1})* (4.18/1000)

Data Collection

Data on feed intake and body weights were recorded weekly to determine growth performance. Feed conversion ratio and other performance parameters were calculated. At the end of the feeding trial (week 16), 4 birds per treatment (a bird/replicate) were randomly selected and slaughtered for gut histomorphometry.

Intestinal Morphology

At the end of the feeding trial, 3 birds per treatment were randomly selected and slaughtered for gut histomorphometry. The entire small intestinal tract was removed and washed with sterile phosphate buffered saline (PBS). Middle sections (3-4 cm in length) of duodenum, jejunum (from the pancreatic loop to Meckel's diverticulum) and ileum (from Meckel's diverticulum to the ileo-caeco-colic junction), were cut and prepared for histological indices. The histological indices were measured according to the method of Giannenas *et al*. (2011). Intestinal tissue samples were fixed in 10% neutral buffered formaldehyde (NBF), thereafter, processed for dehydration, clearing, and embedded in paraffin wax. Tissue sections, 6 µm thick (3 cross-sections from each sample), were cut from the waxed tissue by a microtome, cleared of wrinkles by floating on warm water (55-60°C). They were fixed on slides and stained with haemotoxylin and eosin. Histological indices were examined on a light microscope (Olympus Corporation, Tokyo, Japan) coupled with a computer. Villus height (VH) and crypt depth (CD) were measured and calculation was made for villus height/crypt depth rate. Villus height was measured from tip (with a lamina propria) of the villus to the base (villus-crypt junction) while the crypt depth was measured from the base up to the region of transition between the crypt and villus. Ten measurements were taken per bird for each variable. The average of these values was used for statistical analysis.

Statistical analysis

Data were arranged in a 3×3 factorial layout and subjected to a completely randomized design. Significant ($P<0.05$) differences among treatment means were determined using Duncan Multiple Range Test as contained in SAS (2010) package.

Results

The report of the performance indices measured in Table 2 showed that, turmeric, clove and turmeric + clove had no significant effect ($P>0.05$) on performance indices. However, inclusion levels of feed additive significantly influenced feed intake (FI) and feed conversion ratio (FCR) with 2% inclusion recording the lowest mean value of (63.37g and 5.87) and the 0% inclusion having the highest value of (74.77g and 6.94) respectively. Interaction effect had no significant effect on ($P>0.05$) performance indices (Table 3). However, higher numerical values of final live weight were recorded at 1 and 2 % inclusions of turmeric and turmeric + clove than in 0% inclusions.

Table 4 showed the effects of turmeric, clove, turmeric + Clove and levels of inclusion of the additives on the gut morphology of growing pullets. Significant differences ($P<0.05$) in the duodenum, jejunum and ileum villi height (VH), crypt depth (CD) and villi height: crypt depth ratio (V/C) was observed between the feed additives.

Birds fed turmeric + Clove had the highest duodenal villus height mean value of (1023.56µm) while birds fed turmeric had the lowest mean value of (932.67µm). Duodenum crypt depth of birds fed diet containing clove (480.33µm) recorded the highest value compared to the low and similar values recorded in birds fed diet containing turmeric (448.33µm) and turmeric + clove (459.67µm) respectively. Duodenum villus height: crypt depth of birds fed turmeric + clove (2.23µm) recorded the highest compared to clove (2.04 µm) which had the lowest value but within comparable value to that of birds fed turmeric (2.09µm).

Birds fed turmeric + clove recorded the highest Jejunum villus height value (835.33µm), but within comparable range to that of clove (820.67µm) compared to turmeric (792.67µm) fed birds which had the lowest value. Jejunum crypt depth of birds fed clove (518.67µm) had the highest value which is statistically similar to that obtained in birds fed turmeric (493.66µm) compared to the lowest value obtained in turmeric + clove(447.33µm) fed birds. Jejunum villus height: crypt depth was highest in birds fed turmeric + clove (1.90µm) compared to the lowest value obtained in clove (1.59µm) fed birds which is similar to the value obtained in birds fed turmeric (1.61µm).

Table 2. Main Effect of turmeric, clove, turmeric + clove and level of inclusion on growth performance of growing pullets (week 8-16) Additives Levels of Inclusion (%)

Parameters	Turmeric	Clove	Turmeric + Clove	SEM	0%	1%	2%	SEM
FLW(g/bird)	1365.72	1328.12	1361.19	24.27	1336.05	1366.89	1352.13	34.33
WG (g/bird)	771.06	742.57	760.07	16.82	754.71	762.28	756.70	23.59
DWG(g/bird/day)	11.01	10.61	10.86	0.24	10.78	10.89	10.81	0.34
FI (g/bird/day)	69.97	68.89	67.53	1.34	74.77 ^{a}	68.25 ^{b}	63.37 ^{c}	1.90
FCR	6.36	6.48	6.23	0.18	6.94 ^{a}	6.27 ^{b}	5.87 ^{b}	0.26

FLW: Final live weight, WG: Weight gain, DWG: Daily weight gain, FI: Feed intake, FCR: Feed conversion ratio

Table 3. Interaction effect of turmeric, clove and turmeric + clove and level of inclusion on growth performance of growing pullets (week 8-16)

Feed Additive	Turmeric Clove Turmeric + Clove Inclusion Levels									
	0%	1%	2%	0%	1%	2%	0%	1%	2%	SEM
FLW(g/bird)	1335.14	1368.00	1394.03	1335.00	1350.00	1299.36	1338.00	1382.57	1363	42.04
WG (g/bird)	747.14	764.00	802.03	763.00	757.60	707.11	754.00	765.24	760.97	28.89
DWG(g/bird/day)	10.67	10.92	11.46	10.90	10.83	10.10	10.77	10.93	10.87	0.41
FI (g/bird/day)	73.14 ^{a}	68.58^{bcd}	68.19^{bcd}	76.20 ^{a}	70.86^{abc}	59.62 ^{e}	74.98^{ab}	65.31^{cde}	62.29^{de}	2.32
FCR	6.85^{abc}	6.29^{abcd}	5.95^{bcd}	6.99 ^{s}	6.55^{abcd}	5.92^{cd}	6.96^{ab}	5.97^{abcd}	5.74^{cd}	0.31

FLW: Final live weight, WG: Weight gain, DWG: Daily weight gain, FI: Feed intake, FCR: Feed conversion ratio

Table 4. Main effect of turmeric, clove, turmeric + clove and level of inclusion on Intestinal Morphology of growing pullets (week 8-16)

	Additive				Level of Inclusion (%)			
GI Segment	Turmeric	Clove	Turmeric + Clove	SEM	0	1	2	SEM
				Duodenum				
VH (µm)	932.67^{c}	979.78^{b}	1023.56^{a}	5.60	928.33^{c}	1030.33^{a}	977.33^{b}	7.91
CD (µm)	448.33^{b}	480.33^{a}	459.67^{b}	6.52	470.00^{a}	469.67^{a}	448.67^{b}	9.22
V/C (µm)	2.09^{b}	2.04^{b}	2.23^{a}	0.03	1.98^{b}	2.19^{a}	2.19^{a}	0.04
Goblet cells	11.33	10.33	11.00	0.33	11.00^{a}	11.67^{a}	10.00^{b}	0.47
				Jejunum				
VH (µm)	792.67^{b}	820.67^{a}	835.33^{a}	5.58	755.00^{b}	841.33^{a}	852.33^{a}	7.89
CD (µm)	493.66^{a}	518.67^{a}	447.33^{b}	8.79	511.33^{a}	466.00^{b}	482.33^{b}	12.43
V/C (µm)	1.61^{b}	1.59^{b}	1.90^{a}	0.02	1.48^{b}	1.83^{a}	1.79^{a}	0.03
Goblet cells	10.00	8.67	9.56	0.67	11.89^{a}	8.67^{b}	7.67^{b}	0.95
				Ileum				
VH (µm)	594.67^{a}	587.00^{a}	575.11^{b}	2.87	580.44^{b}	603.67^{a}	572.67^{b}	4.06
CD (µm)	121.70^{a}	115.67^{b}	115.33^{b}	1.68	152.33^{a}	103.00^{b}	97.33^{c}	2.37
V/C (µm)	5.08^{b}	5.31^{a}	5.22^{ab}	0.07	3.82^{b}	5.91^{a}	5.88^{a}	0.09
Goblet cells	6.00	6.56	6.56	0.43	7.44^{a}	5.66^{b}	6.00^{b}	0.60

abcd Means on the same row having different superscript were significantly (P<0.05) different. SEM: Standard Error of Mean, GIT: Gastrointestinal tract, VH: villus height, CD: crypt depth, V/C: villus height: crypt depth

Table 5. Interaction effect of turmeric, clove, turmeric + clove and level of inclusion on intestinal morphology of growing pullets (week 8-16)

GI Segment	Additive Turmeric			Clove			Turmeric +Clove			Level of Inclusion (%)
	0	1	2	0	1	2	0	1	2	SEM
					Duodenum					
VH (µm)	927.00^{d}	936.00^{d}	935.00^{d}	927.33^{d}	997.00^{bc}	1015^{b}	930.67^{d}	1158.00^{a}	982.00^{c}	9.69
CD (µm)	470.00^{b}	455.00^{b}	420.00^{c}	470.00^{b}	464.00^{b}	507.00^{a}	470.00^{b}	490.00^{ab}	419.00^{c}	11.29
V/C (µm)	1.98^{d}	2.06^{cd}	2.23^{ab}	1.97^{d}	2.16^{bc}	2.00^{d}	1.98^{d}	2.37^{a}	2.35^{a}	0.05
Goblet cells	11.00^{ab}	12.00^{a}	11.00^{ab}	11.00^{ab}	11.00^{ab}	9.00^{c}	11.00^{ab}	12.00^{a}	10.00^{bc}	0.58
					Jejunum					
VH (µm)	754.00^{c}	779.00^{c}	845.00^{b}	755.00^{c}	862.00^{ab}	845.00^{b}	756.00^{c}	883.00^{a}	867.00^{ab}	9.66
CD (µm)	512.00^{ab}	483.00^{b}	486.00^{b}	512.00^{ab}	504.00^{ab}	540.00^{a}	510.00^{ab}	411.00^{c}	421.00^{c}	15.22
V/C (µm)	1.47^{d}	1.63^{bc}	1.74^{b}	1.48^{d}	1.71^{b}	1.57^{cd}	1.48^{d}	2.15^{a}	2.06^{a}	0.04
Goblet cells	12.00^{a}	10.00^{ab}	8.00^{bc}	12.00^{a}	8.00^{bc}	6.00^{c}	11.67^{ab}	8.00^{bc}	9.00^{abc}	1.16
					Ileum					
VH (µm)	580.00^{c}	584.00^{c}	620.00^{b}	579.00^{c}	674.00^{a}	508.00^{e}	582.00^{c}	553.00^{d}	590.00^{c}	4.97
CD (µm)	152.00^{a}	115.00^{b}	98.00^{c}	152.00^{a}	99.00^{c}	96.00^{c}	153.00^{a}	95.00^{c}	98.00^{c}	2.91
V/C (µm)	3.82^{e}	5.09^{d}	6.33^{b}	3.82^{e}	6.81^{a}	5.30^{d}	3.81^{e}	5.83^{c}	6.02^{bc}	0.11
Goblet cells	7.00^{ab}	5.00^{b}	6.00^{ab}	7.67^{a}	7.00^{ab}	5.00^{b}	7.67^{a}	5.00^{b}	7.00^{a1b}	0.74

abcde Means on the same row having different superscript were significantly (P<0.05) different. SEM: Standard Error of Mean, GIT: Gastrointestinal tract, VH: villus height, CD: crypt depth, V/C: villus height: crypt depth ratio

Ileum villus height of birds fed turmeric (594.67µm) recorded the highest value but similar to the value obtained in clove (587.00µm) fed birds while lowest value was obtained in birds fed turmeric + clove (575.11µm). Ileum crypt depth of birds fed turmeric (121.70µm) recorded the highest value compared to the low and similar values obtained in birds fed clove (115.67 µm) and turmeric + clove (115.33µm).Birds fed clove (5.31µm) recorded the highest value for Ileum villus height: crypt depth ratio but within comparable range to the value obtained in turmeric + clove (5.22µm) fed birds compared to the lowest value obtained in birds fed turmeric (5.08µm) which is also within comparable range to value obtained in turmeric + clove fed birds.

Interaction effect of turmeric, clove, turmeric + clove and level of inclusion is presented in Table 5. Significant (P<0.05) effect were observed on duodenum, Jejunum and ileum parts of the gastro intestinal tract of birds. Duodenum villus height at 1% inclusion of turmeric + clove (1158.00 µm) recorded the highest value compared to the least value (927.00µm) obtained at 0% inclusion of turmeric and 0% inclusion of clove. Duodenum crypt depth at 2% inclusion of clove (507.00µm) had the highest value compared to the lowest value recorded in birds fed 2% inclusion of turmeric + clove (419.00µm) which is within comparable value to that of birds fed 2% inclusion of turmeric (420.00µm). Similar and higher duodenum villus height: crypt depth ratio was recorded in birds fed 1% inclusion of turmeric + clove (2.37µm) and 2% inclusion of turmeric + clove (2.35µm), while lower and similar values were obtained in birds fed 0% inclusions of clove (1.97µm), 0% turmeric (1.98µm), 1% turmeric (2.06µm), 2% clove (2.00µm) and 0% turmeric + clove (1.98µm) respectively. Duodenum goblet cells at 2% inclusion of CLV (9.00) recorded the lowest value across the varying inclusions.

Jejunum villus height of birds fed 1% inclusion of turmeric + clove (883.00µm) had the highest value but within comparable range to that of birds fed 1% inclusion

of clove (862.00µm) and 2% inclusion of turmeric + clove (867.00µm) respectively while lower and similar values were recorded in all 0% inclusions of the varying combinations across the treatment having birds fed 0% inclusion of turmeric (754.00µm) recording the lowest value. Jejunum crypt depth of birds fed 2% of clove (540.00µm) inclusion recorded the highest value compared to the low and similar values obtained in birds fed 1% inclusion of turmeric + clove (411.00µm) and 2% inclusion of turmeric + clove (421.00µm). Jejunum villus height: crypt depth of birds fed 1% turmeric + clove (2.15µm) inclusion recorded the highest and statistically similar to the value obtained in birds fed 2% turmeric (2.06µm) inclusion compared to the low and similar values obtained at 0% inclusion of turmeric (1.47µm), 0% clove and 0% turmeric + clove (1.48µm) inclusions.

Ileum villus height of birds fed 1% inclusion of clove (674.00µm) recorded the highest value compared to the lowest value obtained in birds fed 2% clove (508.00µm) inclusion. Ileum crypt depth of birds fed 0% inclusions of turmeric (152.00µm); clove (152.00µm) and turmeric + clove (153.00µm) was higher values across the treatment, followed by value obtained in birds fed 1% turmeric (115.00µm) inclusion while lower and similar values were obtained in the rest of the varying inclusions having 1% turmeric + clove (95.00µm) recording the least value. Ileum villus height: crypt depth of birds fed 1% clove (6.81µm) inclusion had the highest value. Ileum goblet cells of birds fed 1% turmeric, 2% clove and 1% turmeric + clove inclusions recorded the lowest and same value (5.00) across the varying inclusions.

Discussion

Phytogenic feed additives have attracted increasing interest as an alternative feeding strategy to replace antibiotic growth promoters; however, variation exists on their biological efficacy on performance characteristics. Reduced feed intake and improved FCR in birds fed 1% and 2% inclusions of feed additives could be attributed to better feed utilization efficiency. These results are in agreement with the work of Oni et al., (2018) who reported reduced feed intake and better feed conversion ratio in pullet chicks fed mixture of chaya leaf, garlic and ginger powders. Increased weight gain, improved FCR with significant reduction in feed intake were reported by Durrani et al., (2006) when broilers were fed turmeric at 0.5% inclusion rate as against that of the control group. This can be seen in birds fed 2% TUM inclusion recording numerical higher weight gain, final live weight and also improved FCR than in control.

Healthy animals are generally characterized as having a well-functioning intestinal tract. The small intestine is responsible for digestion and absorption of ingested feed and its structure is assumed to be related to its function (Yamauchi et al., 2010). Akbarian et al., (2013) indicated that the maintenance of normal morphology and structural integrity of small intestine are imperative for preventing bacterial translocation from the intestinal tract. Purwanti et al. (2014) observed enhanced villi height when curcumin, garlic and their combination were fed to broilers.

Main effect revealed birds fed diets containing turmeric + clove have significantly longer duodenal and jejunal villi as well as best duodenal and jejunal villus height: crypt depth ratio compared to birds fed diets containing turmeric and clove. Villus condition is a common criteria measurement for investigation of the effects of nutrition on gut physiology. Awad et al., (2009) reported that, "longer villus could be considered as an indicator of an active functioning of intestinal villi as it provides more surface area for nutrients absorption. Turmeric + clove can be said to enhance gut physiology by providing more surface area for nutrient absorption. This can be seen in the final live weight of birds fed turmeric + clove than in control at the interaction level. Vieira et al., (2008) documented that in many cases significant correlations were not observed between performance and villus height or crypt depth. Despite higher villus of turmeric + clove at the duodenum and jejunum from the result of the main effect of turmeric, clove and turmeric + clove in this study, turmeric fed birds recorded the best final live weight. This could be as a result of the higher villus height and crypt depth recorded at the ileum of turmeric fed birds. 1 and 2% inclusion of additives produced higher villus height and better villus height: crypt depth ratio at the duodenum, jejunum and ileum layer of birds than in 0% inclusion. Giannenas et al., (2011), reported increased villus height of the birds in duodenum, jejunum and ileum fed 1 and 2 % mushrooms, which is similar to the results of this study.

Result of the interaction effect revealed that duodenum and jejunum layers of birds fed turmeric, clove and turmeric + clove would have a higher intestinal absorptive capacity as higher villus height and villus height: crypt depth were recorded than in controls across the treatment interaction.

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