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Effect of Black Pepper and Jaggery Supplementation with or without Feed Restriction on Broilers Performance

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ABSTRACT

A study was conducted to study the effects of black pepper and jaggery supplementation with or without feed restrictions on growth performance of broilers. In this growth study, 480 chicks were distributed randomly into 8 treatments having total 60 birds per treatment (4 replicates × 15 chicks in each replicate). (T_1- Control group fed *ad-libitum* as per ICAR specification T_2- T_1 with feed restriction (8-10 hrs) T_3- T_1 with 0.5 % black pepper supplementation T_4- T_1 with 0.5 % black pepper supplementation with feed restriction (8-10 hrs) T_5-T_1 with 1% jaggery supplementation T_6- T_1 with 1% jaggery supplementation with feed restriction (8-10 hrs) T_7- T_1 with 0.5% black pepper and 1% jaggery supplementation T_8 - T_1 with 0.5% black pepper and 1% jaggery supplementation with feed restriction (8-10 hrs). Due to feed restriction significant decrease in average body weight gain was observed at 2nd week of age but lower feed intake was observed during 2nd and 4th week. Black pepper supplementation decreased the average body weight gain at 2nd week of age and feed intake at 2nd and 3rd week of age but there was no significant difference in FCR. No Significant difference in average body weight gain and average feed intake was observed except during 5th week of age at which both average body weight gain and average feed intake reduced but no significant difference in FCR observed due to jaggery supplementation. So, it was concluded that significant reduction in average feed intake and average body weight gain was observed due to feed restriction.

Keywords: Broilers, feed restriction, black pepper jaggery supplementation, growth performance

Poultry is the most organized sector in animal agriculture, worth rupees one lakh crores. Within last two decades, the egg production has gone up to 70 billion from few millions and the broiler production has gone to 3.8 million tones. The growth is 6-8% in layers and 10-12% in broilers per year against the growth of agriculture as a whole which is around 2.5%. A profitable poultry production depends largely on feed utilization, faster body weight, absence of disease and low mortality (Kathirvelan, 2016). Feed of poultry constitutes approximately 70% of the total poultry production cost. A lot of efforts are being made to reduce feed cost for optimal economic returns. Owing to ongoing progress in fields of genetics and nutritional aspects of poultry feeding there has been tremendous increase in broiler performance and the market age for finishing body weight has now decreased significantly (Wilson, 2005). If feed is offered *ad-libitum*, broilers consumes 2-3 times above maintenance requirements (Barbato, 1994). This enhanced growth due to *ad-libitum* feeding is unfortunately accompanied by certain ill-effects like high metabolic rate, high mortality, increased body fat, metabolic and skeletal defects (Zubair and Leeson, 1996). So feed restriction strategies have been introduced to reduce these metabolic problems and hence improve economy of broiler production. Feed restriction in poultry farming is a method of feeding in which time or amount of nutritive feed is limited and based on the fact whether the bird is capable of achieving same final body weight as those fed *ad-libitum* or unrestricted (Ballay *et al.,* 1992; Yu and Robinson, 1992). Generally this restriction can be done both quantitatively (reducing daily feed offered) or qualitatively (nutrient dilution). The benefits of early

feed restriction are the savings obtained by improved feed efficiency and reduced incidents of sudden death syndrome (Bhat and Banday, 2000). This method improve feed conversion ratio (Lee and Leeson, 2001; Deaton, 1995) and also allows complete recovery of body weight.

Plant-derived additives used in animal nutrition to improve performance have been called "phytogenic feed additives." Black pepper was found to improve feed digestibility (Singh, 2015). It has been shown that piperine can dramatically increase absorption of selenium, vitamin B complex, β carotene and curcumin as well as other nutrients (Tazi *et al.*, 2014). Piperine enhances the thermogenesis of lipids and accelerates energy metabolism in the body and also increases the serotonin and β-endorphin production in the brain (Al-Kassie *et al.*, 2011). Pepper has been found to have antioxidant properties (Mittal and Gupta, 2000) and anticarcinogenic effect, especially when combined with chili (Vijayakumar and Nalini, 2006). Among its chemical and biological activities, piperine is characterized by antimicrobial (Reddy *et al*., 2004) and anti-inflammatory properties.

Gur is the coarse unrefined, pure sugar made from sugarcane juice. It is also called Jaggery. Jaggery contains 60-85% sucrose, 5-15% glucose and fructose and about 20% moisture. In 10 grams of jaggery, we could found 38.3 calories, 0.4 grams of moisture, 9.8 grams of carbohydrate and 9.7 grams of sugars. It also contains 7.54% of carbohydrate, 3.81% of magnesium, 3.75% of iron, 0.80% of calcium, 0.57% of phosphorus, 0.43% of manganese, 0.31% of Vitamin B6, 0.28% of potassium, 0.22% of selenium, 0.20% of sodium, 0.20% of Vitamin B5, 0.07% of niacin, 0.04% of choline and 0.03% of protein **(source :** www.niam.com).

Keeping in mind, the importance of feed restriction, black pepper and jaggery supplementation, here an effort was made to study the effect of black pepper and jaggery supplementation with or without feed restriction individually as well as combined effect.

MATERIALS AND METHODS

480 Day old unsexed meat type chicks (Vencobb) were procured from local market. Chicks were reared under normal conditions after they were vaccinated and wing banded at 0 day of age. All the birds were weighed individually and allocated to different treatments after removing heavy and light weight birds. Whole experiment was conducted in three phases i.e. starter (1^{st} – 14^{th} day), grower (15^{th} – 21^{st} day) and finisher (22^{nd} – 35^{th} day) phase. In this growth study, 480 chicks were weighed individually at 1 day of age and distributed randomly into 8 groups having total 60 birds per treatment with 4 replicates having 15 chicks in each replicate representing different treatments (T_{1-} Control group fed ad-*libitum* as per ICAR- 2013 specification i.e. starter diet (1^{st} – 14^{th} day) i.e. 22% CP and 3000 Kcal/Kg ME, grower diet (15^{th} – 21^{st} day) i.e. 21.5% CP and 3050 Kcal/Kg ME and Finisher diet (22^{nd} – 35^{th} day) i.e. 19.5% CP and 3100 Kcal/Kg ME.) T_2- $T_1$with feed restriction (8-10 hrs) T_3- T_1 with 0.5 % black pepper supplementation T_4- T_1 with 0.5 % black pepper supplementation with feed restriction (8-10 hrs) T_5- T_1 with 1% jaggery supplementation T_6- T_1 with 1% jaggery supplementation with feed restriction (8-10 hrs) T_7- T_1 with 0.5% black pepper and 1% jaggery supplementation T_8- $T_1$with 0.5% black pepper and 1% jaggery supplementation with feed restriction (8-10 hrs).

Eight broilers diets were formulated for the study for all the three phases i.e. starter (1^{st} – 14^{th} day), grower (15^{th} – 21^{st} day) and finisher (22^{nd} – 35^{th} day) phase as presented in Table 1. The percent ingredient composition of all the phases was kept as per ICAR (2013) specifications. Lysine and methionine levels were maintained as per ICAR (2013) standards in all the treatments during all the phase of growth. Each dietary treatment was fed to quadruplicate group of chicks containing 15 birds in each replicate. Mortality was recorded daily.

Each bird was weighed and feed residue was recorded at weekly interval. The weekly average feed intake and average body weight gain were recorded. The feeed conversion ratio (FCR), protein efficiency ratio (PER) and calorie efficiency ratio (CER0 was calculated. The feeders were removed from 8-10 hours during 8 pm to 6 am (next day) to apply feed restriction. *Ad-libitum* feeding and watering was done throughout the experimental period. Different ingredients used to formulate the diets and different diets formulated (starter, grower and finisher) were analysed for proximate principles, calcium and phosphorus. The chemical composition of different ingredients used for formulation of diets was within the normal range (AOAC, 2000). Proximate analysis of the

Table 1: Feed composition of different dietary treatments of broilers

Ingredients (kg/100 kg) \ Treatments	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Starter diet								
Maize	54.2	54.2	54.8	54.8	55.3	55.3	54.8	54.8
Soybean Meal	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Groundnut Extraction	6.0	6.0	6.5	6.5	7.0	7.0	7.0	7.0
De-oiled Rice Bran	3.0	3.0	1.4	1.4	—	—	—	—
Black Pepper	—	—	0.5	0.5	—	—	0.5	0.5
Jaggery	—	—	—	—	1	1	1	1
Oil	3.0	3.0	3.0	3.0	3.0	3.0	2.9	2.9
Di-calcium Phosphate	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Limestone Powder	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Grower diet								
Maize	58.5	58.5	56.9	56.9	57	57	56.5	56.5
Soybean Meal	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Groundnut Extraction	5.0	5.0	5.5	5.5	5.5	5.5	5.5	5.5
Black Pepper	—	—	0.5	0.5	—	—	0.5	0.5
Jaggery	—	—	—	—	1	1	1	1
Oil	3.0	3.0	3.5	3.5	3.2	3.2	3.2	3.2
Di-calcium Phosphate	1.3	1.3	1.4	1.4	1.7	1.7	1.7	1.7
Limestone Powder	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.0
Finisher diet								
Maize	62.3	62.3	61.8	61.8	61.3	61.3	60.8	60.8
Soybean Meal	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
Groundnut Extraction	4.0	4.0	4.0	4.0	4.5	4.5	4.5	4.5
De-oiled Rice Bran	1.5	1.5	1.5	1.5	1.0	1.0	1.0	1.0
Black Pepper	—	—	0.5	0.5	—	—	0.5	0.5
Jaggery	—	—	—	—	1.0	1.0	1.0	1.0
Oil	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Di-calcium Phosphate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Limestone Powder	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

* Additives (600gm) include Vit A 8,25,000 IU, Vit D_3 1,20,000 IU/, Vit K 100 mg, Riboflavin 500 mg, Thiamine 80 mg, Pyridoxine 160 mg, Vit E 800 mg, Cynacobalamine 100 mcg, Niacin 1200 mg, Calcium pantothenate 80 mg, Manganeese sulphate 25 g, Ferrous sulphate 10 g, Copper sulphate 500mg, Zinc oxide 8g Potassium Iodide 100 mg, Coccidiostat 60g, Methionine 100gm, Salt 300gm

prepared diets was also done and the various parameters were observed to be within required range.

RESULTS AND DISCUSSION

Effects of feed restriction, black pepper and jaggery supplementation are presented in Table 2 and overall effect of feed restriction, black pepper and jaggery supplementation on average feed intake and average body weight gain is presented in Table 3 and feed conversion ratio, protein efficiency ratio and calorie protein efficiency ratio is presented in Table 4.

Table 2: Effect of feed restriction, black pepper and jaggery supplementation on broiler,s performance

Effects of feed restriction						
Weeks	**Restriction**	**ABG**	**AFI**	**FCR**	**PER**	**CER**
Week 1	N	100.97±0.91	119.93±2.09	1.19±0.02	3.86±0.06	0.28±0.01
Week 2	N	170.06±2.78[a]	243.92±5.11[a]	1.43±0.02	3.18±0.05	0.23±0.01
	Y	144.31±2.66[b]	197.62±3.18[b]	1.38±0.03	3.33±0.07	0.24±0.01
Week3	N	268.31±4.68	463.24±10.84	1.73±0.03	2.71±0.05	0.19±0.01
	Y	269.4±3.92	451.64±12.48	1.68±0.05	2.8±0.08	0.2±0.01
Week 4	N	303.73±9.01	628.27±8.9[a]	2.09±0.06	2.48±0.06	0.16±0.01
	Y	295.9±6.05	600.22±6.07[b]	2.04±0.04	2.53±0.05	0.16±0.01
Week 5	N	477.57±11.09	867.4±14.85	1.82±0.03	2.82±0.04	0.18±0.01
	Y	457.32±9.72	841.29±12.18	1.85±0.03	2.79±0.04	0.18±0.01
Effects of black pepper						
Week 1	N	101.24±1	121.8±3.53	1.2±0.03	3.81±0.09	0.28±0.01
	Y	100.7±1.56	118.07±2.26	1.18±0.03	3.9±0.1	0.29±0.01
Week 2	N	163.02±4[a]	228.04±8.02[a]	1.4±0.03	3.28±0.07	0.24±0.01
	Y	151.34±4.04[b]	213.5±6.02[b]	1.41±0.03	3.23±0.06	0.24±0.01
Week 3	N	274.24±3.89	473.04±10.58[a]	1.73±0.04	2.71±0.06	0.19±0.01
	Y	263.47±4.29	441.84±11.54[b]	1.68±0.04	2.8±0.08	0.2±0.01
Week 4	N	307.09±6.11	619.85±5.68	2.03±0.04	2.54±0.05	0.16±0.01
	Y	292.54±8.69	608.64±10.29	2.1±0.06	2.47±0.06	0.16±0.01
Week 5	N	467.05±10.96	863.55±14.09	1.86±0.03	2.77±0.04	0.17±0.01
	Y	467.84±10.53	845.15±13.48	1.81±0.03	2.84±0.04	0.18±0.01
Effects of jaggery						
Week 1	N	101.88±1.17	119.85±3.97	1.18±0.04	3.91±0.11	0.29±0.01
	Y	100.06±1.4	120.02±1.5	1.2±0.02	3.8±0.08	0.28±0.01
Week 2	N	156.6±4.12	225.04±7.07	1.44±0.02	3.17±0.05	0.23±0
	Y	157.76±4.46	216.5±7.44	1.37±0.03	3.33±0.07	0.24±0.01
Week 3	N	270.03±3.71	443.41±8.27	1.65±0.03	2.85±0.06	0.2±0
	Y	267.68±4.84	471.47±13.53	1.76±0.05	2.67±0.07	0.19±0
Week 4	N	293.68±6.39	619.37±4.77	2.13±0.06	2.43±0.05	0.15±0
	Y	305.95±8.6	609.12±10.77	2±0.04	2.57±0.05	0.16±0
Week 5	**N**	485.71±8.94[a]	877.35±11.76[a]	1.81±0.02	2.84±0.03	0.18±0
	Y	449.18±10.33[b]	831.35±13.52[b]	1.86±0.04	2.77±0.05	0.17±0

a, b = Means bearing different superscripts in a row differ significantly (P<0.05).

Effect of feed restriction

Due to feed restriction significant decrease in average body weight gain was observed at 2nd week of age. Significant reduction for average body weight gain for 3rd and 4th week in third week restrictions and fourth week feed restrictions was also reported Malpotra (2017). Similar results were also obtained by Nwachuku and Ibe (1990) and Ramlah *et al.* (1996) who reported depressed body weight by all levels of feed restrictions. Fontana *et al.* (1992), Saleh *et al.* (2005), Zhan *et al.* (2007) and Omosebi *et al.* (2014) also gave similar results. These results indicate that the body weight gain of broilers is related to the feed intake

Table 3: Combined effect of feed restriction, black pepper and jaggery supplementation on average body weight gain and average feed intake

Phase	Average Body Weight Gain							
	Treatments							
	T1	T2	T3	T4	T5	T6	T7	T8
Week 1	101.96 ±2.4	98.1 ±1.33	100.68 ±3.19	104.69 ±1.85	101.79 ±1.59	101.03 ±2.68	100.06 ±5.12	101.33 ±3.42
Week 2	172.05 ±6.36^{ab}	145.45 ±4.44^{cd}	166.75 ±3.5^{ab}	139.04 ±6.11^{d}	180.31 ±4.08^{a}	151.16 ±2.89^{cd}	160.71 ±5.17^{bc}	138.46 ±6.43^{d}
Week 3	274.04 ±12.15	270.39 ±6.46	267.44 ±6.97	268.23 ±5.37	277.41 ±7.95	275.13 ±6.38	254.36 ±8.69	263.84 ±13.22
Week 4	303.54 ±3.79	292.95 ±7.35	287.15 ±24.36	285.98 ±9.38	325.01 ±14.29	301.75 ±18.23	295.41 ±23.17	297.82 ±14.75
Week 5	480.34 ±16.09^{ab}	473.42 ±12.02^{ab}	512.39 ±12.05^{a}	472.78 ±27.49^{ab}	474.2 ±33.59^{ab}	436.32 ±21.86^{b}	473.89 ±8.39^{ab}	442.82 ±10.53 ^{b}
	Average Feed Intake							
Week 1	135.18 ±12.35^{a}	119.5 ±2.78^{ab}	111.36 ±5.71^{b}	113.36 ±2.36 ^{b}	116.61 ±2.57 ^{b}	115.89 ±0.41 ^{b}	117.9 ±2.78^{ab}	125.11 ±3.88^{ab}
Week 2	261.91 ±5.42^{a}	209.36 ±2.61 ^{de}	235.72 ±3.45^{bc}	197.66 ±8.59 ^{e}	253.16 ±6.1^{ab}	196.68 ±4.52 ^{e}	218.57 ±18.19^{cd}	195.73 ±8.8 ^{e}
Week 3	480.32 ±10.23^{ab}	424.14 ±6.31^{bc}	456.02 ±5.02^{abc}	413.15 ±16.16^{c}	481.47 ±7.79^{ab}	506.24 ±28.78^{a}	435.15 ±40.87^{bc}	463.03 ±14.2^{abc}
Week 4	628.78 ±9.16^{ab}	617.95 ±4.26^{ab}	625.65 ±4.17^{ab}	605.11 ±15^{ab}	635.94 ±12.78^{a}	596.73 ±9.36^{ab}	614.92 ±33.25^{ab}	581.1 ±12.93^{b}
Week 5	883.22 ±32.9 ^{a}	878.61 ±4.99 ^{a}	897.34 ±11.29 ^{a}	850.23 ±33.76^{ab}	897.74 ±18.64 ^{a}	851.35 ±16.98 ^{b}	842.98 ±27.48 ^{b}	851.32 ±22.15^{ab}

a,b,c,d,e = Means bearing different superscripts in a row differ significantly (P<0.05).

supporting the evidence that the body weight gain of broiler chickens could be inhibited by feed restrictions (Washburn and Bondari, 1978). But overall weight was found non-significant because of compensatory growth after restrictions as also reported by Jahanpour *et al.* (2015). David and Subalini (2015) also reported that final growth performance was not affected by feed restrictions for 3, 5 and 7 hours.

Significant reduction in average feed intake was reported at 2nd week, 4th week for feed restricted groups. Malpotra (2017) also reported significantly lower feed intake at 2nd week in second week feed restricted group, at 3rd week in third week restricted group and at 4th week in fourth week restricted group. Similar reduction in feed intake due to feed restrictions was also reported by Mehmood *et al.* (2013), Mahmood *et al.* (2007) and Zhan *et al.* (2007). This may be attributed to ample time available in birds without feed restrictions as compared to restricted ones. Similarly, Ewa *et al.* (2006) and Demir *et al.* (2004) also observed significantly less feed intake in feed restricted treatments. Feed intake is significantly reduced due to duration of restriction and level of restriction (Omosebi *et al.* 2014). But Saleh *et al.* (2005) also reported reduction in feed intake following restrictions from 7-14 days of age. Saber *et al.* (2011) and Afsharmanesh *et al.* (2016) also observed non-significant feed intake due to feed restriction in their respective studies.

Although there was no significant difference in FCR during different weeks of age was observed but numerically better FCR was reported in groups fed in feed restriction condition during 2nd, 3rd week of age. Malpotra (2017) studied that feed conversion ratio in 2nd week restricted group was

Table 4: Combined effect of feed restriction, black pepper and jaggery supplementation feed conversion ratio, protein efficiency ratio, calorie efficiency ratio

Phase	Feed conversion ratio (FCR)							
	Treatments							
	T1	T2	T3	T4	T5	T6	T7	T8
Week 1	1.32±0.11^{a}	1.22±0.03^{abc}	1.11±0.04^{c}	1.08±0.03^{c}	1.15±0.02^{bc}	1.15±0.03^{bc}	1.19±0.08^{ab}	1.24±0.07^{abc}
Week 2	1.53±0.04^{a}	1.45±0.06^{ab}	1.41±0.02^{ab}	1.42±0.03^{ab}	1.41±0.03^{ab}	1.28±0.04^{b}	1.38±0.08^{ab}	1.42±0.1^{ab}
Week 3	1.76±0.04^{ab}	1.57±0.04^{b}	1.71±0.05^{ab}	1.54±0.08^{b}	1.74±0.06^{ab}	1.85±0.13^{a}	1.7±0.11^{ab}	1.76±0.07^{ab}
Week 4	2.07±0.05	2.11±0.04	2.23±0.21	2.13±0.11	1.97±0.1	1.99±0.09	2.11±0.13	1.96±0.07
Week 5	1.84±0.01	1.86±0.04	1.75±0.04	1.8±0.03	1.91±0.1	1.96±0.06	1.78±0.09	1.93±0.09
Protein efficiency ratio (PER)								
Week 1	3.5±0.28^{b}	3.74±0.08^{ab}	4.13±0.15^{a}	4.2±0.13^{a}	3.97±0.08^{ab}	3.96±0.1^{ab}	3.87±0.25^{ab}	3.7±0.22^{ab}
Week 2	2.99±0.08^{b}	3.16±0.13^{ab}	3.22±0.04^{ab}	3.2±0.06^{b}	3.24±0.07^{ab}	3.5±0.11^{a}	3.39±0.19^{ab}	3.24±0.22^{ab}
Week 3	2.65±0.07^{ab}	2.97±0.07^{ab}	2.73±0.08^{ab}	3.04±0.18^{a}	2.68±0.09^{ab}	2.56±0.18^{b}	2.77±0.19^{ab}	2.65±0.1^{ab}
Week 4	2.48±0.06	2.43±0.05	2.35±0.19	2.43±0.13	2.62±0.13	2.59±0.12	2.47±0.17	2.63±0.1
Week 5	2.79±0.02	2.76±0.05	2.93±0.06	2.85±0.05	2.7±0.14	2.62±0.08	2.9±0.14	2.68±0.13
Calorie efficiency ratio (CER)								
Week 1	0.26±0.02^{b}	0.27±0.01^{ab}	0.3±0.01^{a}	0.31±0.01^{a}	0.29±0.01^{ab}	0.29±0.01^{ab}	0.28±0.02^{ab}	0.27±0.02^{ab}
Week 2	0.22±0.01^{b}	0.23±0.01^{ab}	0.24±0^{ab}	0.23±0^{b}	0.24±0^{ab}	0.26±0.01^{a}	0.25±0.01^{ab}	0.24±0.02^{ab}
Week 3	0.19±0^{ab}	0.21±0^{ab}	0.19±0.01^{ab}	0.21±0.01^{a}	0.19±0.01^{ab}	0.18±0.01^{b}	0.2±0.01^{ab}	0.19±0.01^{ab}
Week 4	0.16±0	0.15±0	0.15±0.01	0.15±0.01	0.17±0.01	0.16±0.01	0.16±0.01	0.17±0.01
Week 5	0.18±0	0.17±0	0.18±0	0.18±0	0.17±0.01	0.17±0.01	0.18±0.01	0.17±0.01

a, b,c = Means bearing different superscripts in a row differ significantly (P<0.05

significantly better as compared to control. Omosebi *et al.* (2014) and Rincon and Leeson (2002) had reported best FCR with feed restrictions. Saleh *et al.* (2005) also reported significantly higher FCR at 14 days. Restricted birds gave better FCR as compared to unrestricted ones (Mehmood *et al.,* 2013; Ewa *et al.,* 2006). This better FCR in restricted birds could be because of ample time available for digestion and absorption as compared to non-restricted birds. But Yu *et al.* (1990) reported that feed conversion ratio during 4th week was significantly poor than other groups. However, non significant results for effects of feed restrictions on FCR were reported by Saber *et al.* (2011).

Better PER was observed during 2nd and 3rd week of age, however statistically non significant results for PER during different weeks of age were observed. Similar results were reported by Butzen *et al.* (2015) that during different phases no significant differences were found for protein efficiency ratio. But protein efficiency ratio obtained significantly higher for second week feed restricted group during 2nd week and fourth week feed restricted group during 4th week by Malpotra (2017). Overall improved feed efficiency due to feed restrictions followed by compensatory growth was also reported by Al-Taleb (2003); Ramlah *et al.* (1996).

Although there was no significant difference in CER during different weeks of age was observed but numerically better CER was observed during 2nd and 4th week of age. However, Malpotra (2017) observed that feed restriction during 2nd week gave significantly higher value of calorie efficiency ratio. Similar results were also given by Saleh *et al.* (2005) who gave improved calorie efficiency following restriction.

Effect of black pepper on the growth performance

There was decrease in body weight gain in boilers when fed 0.5% black pepper but significantly decrease in average body weight was observed during 2nd week in groups fed

with 0.5% black pepper. But Cardoso *et al.* (2012) reported that piperine did not alter broiler body weight. However, Singh (2015) reported gain in average body weight in groups fed with 0.5% black pepper as compare to groups fed control and groups fed with 1.5% BP. Tazi *et al.* (2014) also reported that 1% BP supplemented groups attained the higher weight gain. Lower feed intake was reported at 2nd week and 3rd week due to black pepper supplementation. Singh (2015) obtained results with lower feed intake during starter phase and grower phase in groups fed with 0.5% BP, 1% BP, 1.5% BP but no difference in feed intake was found during overall phase. Black pepper or its active ingredient piperine helps in arousing digestive liquid in stomach and eradication of infectious bacteria (Tazi *et al.*, 2014) increase production of saliva and gastric secretion, there by improved appetite (Meghwal and Goswami, 2012).

Though there was decrease in average body weight gain and average feed intake due to black pepper supplementation was observed but numerically better FCR was recorded during 3rd week in black pepper fed groups. Cardoso *et al.* (2012) also reported that piperine did not alter FCR. But Singh (2015) reported better FCR in groups having 0.5%. Tazi *et al.* (2014) reported that 1% BP supplemented groups attained best conversion ratio.

No significant difference in PER was observed due black pepper supplementation during different weeks. But Singh (2015) observed better PER in groups diets fed with 0.5% BP as compare to control diet. Hashemi and Davoodi (2010) also reported that phytogenic antibacterial, antioxidant, antistress, gut microflora manipulation, immune enhancement properties are quoted as major mechanism behind the positive effect exerted by black pepper on the growth and health performance of animals. Although numerically better values of CER at 1st week, 3rd week and 5th week of age were observed but these values were statistically non significant. Abou Elkhair *et al.* (2014) reported that dietary supplements with black pepper enhanced the performance and health status of the broiler chicken. As such references regarding effect of black pepper supplementation on CER were not reported in literature.

Effects of jaggery on the growth performance

There was no significant difference in average body weight gain was observed due to jaggery supplementation at different weeks of age except at 5th week of age where significant decrease in body weight gain was observed. It indicated that jaggery can be supplemented at the rate of 1% in broilers diet. But Dhore *et al.* (2013) reported significantly higher weight when jaggery was supplemented in drinking water at the rate of 2g/l along with basal diet as compare to control.

No significant change in average feed intake was observed at different weeks of age due to jaggery supplementation except during 5th week. Significant decrease in average feed intake was observed for 5th week in groups fed with jaggery. Dhore *et al.* (2013) also reported that non-significant change in feed intake was observed when jaggery was supplemented in drinking water at the rate of 2g/l along with basal diet as compare to control.

As there was no significant results were obtained for average body weight gain and average feed intake, non significant change in feed conversion ratio for all weeks was reported in jaggery fed groups. But Dhore *et al.* (2013) was observed better feed conversion efficiency when jaggery supplemented in drinking water at the rate of 2g/l along with basal diet as compare to control.

Although numerically lower PER was reported at different weeks of age in jaggery fed groups but these values were statistically non significant. There was no significant change in protein efficiency ratio and calorie efficiency ratio during different weeks, when jaggery is supplemented in broilers ration at the rate of 1%.

Combined effect of feed restriction, black pepper and jaggery supplementation on growth parameters of broilers

There was no significant difference due to black pepper and jaggery supplementation at 1st week of age. But at 2nd week of age, when feed restriction was applied from 7-17 days for 8-10 hrs daily, there was a significant difference in average body weight gain in feed restriction treatments as compare to their non restricted counterpart.

The black pepper supplementation at the rate of 0.5% (T_3) and black pepper with jaggery at the rate of 1% (T_7) had no significant effect on average body weight gain as compare to control. Cardoso *et al.* (2012) reported that piperine did not alter broiler body weight. The jaggery

supplementation (T_5) had observed highest body weight gain. But it was non significant as compare to control. Dhorey *et al.* (2013) also reported higher body weight gain when jaggery was supplemented in drinking water at the rate of 2g/l along with basal diet as compare to control. However, non significant average body weight gain was observed at 3rd and 4th week of age due to fed restriction, black pepper or jaggery supplementation. But at 5th week of age highest average body weight gain was observed in T_3 (black pepper supplementation) and lowest in T_6 (jaggery with feed restriction). Tazi *et al.* (2014) reported that 1% BP supplemented groups attained the higher body weight gain. But jaggery and black pepper with or without feed restriction reduced the average body weight gain as compare to control.

During 1st week average feed intake significantly reduced due to jaggery supplementation (T_5) as well as black pepper (T_3) as compare to control. At 2nd week average feed intake reduced in all treatments as compare to control except T_5 where jaggery was supplemented. Due to feed restriction the average feed intake reduced significantly in all treatments as compare to their respective non restricted groups. Malpotra (2017) reported significantly lower feed intake in restricted groups as compared to control. Similar reduction in feed intake due to feed restrictions was also reported by Mehmood *et al.* (2013), Mahmood *et al.* (2007) and Zhan *et al.* (2007). At 3rd week significantly decrease in average feed intake was observed in T_4 in which black pepper and feed restriction was applied as compare to control. At 4th week though non- significant difference in average feed intake was observed as compare to control. However maximum feed intake was observed in T_5 (jaggery supplementation) and lowest value was observed in T_8. However, Dhorey *et al.* (2013) showed the results which are significantly different than each other. At 5th week significantly lower value of average feed intake was observed in T_6 and T_7 as compare to control. Non significant reduction in feed intake was observed due to feed restriction in control, black pepper supplemented and jaggery supplemented groups.

During 1st week of age FCR was observed significantly better in black pepper supplemented (T_3) and black pepper supplemented with feed restriction groups as compare to control group (T_1). Singh (2015) and Tazi *et al.* (2014) also reported better FCR in black pepper supplemented groups. T_5 (jaggery supplementation) and T_6 (jaggery supplementation with feed restriction) also reported with better FCR than control groups. Dhore *et al.* (2013) also observed better feed efficiency ratio in jaggery water supplemented group as compare to control group. At 2nd week T_6 was observed with significantly better FCR as compare to control. However, non- significant difference was reported in other treatments as compare to control. At 3rd week of age T_2 (control with feed restriction) and T_4 (black pepper supplemented with feed restriction) were reported with significantly better FCR as compare T_6 (jaggery supplementation with feed restriction) but non-significant difference was observed as compare to control. Malpotra (2017), Omosebi *et al.* (2014), Saleh *et al.* (2005) also reported better FCR in feed restricted groups as compare to non feed restricted groups. At 4th week and 5th week of age, non-significant difference in FCR values was reported in all treatments as compare to control.

At 1st week PER was significantly higher in T_3 (black pepper supplementation without feed restriction) and T_4 (black pepper supplementation with feed restriction) as compare to T_1 (control) and T_7 (jaggery + black pepper without feed restriction) while non significant difference was observed in other treatments as compare to control. At 2nd week of age PER value of T_6 (jaggery with feed restriction) was observed significantly higher as compare to T_1 and T_7. At 3rd week of age PER in T_4 was significantly higher as compare to T_6. But other treatments had no significant effect on PER as compare to control. At 4th and 5th week of age no significant effect of different treatments on PER was observed as compare to control. At 1st week CER was significantly higher in T_3 (black pepper supplementation without feed restriction) and T_4 (black pepper supplementation with feed restriction) as compare to T_1 (control) and T_7 (jaggery + black pepper without feed restriction) while non significant difference was observed in other treatments as compare to control. Ghaedi *et al.* (2014) also concluded that dietary supplements with black pepper enhanced the performance of broiler chickens. At 2nd week of age CER value of T_6 (jaggery with feed restriction) was observed significantly higher as compare to T_1 and T_7.

At 3rd week of age CER in T_4 was significantly higher as compare to T_6. But other treatments had no significant effect on CER as compare to control. At 4th and 5th week of age no significant effect of different treatments on CER was observed as compare to control.

CONCLUSION

From this study, it was concluded that feed restriction significant decrease in average body weight gain and feed intake was observed at 2nd week of age but non-significant difference in FCR was observed. Black pepper supplementation decreased the average body weight gain at 2nd week of age and feed intake at 2nd and 3rd week of age but there was no significant difference in FCR. No Significant difference in average body weight gain and average feed intake was observed except during 5th week of age at which both average body weight gain and average feed intake was reduced.

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