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Dietary effect of *Mentha spicata* on production performance of Sonali chicken

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ABSTRACT

An experiment was carried out to evaluate the performance and antibacterial effect of *Mentha spicata* (mint) on Sonali chicken (crossbred of Rhode Island Red and Fayoumi chicken). A total of 225 day-old chicks were randomly divided into 5 experimental treatments with 3 replicates (15 birds per replicate) arranged in a completely randomized design. Experimental birds in T_2, T_3 and T_4 were provided mint leaves powder meal @ 4ml/L liquid mint extract and 2% and 4% mint powder with feed while T_1 provided growth promoter and T_0 was provided only normal feed was considered as control group. The results of this study indicated that final body weight gain and feed efficiency was increased at dose rate 2% mint leaves meal. In case of meat yield parameters there was no significant ($P>0.05$) difference among treatment groups except carcass weight, breast meat weight and dressing percentage. The breast meat weight, carcass weight and dressing percentage were significantly ($p<0.05$) higher in treatment T_3 group compared to control group. *E. coli* and *Salmonella* load was decreased significantly in treatment groups as compared to the control group. Based on the result it could be concluded that 2% mint leaves meal and 4 ml mint leaf juice/ liter drinking water can be used as growth promoter for production of chicken.

INTRODUCTION

In layers and broilers, herbs and spices are not just appetite and digestion stimulants, but they can influence other physiological functions, help to sustain good health and welfare and also improve their performance (Frankic et. al., 2009). Further, they improve the feed intake, feed conversion ratio (FCR), body weight and lower cholesterol in blood, serum and meat, and increase the tenderness and meat quality along with carcass yield. It is stated that the improvement of FCR resulted from the increase in appetite due to the stimulation of salivary and gastric glands by spearmint oil, the decrease in pathogenic bacteria and better digestibility; besides, it is suggested that spearmint oil may stimulate salivary and gastric glands, and decrease bacteria which in turn improve digestibility and FCR (Abu Isha et al., 2018).

As a medicinal plant spearmint is an herbal plant which contains various types of essential oils, such as menthol, mentone, cavone, methyl acetate, and piper tone. These essential oils promote biological effects such as antimicrobial growth, antioxidation stimulation of bile acid secretion, growth improvement, and ammonia reduction. In laboratory studies, it has been shown that the effects of the essential oils of peppermint inhibit the growth of *Escherichia coli*, *Staphylococcus aureus*, *Salmonella enteritidis*, and *Candida albican.* In addition, it is reported that feeding spearmint increases feed intake and consequently improves growth in chickens (Saleh et al., 2014).

Therefore, the purpose of this research was to evaluate the potential of dried spearmint (*Mentha spicata*) as a feed additive for Sonali chicken (crossbred of RIR and Fayoumi chicken) by measuring its effect on growth performance, better feed conversion efficiency, nutrient digestibility, carcass traits and antioxidant properties. Considering the fact, the study has been undertaken to know the growth performance and bacterial load (*E. coli* and *Salmonella* colony) of

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Sonali chicken supplemented with Mint (*Mentha spicata*) leaf powder and liquid.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Poultry farm belongs to the Department of Dairy and Poultry Science of Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period from February 2020 to April 2020.

Experimental birds

For the experiment two hundred and twenty five day-old Sonali chicks were collected from Palli hatchery, Joypurhat, via local traders.

Layout of the experiment

The chicks will randomly distributed to five dietary treatment groups (T_0, T_1, T_2, T_3, T_4) having three replications in each treatment. The treatments are as follows: T_0 = Control, $T_{1=}$ Antibiotic Growth promoter (Amino Vet), T_2 = 4.0 ml Mint juice/liter drinking water, T_3 = 2.0% Mint powder and T_4 = 4.0% Mint powder.

Collection and preparation of Mint powder and liquid

Mature and disease free Spearmint (*Mentha spicata*) leaves were collected from local market of Dinajpur. After collection and washing, the fresh leaves were grinding and water was added at 1:1 ratio. Then juice were prepared by blending the leaves with pestle and motor and stored in a refrigerator at 4°C to maintain the active ingredients of juice.

For preparation of mint powder, after collection of fresh leaves were dried directly under sunlight and grinded with a blander and stored air tight container until used. Both powder and liquid form of *Mentha spicata* were used in the experiment.

Figure 1: Spearmint leaves

Figure 2: Drying of spearmint leaves (upper) and Powder meal (lower) of spearmint leaves

Calculation

1. Total gain in weight = final weight – initial weight
2. Dressing percentage = (dressed weight ÷ body weight) x 100
3. Total feed consumption = total feed offered – total left-over
4. Feed efficiency = total feed consumed / total gain in weight
5. Mortality rate (%) = no. of dead chickens / total no. of birds as a group × 100

Statistical analysis

The data of feed consumption, growth performance, carcass characteristics and bacterial count were recorded and analyzed by SPSS version-23 software by using one way ANOVA accordance with the principles of Complete Randomized Design (CRD). All values were expressed as Mean± SEM and significance was determined when ($P<0.05$). Mean was compared among the treatment groups by using Duncan test.

RESULTS AND DISCUSSION

This experiment was conducted to evaluate the efficacy of mint leaves powder and liquid meal on production performance in terms of weekly body weight gain, final live weight gain, feed intake, feed efficiency, dressing percentage and bacterial count of Sonali chicken. Mint has been safely used in Asia for many years. There are no established contraindication of mint in use says drugs.com. This experiment was held under the department of Dairy and Poultry Science, Faculty of Veterinary and Animal Science, HSTU, Dinajpur. Day old chicks were randomly divided into 5 groups (T_0, T_1, T_2, T_3 and T_4) after 7 days for assessing the efficacy of mint leaves extract as growth promoter on Sonali birds.

Body weight

At the start of the experiment, the average body weight of the birds did not differ significantly among the treatment group. At 4th weeks the highest values was found in T_1 (246.05 ± 2.75) in commercial growth promoter group and among the mint treatment groups at the T_3 (237.39 ± 1.0g) group that was received @2% mint leaves meal and the lowest values was found in T_0 (232.09±0.67g) that received only feed. Within the mint group respective treatment @4ml/L in drinking water and 2%, 4% in feed in live weight was found (236.60±1.10g), (237.39±1.00g) and (236.63±0.80g). The result of this study clearly showed that among the mint groups, the 2% mint leaves powder meal increase live weight up to 10 weeks of age. Live weight of 5th, 6th, 7th, 8th, 9th and 10^{th} weeks significantly ($p<0.05$) differed among the treatment groups. Live weight gain was significantly ($p<0.05$) highest in T_1 and T_3 group compared to T_0, T_2 and T_4 group. However the inclusion level of 2% mint leave meal was showed maximum live weight (793.08±14g) and minimum live weight was showed (699.37±9.34g) in T_0 treatment group at the terminal stage of experiment. Within the mint treatment group 4% powder was represented lowest live weight gain whereas, 2% treatment group represent highest live weight gain. Scientists showed similar results with the experiment performed. Feeding spearmint increases feed intake and consequently improves growth in broiler chicks (Saleh et al. 2014). In a research, Al-Ankari, Zaki and Al-Sutan found that supplementation of *Mentha piperita* at the level of 1.5% for 35 days showed beneficial results on body weight, feed intake and FCR in broilers (Al-Ankari et al., 2004). Similarly, Nobakht, Norany & Safamehr reported that feeding 0.5% dried *Mentha pulegium* resulted in positive effects on performance in broilers at 42 days of age (Nobakht et al., 2011). Whereas, Ocak et al. reported that supplemental *Mentha piperita* (0.2%) had no effects on broilers body weight and FCR at 42 days of age (Ocak et al., 2008). The controversy among these studies might be due to the differences in mint resources, which vary according to species, active ingredient, harvest time, etc. (Brenes and Roura, 2010).

Table 2: Effect of supplementation of mint leaves meal on body weight of Sonali chicken

Parameter	T_0	T_1	T_2	T_3	T_4	Level of significant
Initial live wt.(g)	29.53±0.11^{a}	30.74±0.178^{c}	30.38±0.140^{bc}	30.17±0.07^{b}	30.18±0.054^{b}	NS
1st week	59.22±0.21^{a}	60.02±0.07^{b}	59.35±0.04^{a}	59.89±0.15^{b}	60.01±0.16^{b}	NS
2nd week	115.44±0.28	115.95±0.17	145.63±1.83	142.96±2.63	157.03±1.78	NS
3rd week	165.81±0.94	167.75±0.69	167.06±0.70	168.18±1.10	168.09±0.68	NS
4th week	232.09±0.67^{a}	246.05±2.75^{c}	236.60±1.10^{ab}	237.39±1.00^{b}	236.63±0.80^{ab}	NS
5th week	291.60±1.41^{a}	315.16±3.98^{b}	297.46±2.08^{a}	313.16±4.32^{b}	297.49±1.46^{a}	*
6th week	366.32±2.74^{a}	398.08±5.33^{b}	378.22±2.61^{a}	397.68±7.70^{b}	378.99±3.17^{a}	*
7th week	441±5.56^{a}	490.34±6.16^{c}	462.69±4.53^{b}	490.63±10.77^{c}	463.71±3.04^{b}	*
8th week	525.74±6.09^{a}	590.35±8.58^{c}	556.81±6.25^{b}	592.10±10.63^{c}	551.15±5.76^{b}	*
9th week	612.36±8.10^{a}	691.24±10.01^{c}	651.34±9.30^{b}	694.41±12.02^{c}	643.57±6.82^{b}	*
10th week	699.37±9.34^{a}	792.23±11.87^{c}	742.42±10.00^{b}	793.08±14.00^{c}	736.02±9.13^{b}	*

The mean values with different superscript (a to c) within the same row differs significantly, at least ($p<0.05$). All values indicate Mean ±Standard Error of mean. NS means statistically not significant, *Means significant at 5% level of significance ($P<0.05$).

Table 3: Effect of mint leaves meal on feed intake and feed efficiency of Sonali chicken

Parameter	T_0	T_1	T_2	T_3	T_4	Level of sig.
Feed intake (g)	1830.58±23.22^{a}	1893.87±7.92^{b}	1851.10±9.22^{ab}	1872.94±21.95^{ab}	1822.88±19.32^{a}	NS
Weight gain (g)	699.37±9.34^{a}	792.23±11.87^{c}	742.42±10.00^{b}	793.08±14.00^{c}	736.02±9.13^{b}	*
Feed efficiency	2.62±0.01^{c}	2.39±0.02^{a}	2.49±.02^{b}	2.36±0.03^{a}	2.47±0.03^{b}	*

The mean values with different superscript (a to c) within the same row differs significantly, at least ($p<0.05$). All values indicate Mean± Standard Error of mean.
NS means statistically not significant, *Means significant at 5% level of significance ($P<0.05$).

Feed intake

The cumulative feed intake of Sonali chicken in different dietary treatment during experimental periods was almost statistically similar (Table 3) and the differences were insignificant ($p>0.05$). However, the lowest feed intake (1822.88±19.32g) was found T_4 group. The birds of T_1 group showed higher feed intake (1893.87±7.92g) compared to others groups. Amasaib et al. (2013) revealed no significant effect for *Mentha spicataon* feed intake. On the other hand Ocak et al., (2008) reported that adding 0.2 percent mint to basal diet help increase growth and reduce mortality in chickens. Thus, these results are contradictory to those findings in which supplementation of laying hens with up to 2% ground peppermint leaves enhanced the feed intake during the late laying period (Abdel Wareth and Lohakare, 2014; Sharma et al., 2020).

Feed efficiency

Feed efficiency of different treatment groups during the experimental period statistically significant ($P<0.05$). The birds of T_3 groups containing 2% mint leaves powder meal converted feed to meat most efficiently. The feed efficiency of T3treatment groups was statistically significant ($P<0.05$) with T_0 group. T_1 and T_3 treatment group was also significant. From (Table 5) feed efficiency was higher at the level of 2% (T_3) mint leaves meal in dietary feed. Highest feed efficiency (2.36±0.03) was found in T_3 groups and lowest feed efficiency (2.62±0.01) was found in T_0 groups. The second highest feed efficiency (2.39±.02) was found in T_1 groups. It was found that 2% of mint leaves powder meal induces

higher feed efficiency. Nobakht and Aghdam Shahriar (2011) report 2% mixture of medicinal herbs (mint, camel thorn and mallow) improved daily gain and FCR than the control group, probably because of the antibacterial and antifungal effects of botanicals used in the experiment.

Dressing percentage

After slaughtering, defeathering and eviscerating and removing all edible and non-edible by-products, dressing percentage of different treatment group showed in Table 4. The table indicated that, there were significant differences among the treatment group. Relatively the heaviest dressing percentage was observed in T_3 (53.03±0.38%) than other treatments T_1 (52.47±0.52%), T_2 (51.67±0.05%), T_4 (51.48±0.11%) and T_0 (50.50±0.03%) respectively. The highest dressing percentage was found (53.03±0.38%) in T_3 treatment group and lowest was found (50.50±0.03%) in T0 group.

Breast meat

Breast meat obtained (Table 4) was statistically significant (P<0.05) among the different treatment group. Supplementation of mint leaves powder 2% was significant (P<0.05) compare to control group. However, highest weight was found (121.97±2.04g) that receive mint leaves powder 2% and lowest was found (104.77±1.07^g) in untreated group T_0.

Table 4: Effect of mint leaves meal on meat yield parameters of Sonali chicken

Parameter	T_0	T_1	T_2	T_3	T_4	Level of significant
Final Live wt (g)	700.13±8.63^a	794.36±10.58^c	743.05±9.89^b	793.71±14.37^c	736.94±8.77^b	**
Carcass wt (g)	353.58±4.49^a	416.95±9.30^c	384.01±5.49^b	421.01±9.81^c	379.42±5.29^b	*
Dressing (%)	50.50±0.03^a	52.47±0.52^{cd}	51.67±0.05^{bc}	53.03±0.38^d	51.48±0.11^b	*
Breast meat wt(g)	104.77±1.07^a	121.45±1.81^c	113.17±1.92^b	121.97±2.04^c	112.77±1.78^b	*
Thigh (g)	123.73±0.63^a	128.99±0.70^c	126.88±0.38^b	129.04±0.80^c	126.54±0.60^b	*
Heart (g)	5.34±0.06^a	5.85±0.04^c	5.58±.05^b	5.84±0.06^c	5.53±0.05^b	*
Liver (g)	21.69±0.52^a	26.95±0.52^c	25.17±0.17^b	26.98±0.79^c	23.78±0.51^b	*

The mean values with different superscript (a to d) within the same row differs significantly, at least (p<0.05). All values indicate Mean±Standard Error of mean.
NS means statistically not significant, *Means significant at 5% level of significance (P<0.05)

Table 5: Effect of pineapple leaves powder on *E. coli* and *Salmonella spp.* count in Sonali chicken

Parameter	Dietary groups					Level of Sig. significance
	T_0	T_1	T_2	T_3	T_4	
Salmonella	211.00±4.35^d	193.00±2.30^c	151.34±1.20^a	163.00±2.51^b	152.67±1.77^a	*
E. Coli	210.67±2.02^c	207.67±4.40^c	176.34±1.77^a	187.34±2.34^b	182.34±2.34^a	*

The mean values with different superscript (a to c) within the same row differs significantly, at least (p<0.05). All values indicate Mean±Standard error of mean.
NS=Non significant, * (P<0.05)

Thigh meat

Thigh meat of Sonali chicken was statistically insignificant (P>0.05) among the different treatment group (Table 4). Best result was observed in supplementation of mint leaves meal treated group T_3 (129.04±0.80g) whereas nutritional commercial group T_1 (128.99±0.70g) then T_2 (126.88±0.38g), T_4 (126.54±0.60g) and T_0 (123.73±0.63g) respectively.

Liver weight

Liver weight of Sonali chicken in different dietary treatment groups was statistically insignificant (p>0.05). From (Table 4) it was seen that liver weight maximum in T_3 treatment group (26.98±0.79g) and minimum in T_0 treatment group (21.69±0.52g)T4 group which contained growth

promoter obtained (26.95±0.52g) near about T_1 group.

Heart weight

Heart weight of Sonali chicken in different dietary treatment groups was statistically insignificant ($p>0.05$). From (Table 4) it was seen that heart weight found maximum in T1group (5.85±0.04g) and minimum in T_0 treatment group (5.34±0.06g). Heart weight of T_1 found higher among the treatment groups. T_3 group which 2% mint powder obtained (5.84±0.06g) near about T_1 group that fed with commercial growth promoter.

Bacterial count

The effect of mint leaves powder preparations on the faecal total bacterial count is presented in the Table 5. The *E. coli* and Salmonella bacteria count was significantly ($p<0.01$) reduced in the treated groups when compared to the control groups. The E. coli and Salmonella bacteria load was increased in the control which was provided only the normal drinking water as against the treatment groups. Highest *E. coli* count was found (210.67±2.02) in T_0 group and lowest E. coli count was found (176.34±1.77) in T_2 group. Highest salmonella count was found (211.00±4.35) in T_0 group and lowest was count (151.34±1.20) in T_1 group. It was concluded that mint leaf powder with feed and mint liquid also reduced the load of *E. coli* and *Salmonella*. These results may be due to antimicrobial effects of mint leaf powder, which might be attributed in reduction of microbial load of birds and improved the feed consumption and feed efficiency. Spearmint oil may stimulate salivary and gastric glands, and decrease bacteria which in turn improve digestibility and FCR (Abu Isha et al., 2018). The stabilizing effect on intestinal microbiota may be associated with intermediate nutrient metabolism (Jamroz et al., 2003).

CONCLUSION

The experiment was conducted to evaluate the efficacy of mint leaves powder meal and mint liquid (Extract) on production performance, dressing yield and *E. coli* and Salmonella bacteria count of Sonali chicken. A total of 225 one day old chicks were purchased. After 7 days of brooding the chick were randomly divided into five treatment groups namely (T_0, T_1, T_2, T_3 and T_4) having three replications in each treatment group. Experimental birds in T_3 and T_4 were provided mint leaves powder @ 2%, 4%, and T_2 with 4% mint liquid(4ml/L drinking water) and T_1 provided Antibiotic growth promoter (amino vit) while T_0 was provided only normal feed. At the terminal stage of experiment the cumulative body weight gain of different treatment groups was T_0 (699.37±9.34g), T_1 (792.23±11.87g), T_2 (742.42±10.00g), T_3 (793.08±14.00g), and T_4 (736.02±9.13g) respectively. Birds that received mint leaves powder meal 2% was gained highest (793.08±14.00g) body weight and lowest was found (699.37±9.34g) in control group. The feed intake among different treatments were non-significant ($p>0.05$). The cumulative maximum feed intake was observed in treated T_1 group 1893.87±7.92g) and minimum in non-treatment group T_4 (1822.88±19.32g). All treatment groups showed significant difference ($p>0.05$) to control groups. Feed efficiency of different treatment was statistically significant ($P<0.05$) compared to T_0 control group. Respective feed efficiency was found T_0 2.62±0.01), T_1 (2.39±0.02), T_2 (2.49±.02), T_3 (2.36±0.03) and T_4 (2.47±.03). But mint treated group (T_3) converted feed to meat most efficiently compared to T_1, T_2, T_4 and T_0 treatment respectively.

Obtained data on meat yield parameters there was no significant ($P>0.05$) difference among treatments groups except carcass weight, breast meat weight and dressing percentage. The breast meat weight, carcass weight and dressing percentage was significantly ($p<0.05$) higher in T_3 group compared to control group T_0. Among the groups highest dressing percentage in group T_3 (53.03±0.38%) was observed in 2% mint leaves group and lowest (50.50±0.03%) in control group. In case of breast meat highest weight (121.97±2.04g) was found in 2% mint leaves group and lowest (104.77±1.07g) in control group. Data obtained on *E. coli* and Salmonella bacteria count were statistically significant ($P<0.05$) among treatments group. The lowest *E. coli* count (176.34±1.77) was shown in supplementation of mint group (T_2) and highest (210.67±2.02) was found in control group (T_0). In Salmonella count

the highest value (211.00±4.35) was found in control group (T_0) and lowest value was found (151.34±1.20) in T_2 group that added with 4% of mint leaves liquid supplement.

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REFERENCES

Abdel-Wareth AAA and Lohakare, JD (2014). Effect of dietary supplementation of peppermint on performance, egg quality, and serum metabolic profile of Hy-Line Brown hens during the late laying period. Animal Feed Science and Technology. https://doi.org/10.1016/j.anifeedsci.2014.07.007.

Abu Isha A, El-Hamid A, Ziena H and Ahmed H (2018). Effect of spearmint (mentha spicata) on productive and physiological parameters of broiler chicks. Egyptian Poultry Science Journal, 38(3), 815–829.

Al-Ankari AS, Zaki MM and Al-Sutan SI (2004). Use of habek mint (*Mentha longifolia*) in broiler chicken diets. International Journal of Poultry Science, 3, 629–634.

Akbari M and Torki M (2014). Effects of dietary chromium picolinate and peppermint essential oil on growth performance and blood biochemical parameters of broiler chicks reared under heat stress conditions. International Journal of Biometeorology, 58, 1383– 1391.

Brenes A and Roura E (2010). Essential oils in poultry nutrition: Main effects and modes of action. Animal Feed Science and Technology, 158, 1–14.

Amasaib EO, Elrahman BHA, Abdelhameed AA, Elmnan BA and Mahala AG (2013). Effect of dietary levels of spearmint (*Mentha spicata*) on broiler chick's performance. Journal of Animal and Feed Research, 3,193-196.

Frankic T, Voljc M, Salobir J and Rezar V (2009). Use of herbs and spices and their extracts in animal nutrition. Acta Agriculturae Slovenica, 94, 95–102.

Nobakht A, Norany J and Safamehr AR (2011). The effects of different amounts of *Mentha pulegium L.* (pennyroyal) on performance, carcass traits, hematological and blood biochemical parameters of broilers. Journal of Medical Plants Research, 5, 3763–3768.

Nobakht A and Aghdam Shahriar H (2011). Effect of medicinal plants Mallow, camel thorn and mint on performance, carcass quality and blood metabolites in broilers. Journal of Animal Science, 3: 51-63.

Ocak N, Erener G, Burak F, Ak M, Sungu A, Altop A and Ozmen A (2008). Performance of broilers feed diets supplemented with dry peppermint (*Mentha piperita* L.) or thyme (*Thymus vulgari* L.) leaves as growth promoter source. Czech Journal of Animal Science, 4, 169–175.

Rahim A, Ali MA and Mohsen D (2012). Effect of mentha extract (Mentha piperita) supplementation in drinking water on performance, plasma lipoproteins, carcass charasteristic and liver color index or weight in broiler chickens. Indian Journal of Animal Sciences, 82(9), 1070-1074.

Rahimi S, Teymouri, ZZ, Karimi TM, Omidbaigi R and Rokni H (2011). Effect of the three herbal extracts on growth performance, immune system, blood factors and intestinal selected bacterial population in broiler chickens. Journal of Agricultural Science and Technology, 13: 527-539

Rahman A, Gultepe EE, Uyarlar C, Cetingul IS, Iqbal A and Bayram I (2017). Effect of mentha piperita (peppermint) extract and its Juice on egg quality traits during different storage time in laying hens. Kocatepe Veterinary Journal, (10)1, 14-20.

Saleh AA, Ijiri D and Ohtsuka A (2014). Effects of summer shield supplementation on growth performance, nutrient utilisation, and plasma lipid profiles in broiler chickens. *Veterinarni Medicina*, 59(11), 536–542.

Sharma MK, Dinh T and Adhikari PA (2020). Production performance, egg quality, and small intestine histomorphology of the laying hens supplemented with phytogenic feed additive. Journal of Applied Poultry Research, 29(2), 362-371.

Toghyani M, Gheisari B, Ghalamkari G and Mohammadrezaei M (2010). Growth performance, serum biochemistry and blood hematology of broiler chicks fed different levels of black seed (*Nigella sativa*) and peppermint (*Mentha piperita*). Livestock Science. 129, 173-178.