



Impacts of Diets Supplemented with Green Tea By-Product on Growth Performance and Hematological Parameters in Goats

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Abstract | The study was conducted to investigate the impacts of green tea by-product supplemented diets on body weight and hematological parameters in goats at Sylhet region of Bangladesh. The goats were assigned to 4 dietary treatments in a completely randomized design. Each treatment had 3 replications with 3 goats per replication. The treatment was replicated two times. Each group numbered as T1, T2, T3 and T0. Goats of all groups were supplied with standard goat feed and fresh drinking water ad libitum. Group T0 was considered as the control and fed with normal goats feed. Goats of group T1, T2 and T3 were maintained as treated groups and group T1 was fed with 0.5% dry Tea by-product with normal goats feed, group T2 was treated with 1% dry tea by-product and group T3 was treated with 2% dry tea by-product respectively. The body weight of the goats was taken at the day 0 of the experiment and again at day 30, day 60 and day 90 to compare with the initial body weight. Blood samples were collected at day 30, day 60 and day 90 of treatment for hematological and biochemical experiments. Body weight was significantly ($P < 0.05$) increased in treated group compared to control group. Effects of green tea by-product on RBC, WBC, Hb and albumin concentration were not significant in treated groups (T1, T2, and T3) compared to control. Cholesterol and BUN concentration were decreased significantly ($P < 0.05$) in treated groups (T1, T2 and T3) compared to control. Based on our study results, it may be concluded that green tea by-product might have significant effect on body weight gain and physiological characteristics.

Keywords | Green tea by-product, Growth performance, Hematological parameters, Black Bengal Goats

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INTRODUCTION

Among the goat breed of Bangladesh, Black Bengal Goat (BBG) is the most prevalent goat breed which is famous for its high adaptability, fertility, prolificacy, delicious meat and superior skin (Devendra and Burns, 1983; Husain et al., 1996). Due to its short generation intervals and higher rates of prolificacy, BBG is very important among the livestock species (Amin et al., 2001). Tenderness of meat and high quality skin of BBG increased its demand in the local as well as foreign markets (Husain et

al., 1996). As goat production is a fairly traditional agricultural activity in rural areas, the goat industry has a bright future in Bangladesh and would be a viable alternative for farmers because of low cost of production. Despite its value and contribution to livestock sector in Bangladesh, BBG production is slower and moderate compare to other animals. Therefore, systematic feeding practices with some additives would be an alternative to increase the BBG production.

Green tea extracted from leaves of *Camellia sinensis*, is a

widely consumed beverage aside from water in the world. It is used for treatment purposes due to its antioxidant and anti-inflammatory properties (Graham, 1992). The bio-flavonoids catechins polyphenols contained in GTB may be responsible for its inhibitory effects against growth of some bacteria. Catechins are the most significant group of substances present in green tea and among them epigallocatechin-3-gallate is mainly responsible for the health benefits (Ishihara et al., 2001).

Green tea consumption within the people of Eastern and South-East Asian country has remarkably increased in recent years. During manufacturing various ready-made tea drinks, the beverage companies produce a large quantity of tea leaf by-products which ultimately causes environmental problems due to its disposal through composting, incineration or in landfills. Though green tea by-product (GTB) is a valuable source of protein, it can be supplemented with animal feed which would be a fruitful alternative (Kondo et al., 2004).

Besides this, GTB has also significant effects to improve the body weight gain and feed efficiency in pigs (Hossain et al., 2012), calves (Sarker et al., 2010) and broilers (Cao et al., 2005) and it is assumed that some bioactive components of GTB (Tsuneki et al., 2004) are responsible for these outcomes. Studies reported that the thiobarbituric acid-reactive substance values in raw meats can be reduced by the effect of polyphenols present in GTB (Horax et al., 2002). In broiler, the cholesterol level in plasma and meat can be reduced by dietary supplementation of GTB (Yang et al., 2003).

A number of studies have been suggested that saponins from different sources diminished serum cholesterol levels in a variety of animals. Matsuura, 2001 and Afrose et al., 2010 reported that saponins act either directly, by inhibiting absorption of cholesterol from the small intestine, or indirectly, by inhibiting reabsorption of bile acids. Where direct inhibition of cholesterol absorption occurs, saponins prevented absorption of not only a high proportion of dietary cholesterol, but also of a high proportion of the cholesterol derived from bile and desquamation of mucosal cells.

The hilly zones on the eastern part of Bangladesh comprised four districts (Sylhet, Moulvibazer, Habigong and Chattogram) are well cultivated with tea because of its significant demand in internal market (Iqbal, 2001). GTB such as factory tea waste, decaffeinated tea waste and tea plant by-products are available in this area. No study was conducted before regarding the effects of GTB in goats of Bangladesh. Therefore, the study was conducted to investigate the effect of GTB on body weight gain and haemato-

logical parameters in Black Bengal goats of Sylhet region of Bangladesh.

MATERIALS AND METHODS

STUDY AREA

The research was carried out in goats of Sylhet region in Bangladesh. The area under lies in the Sylhet district is located in north-east part of Bangladesh and between 24°32' North latitude and 91°52' East longitudes. The average maximum and minimum temperatures are 23° and 7°C, respectively. The annual average rainfall is 3.334mm and humidity is 70%. The annual the average maximum and minimum temperature is 10°C and 0°C, respectively. All the tests for this study were performed in the laboratory of medicine, Faculty of Veterinary, Animal and Biomedical Sciences, Sylhet Agricultural University, Bangladesh.

ANIMALS AND DIETARY TREATMENTS

Information regarding health history, identification, age, sex and breed of goats were recorded. All the goats were providing the same basal diet (Table 1). The number of goats and the housing system were also recorded to gain more information about the predisposing factors for an infection with parasites. The goats were assigned to 4 dietary treatments in a completely randomized design. Each treatment had 3 replications with 3 goats per replication. The goats (36) were alienated into four groups: one control group (Group T0, n=3) and three trial groups, Group T1 (n=3), Group T2 (n=3), Group T3 (n=3). The initial body weight of the three trial groups and one control group is around 11 kg. GTB was collected from different tea processing companies of Sylhet region and dried under sun light for three days. Then the GTB was mixed with the normal diet of the goats. This was used as the crude leaf extract in this experiment. This tea by-product was supplemented with normal feed in three trial groups daily. Group T1 was treated with 0.5%, group T2 was treated with 1% and group T3 was treated with 2% tea by-product. Group T0 named as control group was not given any tea by-product supplement. Feeding trial was continued for a period of 90 days from the beginning of the experiment.

BODY WEIGHT MEASUREMENT

The goats were kept for a 2 weeks adjustment period for becoming habituated to pen living before commencement of the feeding trial. The goats were provided with the experimental diets twice a day (morning and evening). The temperature, lighting and other management procedure were performed according to the standard guidelines of goat management. Additionally, goats were handled in accordance with animal welfare regulations (Ministry of Livestock and Fisheries, 2017). All Efforts were made to minimize the discomfort of animal used.

Table 1: Ingredients and chemical composition of the basal experimental diet

Ingredients	% DM
Maize stover	45
Ground corn	25
Soyabean meal	15
Wheat bran	11.2
Urea	0.2
Calcium carbonate	0.9
Calcium bicarbonate	0.6
Sodium chloride	0.6
Vitamin and mineral salts	1.5
Chemical composition	
DM (%)	89.8
OM (% DM)	92.7
ME (Mcal/kg DM) ¹	2.75
CP (% DM)	12.3
NDF (% DM)	36.7
ADF (% DM)	24.2
Ca (% DM)	0.92
Total P (% DM)	0.74

¹Metabolic energy was calculated according to NRC (1981)

HEMATOLOGICAL PARAMETERS

Blood samples were collected from the goats (jugular vein) of treated and control group in vials containing anticoagulant (Sodium citrate 3.8 %) at day 0 of treatment period for initial screening and day 30, 60 and 90 to determine the effects of GTB on the hematological parameters namely Hemoglobin (Hb) content, Different Leukocyte Count (DLC), Total Erythrocyte Count (TEC), Albumin, Glucose, Blood Urea Nitrogen (BUN), Cholesterol, Total Protein (TP). All the parameters were analyzed by using a blood analyzer (Hunan Zetop Medical Co. Ltd., China).

STATISTICAL ANALYSIS

Data were analyzed by using Statistical Analysis System - Version 9.1 (SAS Ins., Cary, NC, USA). Individual goats were taking into consideration as a unit for analyzing the blood parameters while pens were considered for analyzing growth performance. The results were interpreted as mean with standard error.

RESULTS AND DISCUSSION

Effects of GTB supplementation on body weight gain

The growth performance of BBG in feeding trial supplemented with GTB is presented in Table 2. The impacts of diets supplemented with GTB on growth performance from 0-30 days was significant (p<0.01). In the present study it was observed that at 60 to 90 days of the study

period addition of GTB in diets have some positive effects on weight gain (p<0.01). The results of the present study stated that diets supplemented with GTB increased the average weight gain of BBG. Consistent with our results, study also reported that green tea supplemented diets increased the average daily gain in goats (Tan et al., 2011). A finding of another study is in agreement with our results which reported that a diet supplemented with 2.0% GTB has also increased weight gain of finishing pigs (Hossain et al., 2012). GTB comprises of tea catechin which maintains the balance of microflora and increases the digestibility of the nutrients and this tea catechin may be responsible for this increased weight gain (Tan et al., 2011). In contrast, other studies reported that due to the presence of tannin in green tea, different levels of green tea supplemented with basal diets reduced the body weight gain in rats and broilers (Sayama et al., 2000; Kaneko et al., 2001). Because of phenolic compounds in tea, GTB has been proposed as a strategy for weight gain and maintenance.

Table 2: Body weight (Mean±SD) of different groups (n=4) after treating with GTB

Groups/Treatment	Body weight		
	Day30	Day60	Day90
Group T ₁	12.37±0.12 ^c	14.23±0.25 ^{ab}	16.20±0.17 ^b
Group T ₂	13.07±0.12 ^b	14.77±0.42 ^a	16.10±0.66 ^a
Group T ₃	12.90±0.20 ^b	15.70±0.96 ^b	17.93±0.31 ^c
Group T ₀	13.53±0.15 ^a	14.13±0.12 ^a	15.53±0.45 ^{ab}
Level of significance	**	*	**
P- values	0.0001	0.0523	0.0018

EFFECTS OF GTB SUPPLEMENTATION ON HEMATOLOGICAL PARAMETERS

The effect of GTB on RBC count was not significant in treated groups (Table 3). Our study showed the stability of RBC in treated groups but not increased significantly. Other study reported that hematological effects in PPE-treated dogs included mild to marked increase in white blood cells, neutrophil, monocyte, platelet, and platelet crit (percentage volume of platelets) values (Kapetanovic et al., 2009) which is not in agreement with our results. In group T1 average number of RBC decreased as the day progressed due to some physiological and environmental factors which is similar with previous findings (Elkirdasy et al., 2015) who reported that increased RBC count of tea and/or ginger treated diabetic rabbits could be due to the lowered lipid peroxide level in RBC membrane leading to a decreased susceptibility of RBC to hemolysis. Previous results also suggested that, extracts of green tea possess antioxidant properties and help in RBC membrane stabilization by binding to proteins and carbohydrates which are components of RBC membrane and therefore may prevent

breakdown of RBC membrane and antagonize the anemic effect (Elkirdasy et al., 2015).

Table 3: RBC Count (Mean±SD) of different groups (n=4) after treating with GTB

Groups/ Treatment	RBC(million/ml)		
	Day30	Day60	Day90
Group T ₁	7.87±0.68 ^c	6.83±0.70 ^b	6.37±.051 ^b
Group T ₂	6.33±0.21 ^b	6.50±0.30 ^a	6.70±0.53 ^{ab}
Group T ₃	7.00±0.56 ^a	7.17±0.31 ^a	8.17±0.31 ^a
Group T ₀	6.80±0.75 ^b	5.03±0.21 ^b	5.80±0.26 ^{ab}
Level of significance	**	**	*
P- values	0.0013	0.0002	0.0640

Table 4: WBC count (Mean ± SD) of different groups (n = 4) after treating with GTB

Groups/ Treatment	WBC(million/ml)		
	Day30	Day60	Day90
Group T ₁	5.40±0.56 ^b	8.33±0.23 ^c	7.00±0.85 ^b
Group T ₂	6.43±1.23 ^b	12.47±0.38 ^a	7.73±0.78 ^b
Group T ₃	8.87±1.53 ^a	11.27±0.12 ^b	8.00±0.40 ^b
Group T ₀	6.27±0.57 ^b	7.60±0.17 ^d	9.20±0.17 ^a
Level of significance	*	**	**
P- values	0.0200	0.0000	0.0149

Values with different letter in a column differ significantly (p<0.05)

Table 5: Hb (Mean ± SD) of different groups (n = 4) after treating with GTB

Groups/Treat- ment	Hb (gm/dl)		
	Day30	Day60	Day90
Group T ₁	6.47±0.21 ^b	5.80±0.61 ^b	5.17±1.02 ^b
Group T ₂	7.63±0.23 ^a	6.67±0.76 ^{ab}	6.87±0.21 ^a
Group T ₃	7.83±0.45 ^a	7.50±0.62 ^a	6.90±0.50 ^a
Group T ₀	5.93±0.25 ^b	6.00±0.56 ^b	5.83±0.80 ^{ab}
Level of signif- icance	**	*	*
P- values	0.0001	0.0445	0.0436

Values with different letter in a column differ significantly (P<0.01; P<0.05)

Hematological analysis revealed that administration of green tea did not adversely affect the red blood cell, white blood cell and platelet count of the rats. Even green tea is effective against hypercholesterolemia and hyperglycemia (Yousaf et al., 2014). Similar with these findings, our study showed that GTB had no adverse effects on RBC, WBC, Hb and albumin concentration of BBG (Table 3, 4, 5, 6). It is advisable to consume an iron rich diet or couple green

tea consumption with iron rich supplements because constant consumption of green tea can reduce haemoglobin levels. Due to the effect of GTB on haemopoietic organs, consuming iron and multivitamin supplements will not only nullify the negative effects of green tea but will also allow the green tea to effectively burn fat and eliminate the circulating free radicals (Nihal A Sachdev, 2017). Studies suggested that GTB act as a cofactor for methionine synthase and L-methylmalonyl-CoA mutase. Methionine sy-

Table 6: Albumin (Mean ± SD) of different groups (n = 4) after treating with GTB

Groups/ Treatment	Albumin		
	Day30	Day60	Day90
Group T ₁	1.17±0.15 ^b	1.27±0.06 ^b	1.10±0.03 ^b
Group T ₂	2.33±0.21 ^{ab}	1.47±0.08 ^a	1.47±0.08 ^a
Group T ₃	1.50±0.10 ^a	1.40±0.10 ^{ab}	1.17±0.06 ^b
Group T ₀	1.10±0.10 ^b	1.33±0.04 ^{ab}	1.13±0.03 ^b
Level of significance	NS	*	**
P- values	-	0.0421	0.0001

Values with different letter in a column are not significantly differ

Table 7: TP (Mean ± SD) of different groups (n = 4) after treating with GTB

Groups/ Treatment	TP		
	Day30	Day60	Day90
Group T ₁	6.13±0.35 ^{bc}	6.67±0.32 ^{ab}	6.23±0.15 ^b
Group T ₂	6.63±0.64 ^{ab}	7.37±0.21 ^a	7.23±0.32 ^a
Group T ₃	6.10±0.36 ^a	7.33±0.38 ^a	7.83±0.31 ^{ab}
Group T ₀	6.70±0.44 ^c	6.10±0.52 ^b	6.90±0.46 ^a
Level of significance	*	**	*
P- values	0.0283	0.0092	0.0332

Values with different letter in a column differ significantly (p<0.01, P<0.05)

Table 8: Cholesterol (Mean ± SD) of different groups (n = 4) after treating with GTB

Groups/ Treatment	Cholesterol		
	Day30	Day60	Day90
Group T ₁	66.00±4.58 ^{ab}	64.00±2.65 ^a	64.33±2.52 ^b
Group T ₂	69.33±1.53 ^a	66.67±0.76 ^a	65.67±5.51 ^a
Group T ₃	66.33±2.52 ^a	63.33±2.31 ^a	61.00±2.65 ^a
Group T ₀	71.00±3.00 ^b	71.00±2.00 ^b	73.33±4.93 ^b
Level of significance	*	*	**
P- values	0.0279	0.0498	0.0029

Values with different letter in a column differ significantly (p<0.01; p<0.05)

-n-thase catalyzes the conversion of homocysteine to methionine (Kadayifci et al., 2018).

Table 9: Glucose (Mean ± SD) of different groups (n = 4) after treating with GTB

Groups/ Treatment	Glucose		
	Day30	Day60	Day90
Group T ₁	62.67±5.13 ^a	61.00±1.00 ^b	63.33±9.61 ^a
Group T ₂	67.33±7.64 ^a	78.67±2.08 ^a	63.33±5.13 ^a
Group T ₃	69.33±10.26 ^a	61.67±3.06 ^b	72.33±5.13 ^a
Group T ₀	67.33±7.51 ^a	64.67±2.08 ^b	63.67±6.11 ^a
Level of significance	NS	**	NS
P- values	-	0.0000	0.3390

Values with different letter in a column differ significantly (p<0.01)

NS = Not significant Table 10: BUN (Mean ± SD) of different groups (n = 4) after treating with GTB

Table 10: BUN (Mean ± SD) of different groups (n = 4) after treating with GTB

Groups/ Treatment	BUN		
	Day30	Day60	Day90
Group T ₁	14.87±0.67 ^a	14.43±1.38 ^a	15.93±1.10 ^a
Group T ₂	13.60±0.35 ^a	13.40±0.78 ^b	12.33±0.76 ^b
Group T ₃	13.80±0.61 ^b	13.50±0.56 ^b	12.17±1.80 ^b
Group T ₀	15.40±0.56 ^a	14.90±0.50 ^a	17.07±0.50 ^a
Level of significance	**	**	**
P- values	0.0023	0.0062	0.0137

Values with different letter in a column differ significantly (p<0.01).

Table 7 showed that the total protein (TP) concentration was increased significantly in treated groups of our study. Previous studies reported that green tea in addition to a high-protein diet had no additive effect on weight maintenance over the long-term (Hursel and Westerterp-Plantenga, 2011). Protein concentration of GTB (CP-22-35%) may have some positive effect in gaining weights of goats (Yang et al., 2003).

The present study showed that values of cholesterol with different letter in a column differ significantly (p<0.01; p<0.05) (Table 8). Result shows that blood cholesterol concentration was decreased by treating with GTB. Fiber of the GTB may affect the cholesterol components because fiber is an indigestible feed component affecting cholesterol metabolism and concentration of cholesterol in blood (Balmer and Zilversmit, 1974). Study also reported that serum cholesterol levels in rats were decreased as dietary fiber content was increased (Tsai et al., 1976).

Similar results were observed in laying hens (Menge et al., 1974). Lactating cows feeding with ensiled green tea waste showed significant suppression of serum cholesterol content (Kondo et al., 2004). Study also reported that diets supplemented with green tea decreased plasma cholesterol level (Crespy and Williamson, 2004).

It was found that there was no significant change between the treated and control group in terms of glucose concentration (Table 9). However, it was observed that glucose concentration was decreased in control group more consistently than in treated groups. Green tea (GT) extract provides a beneficial effect on long-term diabetic nephropathy via suppressing hyperglycaemia and preventing glycogen accumulation in the proximal tubules. The therapeutic property of GT seems propitious in improving kidney nephropathy by significantly improving serum and urine parameters. These findings support the importance of controlling blood glucose levels and maybe slowing or even reversing some of the early pathologies of diabetic nephropathy (Renno et al., 2008). BUN concentration decreased significantly in treated groups than control group (Table 10). Study reported that in malaria infected people, green tea extract has potent antioxidant and anti-inflammatory properties to decrease BUN and creatinine where polyphenols of green tea are useful supplements (Somsak et al., 2013).

CONCLUSIONS

Our study suggests that GTB supplementations in diet have significant effect on growth performance and certain hemato-biochemical parameters in goats. Therefore, GTB may be recommended to use as dietary supplementation in goats in specific ratio. However, further study is needed to see any adverse effect of GTB in goats in relation to histopathology and biochemistry before making final conclusion regarding the beneficial effect of GTB in goat.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTION

MMUR and MMR¹ designed the research work, MMUR and MAK collected and analyzed the samples. MSRC, MBU, MMH, MMR² and MRI analyzed the data. MMR¹ corrected, interpreted and finalized the manuscript.

- Afrose S, Hossain MS, Tsuj H (2010). Effect of dietary karaya saponin on serum and egg yolk cholesterol in laying hens. *Br. Poult. Sci.* 51:797–784. <https://doi.org/10.1080/00071668.2010.526924>
- Amin MR, Husain SS, Islam ABMM (2001). Reproductive peculiarities and litter weight in different genetic groups of Black Bengal does. *Asian-Australasian Journal of Animal Science*, 14(3): 297-301. <https://doi.org/10.5713/ajas.2001.899>
- Balmer J, Zilversmit DB (1974). Effects of Dietary Roughage on Cholesterol Absorption, Cholesterol Turnover and Steroid Excretion in the Rat. *J. Nutr.* 104:1319–1328. <https://doi.org/10.1093/jn/104.10.1319>
- Cao BH, Karasawa Y, Guo YM (2005). Effects of green tea polyphenols and fructo-oligosaccharides in semi-purified diets on broilers' performance and caecal microflora and their metabolites. *Asian-Australasian J. Anim. Sci.* 18:85–89 <https://doi.org/10.5713/ajas.2005.85>.
- Crespy V, Williamson G (2004). A Review of the Health Effects of Green Tea Catechins in In Vivo Animal Models. *J. Nutr.* 134:3431S-3440S. <https://doi.org/10.1093/jn/134.12.3431S>
- Devendra C, Burns M (1983). *Goat production in the tropics.* Commonwealth Agricultural Bureaux, Franham House, Franham Royal, UK, pp: 183.
- Elkirdasy et al. (2015). Hematological and immunobiochemical study of green tea and ginger extracts in experimentally induced diabetic rabbits. *Acta. Pol. Pharm. Drug. Res.* 72:497–506.
- Graham HN (1992). Green tea composition, consumption, and polyphenol chemistry. *Prev. Med. (Baltim)* 21:334–350. [https://doi.org/10.1016/0091-7435\(92\)90041-F](https://doi.org/10.1016/0091-7435(92)90041-F)
- Horax R, Hettiarachchy NS, Yang CK, Cai R, Satchithanandam E JP, Crandall M G, Dickson JNS (2002). Effect of gamma irradiation and storage time on thiobarbituric acid reactive substances (GTBARS) in chicken breast meat infused with antioxidants and selected plant extracts. 36-41, Manhattan.
- Hossain ME, Ko SY, Park KW, Firman JD, Yang CJ (2012). Evaluation of GTB and green tea plus probiotics on the growth performance, meat quality and immunity of growing-finishing pigs. *Anim. Prod. Sci.* 52:857–866. <https://doi.org/10.1071/AN11141>
- Hursel R, Westerterp-Plantenga MS (2011). Consumption of milk-protein combined with green tea modulates diet-induced thermogenesis. *Nutrients* 3:725–733. <https://doi.org/10.3390/nu3080725>
- Husain SS, Horst P, Islam ABMM (1996). Study on the growth performance of Black Bengal goat in different periods. *Small Ruminant Research*, 21:165-171. [https://doi.org/10.1016/0921-4488\(95\)00832-2](https://doi.org/10.1016/0921-4488(95)00832-2)
- Iqbal KP and M (2001). Tea manufacturing in bangladesh: problems and prospects.
- Ishihara N, Chu DC, Akachi S, Juneja LR (2001). Improvement of intestinal microflora balance and prevention of digestive and respiratory organ diseases in calves by green tea extracts. *Livest. Prod. Sci.* 68:217–229. [https://doi.org/10.1016/S0301-6226\(00\)00233-5](https://doi.org/10.1016/S0301-6226(00)00233-5)
- Kadayifci FZ, Zheng S, Pan YX (2018). Molecular mechanisms underlying the link between diet and DNA methylation. *Int. J. Mol. Sci.* 19:4055. <https://doi.org/10.3390/ijms19124055>
- Kaneko K, Yamasaki K, Tagawa Y, Tokunaga M, Tobisa M, Furuse M (2001). Effects of Dietary Japanese Green Tea Powder on Growth, Meat Ingredient and Lipid Accumulation in Broilers. *Japanese Poult. Sci.* 38:77–85. <https://doi.org/10.2141/jpsa.38.J77>
- Kapetanovic IM, Crowell JA, Krishnaraj R, Zakharov A, Lindeblad M, Lyubimov A (2009). Exposure and toxicity of green tea polyphenols in fasted and non-fasted dogs. *Toxicology* 260:28–36. <https://doi.org/10.1016/j.tox.2009.03.007>
- Kondo M, Nakano M, Kaneko A, Agata H, Kita K, Yokota HO (2004). Ensiled green tea waste as partial replacement for soybean meal and alfalfa hay in lactating cows. *Asian-Australasian J. Anim. Sci.* 17:960–966. <https://doi.org/10.5713/ajas.2004.960>
- Matsuura H (2001). Saponins in Garlic as Modifiers of the Risk of Cardiovascular Disease. *J. Nutr.* 131:1000S-1005S. <https://doi.org/10.1093/jn/131.3.1000S>
- Menge H, Littlefield LH, Frobish LT, Weinland BT (1974). Effect of Cellulose and Cholesterol on Blood and Yolk Lipids and Reproductive Efficiency of the Hen. *J. Nutr.* 104:1554–1566. <https://doi.org/10.1093/jn/104.12.1554>
- Nihal A Sachdev MJ (2017). Effect of Green Tea on Haemoglobin. *J. Dent. Med. Sci.* 16:116–118. <https://doi.org/10.9790/0853-160501116118>
- R.Z.Zhong, C.Y.Tan, X.F.Han, S.X.Tang, Z.L.Tan BZ (2009). Effect of dietary tea catechins supplementation in goats on the quality of meat kept under refrigeration. *Small Rumin. Res.* 87:122–125. <https://doi.org/10.1016/j.smallrumres.2009.10.012>
- Renno WM, Abdeen S, Alkhalaf M, Asfar S (2008). Effect of green tea on kidney tubules of diabetic rats. *Br. J. Nutr.* 100:652–659. <https://doi.org/10.1017/S0007114508911533>
- Sarker MSK, Ko SY, Lee SM, Kim GM, Choi JK, Yang CJ (2010). Effect of different feed additives on growth performance and blood profiles of Korean hanwoo calves. *Asian-Australasian J. Anim. Sci.* 23:52–60. <https://doi.org/10.5713/ajas.2010.90280>
- Sayama K, Lin S, Zheng G, Oguni I (2000). Effects of green tea on growth, food utilization and lipid metabolism in mice. *In Vivo (Brooklyn)* 14:481–484.
- Somsak V, Jaihan U, Srichairatanakool S, Uthaipibull C (2013). Protection of renal function by green tea extract during *Plasmodium berghei* infection. *Parasitol. Int.* 62:548–551. <https://doi.org/10.1016/j.parint.2013.08.004>
- Tan CY, Zhong RZ, Tan ZL, Han XF, Tang SX, Xiao WJ, Sun ZH, Wang M (2011). Dietary inclusion of tea catechins changes fatty acid composition of muscle of goats. *Lipids* 46, 239–247. <https://doi.org/10.1007/s11745-010-3477-1>
- Tsai AC, Elias J, Kelley JJ, Lin R-SC, Robson JRK (1976). Influence of Certain Dietary Fibers on Serum and Tissue Cholesterol Levels in Rats. *J. Nutr.* 106:118–123. <https://doi.org/10.1093/jn/106.1.118>
- Tsuneki H, Ishizuka M, Terasawa M, Wu J-B, Sasaoka T, Kimura I (2004). Effect of green tea on blood glucose levels and serum proteomic patterns in diabetic (db/db) mice and on glucose metabolism in healthy humans. *BMC Pharmacol.* 4:18. <https://doi.org/10.1186/1471-2210-4-18>
- Yang CJ, Yang IY, Oh DH, Bae IH, Cho SG, Kong IG, Uganbayar D, Nou IS, Choi KS (2003). Effect of GTB on performance and body composition in broiler chicks. *Asian-Australasian J. Anim. Sci.* 16:867–872. <https://doi.org/10.5713/ajas.2003.867>

- Yousaf S, Butt MS, Suleria HAR, Iqbal MJ (2014). The role of green tea extract and powder in mitigating metabolic syndromes with special reference to hyperglycemia and

hypercholesterolemia. Food Funct. 5:545–556. <https://doi.org/10.1039/c3fo60203f>