



# Potential impacts of dietary inclusion of green tea (*Camellia sinensis* L.) in poultry feeding: a review

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**Abstract** This paper reviews the use of green tea (*Camellia sinensis* L.) in poultry diets in particular, drawing together the findings of various recent studies, in which attention has been paid to the role of green tea in improving the health of animals and humans. Green tea improved feed intake, final body weight, and nutrient use efficiency and could be used as growth promoter in place of antibiotics. Furthermore, green tea improved immunity against coccidiosis, Newcastle disease, decreased plasma low-density lipoprotein, and decreased serum cholesterol. Animal product quality was improved through decreased meat peroxidation, reduced abdominal fat, improved meat quality, and increased chemical composition of meat. Similarly, egg yolk cholesterol was decreased, egg yolk color was improved, and there was increase in yolk alpha-tocopherol. In quail, green tea improved

the intestinal weight, decreased plasma low-density lipoprotein, egg yolk cholesterol, increased edible parts of egg, and improved feed intake and weight gain. Results about green tea showed that it could be supplemented in the diet of broiler, layers, and quail with positive result. This information will be useful for poultry nutritionists, although studies that are more detailed are still needed to prove the effect of green tea on poultry feeding in different situations.

**Keywords** Broiler · Quails · Laying hen · Green tea · Growth · Performance

## Introduction

Livestock researchers have searched for effective, safe and cost-effective alternatives (Abbas et al. 2011; Attia et al. 2017) to antibiotic in raising food animals since the ban on the use of antibiotic due to its effect on the environment and consumers health. This ban started in Europe, and its effect is now intercontinental. This is evident from scientific research output/publication globally, which now focus on alternatives to antibiotics. Phytochemicals or bioactive components in plants are of health benefits to livestock if harnessed and used in right quantity (Adegbeye et al. 2018). Plant leaves (powdered or herbal extract), herbs, spices, and other plant-based products used in

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livestock production for improvement in performance, as substitute for antibiotics, activate digestive enzyme and stimulate immune functions (Brenes and Roura 2010) and may be referred to as phytogetic feed additives. They are used as alternative to antibiotic growth promoter, due to the bioactive components or phytochemicals in them.

Several plant leaves such as Thyme, peppermint, neem, and pawpaw leaf have been used to improve growth performance, meat yield, and gut microflora (Erener et al. 2011; Nideou et al. 2017). To enhance agricultural waste recycling and resource use productivity, green tea leaves that are wasted during pruning may be used in poultry (Angga et al. 2018) feed. Tea (*Camellia sinensis* L.) is a perennial, evergreen and cross-pollinated plant bearing white flowers and green fruits with two to three seeds (Khan 2014). Green tea is nutritionally valuable, contains essential nutrient, including amino acid of which L-theanine accounts for more than half of the total amino acid (Khan 2014), and has polyphenol catechin (Samynathan et al. 2016; Angga et al. 2018).

Green tea has been reported to reduce total cholesterol and LDL cholesterol, increase HDL in plasma (Yang et al. 2003) and egg yolk cholesterol through prevention of bile reabsorption and conversion of liver cholesterol to bile acid (Muharlién 2010; Khan 2014). In addition, it has been found to disrupt coccidia oocysts sporulation processes through enzyme inhibition (Jang et al. 2007; Molan and Faraj 2015). Hence, this review is meant to elucidate the benefits of green tea in poultry production.

## Green tea

### Scientific classification

Green tea belongs to the plant kingdom, and they are from the order Ericales, family Theaceae, genus *Camellia*, and species *sinensis*. It usually goes by the binomial scientific name (*Camellia sinensis* L.) Kuntze (Namita et al. 2012).

### Characteristics and chemical composition of green tea

Green tea, *Camellia sinensis* L., is one of the widely used medicinal herbs in the world, and it is used in

cosmetic, pharmaceutical, and nutritional products. This plant contains high amounts of polyphenols in which the catechins are the main polyphenols, while epithelial catechin-3 galatea is the main active compound (Yang and Koo 1997).

Polyphenol compounds (catechins) in green tea are more abundant than in black tea (oxidized green tea). The health effects of green tea are: reduction in the risk of cardiovascular disease, reduction in the incidence of some cancers, lowering the blood pressure, weight control due to reducing hunger, prebiotic, antimicrobial and antiviral properties, protection against Sun's ultraviolet rays, increased bone density, and positive effects on immunological function (Donsì et al. 2011).

### Medicinal properties of green tea

Green tea has a variety of properties, including anti-cancer activity, prevention of cardiovascular disease, lowering of blood pressure, anti-diabetic and anticoagulant properties, weight reducer, arthritis reducer, tooth and bone strengthening, sedative and anti-stress properties and enhancer of brain function (Cabrera et al. 2006; Santini and Novellino 2017).

The protective ability of green tea on cardiovascular diseases is due to its antioxidant activity. In fact, oral intake of green tea extract by human volunteers increased resistance of plasma LDL to oxidation in the body, which may reduce the risk of arthritis (Miura et al. 2000; Santini et al. 2013).

## Green tea and poultry feeding

### Effect of green tea on broiler chicken

#### *Feed intake and body weight gain*

Body weight gain is an important parameter that reflects how a bird uses/convert feed consumed to muscle. Also, the body weight gain is important in chicken meat production as it influences the monetary value birds are sold and its profitability. It is also used to determine the quality of feed given to birds and the ability of the birds to convert those feed within a short period of time. This body weight gain associated with broiler is what differentiates them from indigenous, but unimproved breed or strain of birds. With increasing human population in developing countries,

it is important that they strive to improve the growth potential of their indigenous birds. A success in this has been done in Nigeria, with an improved breed called FUNAAB Alpha developed from indigenous chicken after 24 years of rigorous selection and cross-breeding. Furthermore, plant seeds, herbs and spices have been used to promote body weight gain in ruminant and nonruminant species, as replacement for medically important antibiotics. Green tea is one of them. Lower feed intake but increased body weight gain is a welcoming idea in livestock production as it indicated feed efficiency. Higher-dose green tea powder reduced feed intake and increased body weight, which improved the feed conversion ratio of the broiler chickens (Biswas and Wakita 2001). The supplementation of fish oil, green tea powder and their combination on broiler improved the feed intake, final body weight gain, and feed efficiency (Saraee et al. 2015). The combination exerted a positive effect on feed expenditure and other production indicators. The presence of phytochemical in herbs has shown that they could offer health benefits. Also, herbs are known to serve as digestive stimulants (Janz et al. 2007) which may induce endogenous digestive enzyme secretion. However, Rahmani et al. (2008) showed that green tea leaf powder in diet of broiler on the performance broiler meat significantly reduced average body weight, feed intake, daily weight gain and abdominal fat, and increased feed conversion ratio of chickens through the whole period, as well as increased pancreatic size at 42 days of age. In El-Deek et al. (2012), 1.5 g green tea per kilogram of diet was evaluated whether it could serve as an alternative to oxytetracycline, and act as a growth promoter in broiler fed two levels of crude protein. Despite the reduced crude protein down to 21%, green tea increased the growth rate in 45 days and decreased the feed conversion ratio by 10.4%. In a time where environmental pollution in livestock production is a concern, the ability of green tea to improve growth rate is laudable. The decreased dietary protein would also reduce the quantity of nitrogen that could have been excreted in the feces and would have caused air pollution through ammonia emission and indirectly contributed to nitrous oxide emission (Tables 1, 2, 3).

### Quality of carcasses and meat

Meat quality is an important characteristic when examining animal products. It also influences the shelf life, taste, flavor of the meat and consumers' preference for it. Saraee et al.'s (2014) study showed that green tea powder and fish oil alone or in combination on broiler reduced the fat content of the abdomen in the broiler. Hrnčár and Bujko's (2017) study showed that different levels of green tea had no effect on carcass parameters, carcass products, and most internal organs in broiler. Sarker et al.'s (2010) study with green tea and biotite on performance of meat quality and growth of the organs in Ross broiler showed that adding low levels of green tea (0.5%) and the natural mineral, biotite, up to 1% (to some higher levels, i.e., 1.0%) instead of antibiotic oxytetracycline improved the growth performance, meat quality and growth of internal organs in broiler chickens. Erener et al. (2011) examined the growth performance, meat quality, and counts of coliform bacteria in the cecum in the broiler chickens fed with green tea extract. The results of that experiment showed that production was improved directly by physiological mechanisms such as tuning the bacterial population of the cecum in the treatments containing green tea extract. Sarker et al. (2010) observed that a 0.5% green tea diet was beneficial to the growth of broiler chickens and the chemical composition of their meat. Biswas and Wakita (2001) observed that the presence of different levels of green tea leaf powder in the diet significantly decreased the amount of thigh meat and abdominal fat and also reduced the amount of thiobarbituric acid, which is a measurement index of the incidence of peroxidation of lipids in meat, and consequently increased storage duration.

Thinh et al.'s (2016) study of green tea powder supplementations in broiler showed that there was no effect on meat organoleptic quality and meat quality, but decreased cholesterol levels in the meat of broiler chickens. Liu et al. (2018) examined the effect of the amount and duration of consuming green tea powder on growth performance, carcass characteristics, blood parameters, and fat metabolites in broiler chickens and showed that green tea in the diet had a positive effect in reducing abdominal fat and lipid metabolites and produced antioxidants.

**Table 1** Summary of findings on the effect of green tea in broiler diet

Shape of use	Animal	Summary of findings	References
Powder	Broiler chickens	Improved growth performance, meat quality, and growth of the internal organs	Sarker et al. (2010)
Powder	Broiler chickens	Increased cellular and humoral immunity against coccidiosis	Abbas et al. (2017)
Extract	Broiler chickens	Didn't apparently do anything at all!!!!	Erener et al. (2011)
Powder	Broiler chickens	Reduced feed intake and increased body weight and thus improved the feed conversion ratio	Biswas and Wakita (2001)
Powder	Broiler chickens	Improved production of lean meat and broiler chicken production	Kaneko et al. (2001)
Powder	Broiler chickens	Improved chemical composition of meat	Sarker et al. (2010)
Powder	Broiler chickens	The use of green tea in broiler chickens led to a reduction in mortality and a change in the bacterial population of the large intestine	Cao et al. (2005)
Powder	Broiler chickens	The use of green tea powder and fish oil resulted in an improvement in abdominal fat in the carcasses of broiler chickens	Saraee et al. (2014)
Powder	Broiler chickens	The use of fish oil and green tea powder led to a significant decrease in plasma LDL, an improvement in the antioxidant status due to increased plasma uric acid, and the improvement in lipid status in the plasma caused by LDL reduction, decrease in the performance of broiler chickens by using green tea powder without fish oil	Alimohammadi-Saraei et al. (2016)
Powder	Broiler chickens	The use of green tea powder did not affect the feed intake, conversion ratio, carcass percentage, liver cholesterol, and plasma cholesterol in broiler chickens	El-Deek and Al-Harathi (2004)
Powder	Broiler chickens	The use of green tea powder reduced masses of body fat, serum triglyceride, LDL cholesterol and total cholesterol and increased HDL cholesterol	Huang et al. (2013)
Powder	Broiler chickens	The use of Japanese green tea powder resulted in decreasing fat deposition and cholesterol, lowering oxidative properties and had no significant effect on the overall performance of broiler chickens	Biswas and Wakita (2001)
Powder	Broiler chickens	The use of green tea leaf powder and vitamin E resulted in a decrease in the mean body weight, feed intake, daily weight gain and abdominal fat, and an increase in the feed conversion ratio of chickens through the whole period as well as an increase in pancreas size at 42 days of age	Rahmani et al. (2008)
Powder	Broiler chickens	The use of tea leaf powder reduced the amount of thigh meat and abdominal fat, feed intake, body weight and serum cholesterol, and increased feed conversion ratio	
Powder	Broiler chickens	The use of green tea and fish oil did not affect the performance, stimulated humoral immune responses, and weakened against Newcastle disease	Zarezadeh et al. (2013)
Powder	Broiler chickens	The use of green tea resulted in lower body weight and cholesterol in broiler chickens	Yang et al. (2003)
Powder	Broiler chickens	The use of dietary fish oil and green tea supplementation resulted in the balance of cecal microflora, ileum, gizzard and apparent health of broiler chickens	Seidavi and Simões (2015)
Powder	Broiler chickens	The use of green tea resulted in an increase in the number of beneficial bacteria ( <i>Lactobacillus</i> spp. and <i>Bifidobacterium</i> spp) and the reduction in pathogenic bacteria ( <i>Clostridium</i> spp. and <i>Bacteroides</i> spp.) in cecum	Thomas et al. (2010)
Powder	Broiler chickens	The use of fish oil and green tea powder affected the body weight of broiler chickens, feed intake, feed efficiency, feed cost and production index	Saraee et al. (2015)
Powder	Broiler chickens	The use of green tea powder had a positive effect on the immunity of broiler chickens	Seidavi et al. (2017)
Powder	Broiler chickens	Using green tea powder reduced abdominal fat and fat metabolites and created antioxidants	Liu et al. (2018)

**Table 1** continued

Shape of use	Animal	Summary of findings	References
Extract	Broiler chickens	The use of green tea extract resulted in antioxidant potential of broiler chickens	Shahid et al. (2013)
Powder	Broiler chickens	The use of green tea and fish oil resulted in beneficial effects on the immune system of broiler chickens, and green tea powder improved the immune system of broiler chickens	Saraee et al. (2014)
Powder	Broiler chickens	The use of green tea did not affect PCV, intestinal absorption of D-xylose, total serum protein, lipid profile, and mineral concentrations as well as performance parameters of broiler chickens	Shomali et al. (2012)
Powder	Broiler chickens	The use of green tea improved the performance of broiler production	Khan (2014)
Powder	Broiler chickens	The use of green tea did not affect the performance characteristics, organoleptic quality of meat and meat quality, but reduced cholesterol in broiler chickens	Thinh et al. (2016)
Powder	Broiler chickens	The use of green tea did not affect final body weight, feed intake, carcass parameters, carcass products and most of the internal organs in broiler chickens	Hrnčár and Bujko (2017)
Extract	Broiler chickens	The use of green tea and faecalis microencapsulated enterococcus resulted in improved immune system, reduced total cholesterol and increased the concentration of serum biochemical parameters	Song et al. (2016)
Extract	Broiler chickens	The use of green tea, cumin, leaf artemisia resulted in improved performance and health of broiler chickens, but CLE negatively affected body weight and feed intake in broiler chickens	Khalaji et al. (2011)
Powder	Broiler chickens	The use of green tea resulted in an increase in the growth rate at 45 days of age and an improvement in feed conversion ratio up to 10.4%	El-Deek et al. (2012)

### Immune response and antioxidant status

The natural body defenses against invasive pathogens are known as the immune system. Various components of the body play vital role in the immune system such as the gut lining, spleen, and bursa of Fabricius. One of the common ways to evaluate the body immune system is the white blood cell and its cell differentiation such as basophils, lymphocyte, and eosinophil. The ban on the use of antibiotics necessitates the search for phytogenic feed additive capable of enhancing the natural body defense of birds without compromising the welfare and productivity. Coccidia parasite is an important pathogen in poultry production, and it thrives well in unclean and highly humid poultry environmental and occurs more in deep litter system. It affects feed intake, feed conversion, weight gain and causes highly mortality if not addressed in time. Abbas et al. (2017) examined the effect of green tea against coccidiosis in chickens and showed that there was increased cellular and humoral immunity against coccidiosis, due to increased immunogenic response and immunoglobulin levels (i.e., total, IgG and IgM). Zarezadeh et al. (2013) examined the effect

of adding green tea and fish oil to broiler diets on humoral immune response against Newcastle disease. The results showed that during the whole period, adding 1.5% of fish oil and 1.5% of green tea to broiler diets triggered humoral immune response and caused weakness against Newcastle disease, respectively. Song et al. (2016) examined the effects of dietary supplementations including microencapsulated *Enterococcus faecalis* and green tea extract on growth performance, immune system, and serum biochemical parameters of broiler chickens. The results of that experiment showed that increasing IgG and IgA levels resulted in improving immune systems, decreasing total cholesterol and increasing serum biochemical parameters. Alimohammadi-Saraei et al. (2016) also examined the response of plasma molecules and body size in broiler chickens to fish oil and green tea powder. The results showed that using green tea powder (15 g/kg of diet) significantly decreased plasma low-density lipoprotein, without affecting the high-density lipoprotein, thereby reducing the ratio of low-density lipoprotein to high-density lipoprotein and improving the lipid status. In addition, the use of green tea improved the antioxidant status due to the

**Table 2** Summary of findings on the effect of green tea in laying hen diet

Shape of use	Animal	Summary of findings	References
Powder	Laying hens	The use of green tea powder led to lower egg cholesterol, had a beneficial effect on egg quality and performance and egg color and increased appearance value of eggs and decreased eggshell thickness	Uganbayar et al. (2005)
Powder and extract	Laying hens	The use of green tea powder and aqueous extract of green tea reduced cholesterol and the value of TBA of egg yolk and improved production and reproductive performance	Abdo et al. (2010)
Powder	Laying hens	The use of green tea powder led to a reduction in eggshell thickness	Uganbayar et al. (2005)
Powder	Laying hens	The use of Japanese green tea powder resulted in a high durability of albumin tissue and lower cholesterol in yolk, without altering the overall performance of laying hens	Biswas et al. (2000)
Powder	Laying hens	The use of garlic and green tea led to the reduction in egg yolk cholesterol in laying hens	Azeke and Ekpo (2008)
Powder	Laying hens	The use of green tea powder resulted in appropriate egg production and egg weight	Kojima and Yoshida (2008)
Extract	Laying hens	The use of green tea extract reduced egg weight in laying hens	Yamane et al. (1999)
Powder and Extract	Laying hens	The use of green tea powder and extract, Marigold and $\alpha$ -Tocopheryl acetate resulted in improved performance and egg quality (yolk weight and indicator), decreased cholesterol and triglyceride in egg yolk	Ariana et al. (2011)
Extract	Laying hens	The use of green tea extract improved egg quality by increasing the thickness of albumin	Yamane et al. (1999)
Extract	Laying hens	The use of green tea extract reduced crude fat in egg yolk	Biswas et al. (2000)
Powder	Laying hens	The use of green tea powder led to the reduction in egg yolk cholesterol	Uganbayar et al. (2005)
Powder	Laying hens	The use of Korean, Japanese, and Chinese green tea resulted in improved egg performance and quality, and Chinese green tea powder caused the greatest reduction in the cholesterol of egg yolks	Uganbayar et al. (2006)
Powder	Laying hens	The use of green tea and seaweed resulted in improved egg production, egg quality, physiological performance, and immunity of laying hens	Rizk et al. (2017)
Powder	Laying hens	The use of green tea resulted in decreased egg yolk cholesterol and had an effect on egg quality parameters	Khan (2014)

**Table 3** Summary of findings on the effect of green tea in quail diet

Shape of use	Animal	Summary of findings	References
Powder	Quail	The use of green tea led to an increase in high-density lipoprotein (favorable lipid) levels in the blood serum	Zarghi and Golian (2014)
Powder	Quail	The use of green tea resulted in a relative weight increase in duodenum, jejunum, plasma LDL, yolk cholesterol, edible parts of egg, feed intake, and weight gain of the growing quails	Karimi and Pazaki (2013)

increase in plasma uric acid. However, Huang et al. (2013) examined that green tea supplementation reduced body fat mass, serum triglyceride and

cholesterol (low-density lipoprotein) and total cholesterol but increased cholesterol (high-density lipoprotein).

Seidavi et al. (2014) studied that green tea had beneficial effects on the immune system of broiler chickens. This is because, its polyphenols (Santini and Novellino 2017), especially catechins that have antibacterial and antioxidant properties, are a valuable treatment for chronic immune disorders and improved hemorrhoid responses to influenza and Newcastle diseases. In another study, Seidavi et al. (2017) showed that dietary green tea powder did not adversely affect the immunity of broiler chickens. Thomas et al. (2010) increased the number of beneficial bacteria (*Lactobacillus* spp. and *Bifidobacterium* spp.) and reduced the pathogenic bacteria (*Clostridium* spp. and *Bacteroides* spp.) in the cecum of broiler chickens after 35 days of consuming the supplementation of green tea. Seidavi and Simões (2015) examined dietary fish oil and green tea supplementation on gastrointestinal tract microflora, and the result showed that using fish oil up to 2.0% and green tea supplementation up to 1.5% had no adverse results on the diet and the general health of broiler chickens, and can even balance the cecal microflora, with those of the ileum and gizzard. Shahid et al. (2013) examined the effect of polyphenol-rich green tea extract as an antioxidant on the performance of broiler chickens during the weeks 0–4. The results showed that the antioxidant potential of green tea extract was confirmed even if synthetic compounds did not exist in the formulation.

#### Conclusion on broiler chickens

The use of green tea extracts, whether in powder or extracts form, improves growth performance, meat quality, and the growth of the internal organs. It increases cellular and humoral immunity against coccidiosis, reduces feed intake and increases body weight, reduces abdominal fat in the carcass, decreases plasma LDL, improves antioxidant status due to increased plasma uric acid, and improves lipid metabolism due to LDL reduction. Furthermore, it reduces body fat masses, serum triglyceride, LDL cholesterol, total cholesterol results in low fat deposition in meat, reduces the amount of thigh meat triggers humoral immune responses, and reduces meat cholesterol. It creates balance in cecal ileum and gizzard microflora, increases the number of beneficial bacteria (*Lactobacillus* spp and *Bifidobacterium* spp) and reduces the pathogenic bacteria (*Clostridium* spp

and *Bacteroides* spp) in the cecum, positively affects immunity, fat metabolites and antioxidants in broiler chickens.

Eggs yolk is an important source of dietary cholesterol, and the association between cholesterol and coronary heart disease has lowered their consumption (USDA 2000).

#### Effect of green tea on performance and egg quality of laying hens

Laying hen are birds raised for producing eggs, mostly consumption purpose, although the breeders among them lay eggs for hatching. In egg-laying birds (Naviglio et al. 2012), parameters such as egg shell thickness, egg yolk colors, and egg cholesterol are attributes of egg quality and hatchability. Egg quality traits are those that affect its acceptability to the consumers (John-Jaja et al. 2016). Uganbayar et al.'s (2005) study showed that 2% green tea powder can reduce cholesterol levels in egg and has positive effect on egg color and raises the apparent value of eggs, but reduced egg shell thickness. Uganbayar et al. (2006) showed that 1–2% Chinese green tea reduced cholesterol of egg yolk. Khan (2014) examined the use of green tea (*Camellia sinensis*) as an herbal substance in poultry diets. The results of that experiment showed that the addition of green tea to the diet of laying hens could improve production performance and reduce cholesterol levels in egg yolks, and its potential effects alter egg quality parameters.

In Abdo et al. (2010), green tea powder in the diet of laying hens at levels of 1.0–3.0% or green tea extracts at levels of 0.5–1.5 L per 100 kg of feed can reduce cholesterol and the thiobarbituric acid value of egg yolk. This means that its potential impact is on egg quality parameters, especially during storage, improvements in production and reproductive performance of both male and female chickens.

Evaluation of the long-term feeding effect of Japanese green tea powder on the laying hen performance and egg quality (Biswas et al. 2000) indicates that green tea powder could modify the components of the edible parts of egg and lead to favorable consumer characteristics such as high durability of albumin tissue and lower cholesterol in yolk, without changing the overall performance of laying hens during the test year. Yamane et al. (1999) and Biswas and Wakita (2001) reported that feeding green tea extract to laying

hens improved the quality of eggs by increasing the thickness of albumin and reducing the crude fat in egg yolks in a short-term experiment.

Comparative study of green tea and garlic on reducing egg yolk cholesterol by Azeke and Ekpo (2008) indicates that both plants have a high potential for reducing egg yolk cholesterol in the eggs of laying hens. The study of Kojima and Yoshida (2008) on performance of laying hens at the final laying stage showed that alpha-tocopherol in the egg yolk was related to the consumption of green tea powder, and up to 1% in the diet of laying hens is beneficial to egg production and egg weight. Similarly, Ariana et al.'s (2011) study showed that the effect of green tea powder and extract, on the performance, egg quality and egg yolk cholesterol level in laying hens at the final stages of production had a significant effect on egg quality and function (weight and yolk index). Cholesterol and triglyceride levels of egg yolk were also reduced by using green tea. The diets containing 0.5% green tea extract reduced feed intake and feed conversion ratio compared to control group. Rizk et al. (2017) examined the effect of green tea and seaweed on the production and physiological performance of laying hens in the final stages of production. The results of that experiment showed that the supplementation of 0.1% red seaweed and green tea in the diet of laying hens in the late stages of production could improve egg production, egg quality, physiological performance and immunity of laying hens.

#### Conclusion on laying hens

The use of green tea extract, powder, and essence led to the reduction in egg cholesterol, beneficial effects on egg performance and quality, egg color, increased egg appearance value, decreased eggshell thickness, decreased TBA of egg yolk, improved production and reproductive performance of high-durability albumin tissue and egg weight loss, improved performance and internal egg quality (yolk weight and indicator), decreased egg yolk triglyceride, feed intake and feed conversion ratio, improved egg quality by increasing albumin thickness, and improved the physiological performance and immunity of laying hens.

#### Effect of green tea on quails

Zarghi and Golian (2014) examined the effect of green tea on the performance and blood metabolites of quail. The results of that experiment showed that adding green tea to the diet increased the level of high-density lipoprotein (favorable lipid) in blood serum. Karimi and Pazaki (2013) examined the effects of green tea on blood parameters, egg quality, carcass and growth performance in the quails fed with and without cholesterol. The results of that experiment showed that adding 1% cholesterol to the diet increased the weight of jejunum, blood heterophil, yolk cholesterol and feed intake, but did not raise blood cholesterol (while expected). Adding 3% of green tea increased the relative weight of duodenum and jejunum, plasma low-density lipoprotein, egg yolk cholesterol, edible parts of egg, feed intake, and weight gain of the growing quails.

#### Conclusion on quails

The use of green tea extract, powder, and essence increased high-density lipoprotein (favorable lipid) levels in blood serum, relative weight gain of duodenum and jejunum, plasma LDL, yolk cholesterol, edible parts of egg, feed intake, and weight gain of Japanese quail.

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#### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interests.

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