Suppression of avian hepatic cholesterogenesis by dietary ginseng

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The effect of the ginseng root powder on avian hepatic cholesterol biosynthesis and serum lipoprotein cholesterol levels were examined. Lohman strain broiler females were fed for 4 weeks a corn-based diet (control) or an experimental diet in which 0.25% Korean ginseng was incorporated (treatment). B.-hydroxy-B-methylglutaryl-CoA) HMG-CoA reductase activity was significantly lower ($P < 0.01$) in the treatment group (47% of control activity). Ginseng treatment affected a lowering of the serum total cholesterol level (83% of control, $P < 0.05$) and of serum low density lipoprotein cholesterol level (77% of control, $P < 0.05$). The mechanism of the hypocholesterolemic action of ginseng involves the suppression of cholesterol biosynthesis.

Keywords: Avian; cholesterol; ginseng; LDL cholesterol

Introduction

Heart disease remains one of the leading causes of death in the world. The publication "Dietary Goals for the United States" included recommendation for a reduction in cholesterol consumption as a means of preventing heart diseases.[1] Hence, dietary cholesterol has become an important issue to consumers. The recommendations have gained support as the role of high serum cholesterol as one of the primary risk factors in the incidence of coronary heart disease is established.[2] Most of the studies in this area become preventive in nature and mainly focused on lowering plasma cholesterol. The role of nutritional factors in changing plasma cholesterol concentrations has gained considerable attention.[3-11] The rate-limiting step in the cholesterol biosynthesis is generally accepted to be the conversion of 3-hydroxy-3-methylglutaryl-CoA (HMG-CoA) to mevalonic acid (MVA) catalyzed by HMG-CoA reductase.[12,13] The research of the hypocholesterolemic agent in predominantly vegetarian human diet has shown the suppressive effects of plant materials on serum cholesterol and hepatic cholesterol biosynthesis by inhibition HMG-CoA reductase in an animal model.[14-16]

The root of Korean ginseng is *Panax ginseng*. C.A. Mayer has reported that it has opposite effects on blood pressure, carbohydrate metabolism, hemolysis, and cholesterol metabolism.[17] This trial is undertaken to study the effect of dietary ginseng on serum and hepatic levels of cholesterol and its derivatives as well as on hepatic HMG-COA reductase activity in chickens.

Materials and methods

Materials

Experimental materials were purchased from the following sources: Bovine serum albumin (Nutritional Biochemicals Corporation, Cleveland, OH); DL-3-Hydroxy-3-methyl-[3-C^{14-}] glutaryl-CoA (specific activity, 26.3 mCi/mmole), and Aquasol (Scintillation solution) (New England Nuclear, Boston, MA). Korean ginseng and the other diet components were obtained locally. All other chemicals were of analytical grade.

Animals and diets

Lohman strain broiler female chickens (4 weeks, 1069 ± 106 g) were purchased from a local hatchery. The birds were randomly caged in groups of 14 in two large, similar cages. One group (control) was fed appropriate corn-based diet (Provimei), and the other group (experiment) was fed the corn-based diet containing 0.25% Korean ginseng powder. Feed was provided for both groups (ad libitum) with a 24-hour photo-period for 23 feeding days; the chickens were fasted for 28 hours and then were re-fed for 72 hours.

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The birds were killed by severing the carotid arteries. Blood samples were collected, and the liver of each bird was removed, washed with cold saline solution (0.9 NaCl), weighed, and prepared for the analysis described below. The Korean ginseng root powder was incorporated into the experimental diets.

Liver homogenates

The liver homogenates were prepared in 0.1 M potassium phosphate buffer, pH 7.4, containing 0.004 M $MgCl_2$, 0.001 M EDTA, and 0.002 M dithiothreitol. The tissue was chopped and suspended in the buffer (1:2, w:v), and homogenate was centrifuged for 10 minutes at 5000 g. The supernatant was passed through cheesecloth and the volume was recorded. An aliquot (5 ml) was stored at −20°C for lipid determination and the remaining supernatant was then centrifuged at 2000 g (10 minutes) and 100,000 g for 60 minutes, successively. The 100,000 g precipitate (microsomes) was stored at −20°C. The microsomes were assayed for HMG-CoA reductase activity. Protein concentrations were estimated by a modification of the Biuret method using bovine serum albumin as a standard.[18]

Expression of data and statistical methods

Enzyme data is presented as specific activity (units/mg microsomal protein/minute). Statistical comparison of results was performed by a simple t-test.[19]

Results

The average weight gain of the groups of broiler chickens fed the ginseng-supplemented experimental diets (78.5 ± 16.3) was equal to that of the control diet group (77.6 ± 10.2). However, the average liver weight of the ginseng-supplemented experimental group was slightly higher (7.9%) than that of the control group (*Table 1*). Moreover, the feed consumption of the ginseng-supplemented experimental group was slightly lower (8.8%) than that of the control group which was reflected in an 11% increase of feed efficiency in ginseng-supplemented experimental group over that of the control group (*Table 1*).

HMG-CoA reductase activity in chicks fed the ginseng-supplemented diet were significantly lower (47%) of that in chicks fed the control diet ($P < 0.01$) (*Table 2*).

The above enzyme inhibition by ginseng supplementation was expressed in the serum and liver cholesterol levels. The levels were more than 16% lower and more than 11% lower, respectively, than those levels in the control broilers (*Table 3*).

Further reflection of HMG-CoA reductase inhibitor by ginseng supplementation was shown in the serum LDL level. Although HDL levels were equal in both the experimental and control groups, the LDL level was more than 23% lower in the ginseng-supplemented group than in the control group of broilers (*Table 3*).

Table 2 The effect of ginseng on the activity on HMG-CoA reductase in broiler chickens

Diet	HMG-CoAR specific activity (Pmoles of mevalonic) acid synthesized/min/mg of microsomal protein)
Control	603.5 ± 102.7
Ginseng	281.9 ± 124.7[a]

[a] Significantly different from control at $P < 0.01$. Data expressed as means ±SD; $N = 14$ chickens per group.

Table 3 The effect of ginseng on serum and liver cholesterol levels in broiler chickens

Values mg/dl	Serum cholesterol[a]			
Diet	Total	HDL	LDL	Liver cholesterol[b]
Control	167.7 ± 29	42.2 ± 7	75.2 ± 14	410.9 ± 17.9
Ginseng	139.5 ± 15.3[c]	41.1 ± 6	57.5 ± 11[c]	362.8 ± 16.9[c]

[a] Feeding period was 4 weeks: Time of killing was 08:00; Data expressed as means ± SD; $N = 14$ chickens per group. [b] mg/dl of 5000 g supernatant fractions of liver. [c] Significantly different from control at $P < 0.05$.

Discussion

The relatively higher weight gain and feed efficiency despite lower feed consumption in the chickens fed on ginseng-supplemented feed (*Table 1*) demonstrates the mutual benefit for the farmer and the consumer. The poultry farmer spends less on feed and gains more poultry meat, and the consumer gets hypocholesterolemic chickens, which may reduce the risk of being atherosclerotic and may increase the chance of being healthy.

One may suspect that edema might have been mistaken for true weight gain, but this is unlikely because edema is a consequence of protein deficiency. This is

Table 1 Body weight gain, feed consumption, and feed efficiency by control and ginseng-supplemented groups

Group	No. of chicks	Body wt. (g)		Av. gain/ Chick (g/d)	Av. feed Consumption g/d/Chick	Feed efficiency (g gain/g feed)	Liver Weight (g)
		Initial	Final				
Control	14	1022 ± 122	2807 ± 315	77.6 ± 10.2	171.7 ± 33.1	0.45	56.6 ± 11.2
Ginseng	14	1069 ± 106	2853 ± 397	78.5 ± 16.3	156.6 ± 42.2	0.50	61.1 ± 12.3

not the case in our study. Liver microsomal protein of ginseng and control broilers were 15.08 ± 2.4 and 14.89 ± 2.1 mg of 100 k (100,000 g) precipitate/ml of buffer, which indicates that protein in chickens fed ginseng was like that of controls and even slightly higher. If this viable protein is normal, then all other protein are unlikely to be deficient, which means that the change in the weights could not be due to edema.

Wherever unrefined cereals and vegetable products form the major part of the diet, the incidence of hypercholesterolemia and cardiovascular disease was low.[20-22] In man, Grundy showed the association between cholesterol and coronary heart disease.[2] Endo related the action of the cholesterol-lowering agents to the inhibition of HMG-CoA reductase.[23]

Much of the literature dealing with ginseng is available in abstract forms.[24-26] In this study, the avian hepatic HMG-CoA reductase activity was 47% of control when 0.25% Korean ginseng root powder-supplemented diet was fed (*Table 2*). The relationship between hepatic HMG-CoA reductase activity and liver cholesterol, serum total, and LDL- (but not HDL) cholesterol has been manifested (*Table 3*). The manifestation was further shown in the LDL/HDL ratio. The ratio in the ginseng group was 1.39 versus 1.78 in the control broiler females, with a decrease in the ratio of 22%. These results confirmed the previous observation, that the daily ingestion of 1 g Wisconsin ginseng root powder for 2 to 4 months by 6 free-living human subjects effectively lowered their total and LDL cholesterol levels.[27] The elevation of HDL cholesterol in human subjects[27] was not demonstrated in the avian model (*Table 3*).

Ginseng was found to lower HMG-CoA reductase activity, liver cholesterol, and serum total and LDL cholesterol levels without affecting the HDL cholesterol level (*Tables 2 and 3*). Effectors of changes in avian hepatic HMG-CoA reductase activity, liver, and serum cholesterol levels have been isolated in previous studies from other foods.[28-30]

One may think of a possibility of liver toxicity. However, in this study, without any biochemical or histopathological studies on the livers, it was the investigators' impression, based on simple observation, that all livers were brownish in color and normal in shape. No morphological abnormalities or spots of discoloration were observed. Previous reports on dogs fed on much higher doses of ginseng extract showed no pathological or toxic effects.[31]

Whether ginseng plays a role in suppressing serum cholesterol levels and the incidence of cardiovascular diseases of populations remains to be demonstrated.

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