INFLUENCE OF COCONUT OIL AND SUNFLOWER OIL ON PLASMA AND LIVER LIPID PROFILE AND PRODUCTION PERFORMANCE IN JAPANESE QUAIL *(Coturnix coturnix japonica)*

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **INFLUENCE OF COCONUT OIL AND SUNFLOWER OIL ON PLASMA AND LIVER LIPID PROFILE AND PRODUCTION PERFORMANCE IN JAPANESE QUAIL** ***(Coturnix coturnix japonica)*** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **INFLUENCE OF COCONUT OIL AND SUNFLOWER OIL ON PLASMA AND LIVER LIPID PROFILE AND PRODUCTION PERFORMANCE IN JAPANESE QUAIL** (***Coturnix coturnix japonica***) is a record of research work done independently by **Mrs. Mini, K.P.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Ischaemic heart disease is an important health problem in both developing as well as developed countries. The role of dietary factors in the genesis and development of atherosclerosis and its complications has been highlighted. Ingestion of saturated fats has been incriminated with the production of elevated serum cholesterol levels, both in humans and in experimental animals. Epidemiological studies have established a high serum cholesterol level with the intake of a diet having a high fat content, and a low ratio of polyunsaturated/saturated fatty acids which act as risk factors for the development of occlusive coronary artery disease.

Much controversy exists regarding the specific relationship between diet, plasma lipids and development of heart disease in humans. Although spontaneous aortic disease is extremely wide spread in the animal kingdom, the close resemblance of avian atherosclerosis to the human disease has been recognized only from the early part of the twentieth century. Japanese quail has been recognized as an animal model for studies on atherosclerosis (Shih *et al.*, 1983 and Casale *et al.*, 1992).

Research work in poultry is often handicapped by limitations in budget, time and space. Some of these problems can be alleviated by using Japanese quail (*Coturnix coturnix japonica*) as a pilot animal for the more expensive experiments on chicken or turkeys. Coturnix quail is recommended as a model avian species for research especially to embryologists and physiologists because of its hardiness, easiness of handling, small size and great laying ability. Quail eggs have lesser albumen and more yolk content than chicken eggs, and the small size of eggs permits the cholesterol conscious people to consume a few of them so as to regulate their intake of food cholesterol. Meat and egg with low fat and cholesterol content would naturally be preferred as items of human food. Recently rearing of quails for eggs and meat is becoming more and more popular in every part of Kerala.

Fats and oils in the ration of laying hen are having some influence on yolk lipid formation and composition. Research reports have revealed that one of the prime factors in hyper-cholesterolaemia and subsequent development of coronary vascular disease (CVD) is the intake of diets rich in cholesterol. The quality and nature of dietary fat in laying hen's ration have been found to influence the sterol metabolism of the hen and consequently the yolk lipid composition.

Several reports have implicated coconut oil as one of the major factors involved in the increase of plasma cholesterol level leading to increased susceptibility for coronary vascular disease in human beings and animals. This led to the search for other vegetable oils like sunflower oil in place of coconut oil. Reports contrary to this are also aplenty. All the same, coconut oil is truly by far the most easily available edible oil in Kerala. More over, coconut oil has been a dietary component for Keralites from time immemorial. Coconut oil is a source of dietary saturated fatty acids and sunflower oil is a source of dietary unsaturated fatty acids. Gingelley oil is the most commonly used fat source in poultry ration. Hence it was thought worthwhile to study the comparative effect of coconut oil and sunflower oil against gingelley oil (control) in their influence on lipid status as well as production performance of Japanese quails. The present investigation was attempted in order to probe certain aspects of lipid metabolism in Japanese quails with the objectives of:

1. Assessing the influence of dietary oils as coconut oil and sunflower oil against gingelley oil on the lipid profile in plasma (total lipid, triglyceride, total cholesterol, HDL-C, (VLDL+LDL)-C and phospholipid) and liver (total lipid, triglyceride, total cholesterol and phospholipid) and the weight of the liver.

2. Assessing the influence of these dietary oils on total lipid and total cholesterol content in egg yolk.

3. Evaluating the influence of these different dietary oils on the production performance of Japanese quails by recording the egg production, egg weight, egg mass, feed consumption, body weight and feed efficiency.

Review of Literature

2. REVIEW OF LITERATURE

2.1 Lipid profile in plasma

2.1.1 Total lipid

Lipid materials constitute 10 to 13 per cent of total blood plasma of chicken. The relative composition of individual lipid components in the lipid material is maintained by various mechanisms operating in the body. Dietary habits strongly influence the level of lipids and their relative composition.

Call and Call (1974) demonstrated a higher serum total lipid content in Japanese quails supplemented with dietary dieldrin. Maurice and Jensen (1978) recorded a higher plasma total lipid content in Japanese quails fed cholesterol in their diets. According to Girishkumar (1997) supplementation of onion and garlic in the feed of Japanese quails caused an elevation of the plasma total lipid content.

Plasma total lipid content was reduced after starvation for 48 hours in Japanese quails (Shapira *et al.*, 1979). However, Rogel and Vohra (1986) could not produce a reduction in plasma total lipid content of Japanese quails by feeding oat husks and its fractions in the ration.

Walker *et al.* (1951) reported that incorporation of vegetable oils as high as 18 per cent in layer ration of domestic fowls had only negligible influence on the level of blood lipids. Similarly only a nonsignificant change in plasma total lipid content of laying hens was noticed by the dietary garlic oil (Reddy *et al.*, 1991) and corn oil (Takita *et al.*, 1995).

However, Weiss and Fisher (1957) observed an increase in the plasma lipid content when animal fat (5 to 10%) was added to the layer diet. According to Kirchner and Hartfiel (1974) and Neill *et al.* (1977) total blood lipid content in White Leghorn birds had strong correlation with sexual maturity and egg production (Yu *et al.*, 1976). Noble and Cocchi (1990) and Joshi *et al.* (1992) were of the opinion that laying chicken had higher total lipid content in blood than non laying ones. A lowering of concentration of blood total lipid was observed by the addition of naked barley bran to a diet containing cholesterol (Chochi *et al.*, 1984) and by the addition of two per cent palm kernel oil to the diet of biotin deficient chicks (Oloyo and Ogunmodede, 1993).

Plasma total lipid content was reduced by Vitamin A deficiency in broiler chicken (Nikiforova and Dvinskaya, 1984) and by riboflavin deficiency in ducklings (Lin *et al.*, 1993).

El-Husseiny *et al.* (1980) got a higher serum total lipid content in rats fed on a diet with cotton seed oil (5%) than with olive oil, groundnut oil, soyabean oil, sunflower seed oil or maize oil. Adamopoulos *et al.* (1996) observed a higher fasting plasma total lipid content in rats fed with cholesterol than with olive oil or safflower oil.

2.1.2 Triglyceride

Triglyceride is a major lipid component in the plasma. One of the factors to control hypertriglyceridemia is the rate of removal of triglyceride lipoproteins from circulation and their uptake by extrahepatic tissues, which is a function of lipoprotein lipase (LPL). Triglyceride is the storage form of energy. It acts as a fuel as well as a source for fatty acids. The fatty acids released from triglycerides are utilized for the synthesis of other classes of lipids.

Starving for 48 hours reduced plasma triglyceride content in Japanese quails was reported by Shapira *et al.* (1979). Labate and Dam (1980) could not observe any change in serum triglyceride concentration on supplementation of hydroxy methyl glutaryl coenzyme A (HMG-CoA) in the feed of Japanese quails. Rogel and Vohra (1986) recorded an increase in the plasma triglyceride concentration in Japanese quails by feeding crude hemicellulose isolated from wheat bran for a period of 24 days. As in the case of White Leghorn birds

dietary fish oil and linseed oil caused a reduction in the serum triglyceride content in Japanese quails compared to dietary beef fat or safflower oil (Hood, 1991).

Itoh *et al.* (1995) has shown sex related differences in the plasma triglyceride content. According to them female Japanese quails had higher plasma triglyceride content than males. Dietary onion and garlic caused an increase in the level of triglyceride in plasma of Japanese quails (Girishkumar, 1997).

According to March (1984) previous consumption of the high oil diet increased post prandial triglyceride concentration in the plasma of broiler chicken, but reduced it in the White Leghorn chicken. Dietary pantethine (Tanaka *et al.*, 1989) and sorbose (Furuse *et al.*, 1990) were effective in reducing triglyceride concentration of plasma and serum in White Leghorn birds.

Feeding of polyunsaturated fatty acids in the diet decreased, the triglyceride concentration in VLDL and LDL fraction (Phelireplace and Watkins, 1990) and the total triglyceride content (Prakash *et al.*, 1996) in plasma. Furuse *et al.* (1992) also observed a reduction in serum triglyceride level in White Leghorn laying hens given γ-linolenic acid in the feed. Van Elswyk *et al.* (1994) and Prakash *et al.* (1996) recorded a lower value for serum triglyceride in White Leghorn

laying hens fed with fish oils. An *et al.* (1995) also got a lower serum triglyceride content in chicken maintained on a diet with linseed oil compared to that with safflower oil. According to Rodriguez *et al.* (1993) and Castillo *et al.* (1994) feeding coconut oil which is rich in saturated fatty acid increased plasma triacylglycerol level in chicks.

A higher serum triglyceride content in broiler chicks fed on barley oil than on maize oil was observed by Wang *et al.* (1993). Feeding of combination of maize oil and rice bran oil gave lower serum triglyceride concentration in growing chickens, than that of individual oils (Fan *et al.*, 1995).

Influence of sex on plasma triglyceride concentration in White Leghorn birds was recorded by Yu *et al.* (1976), Brackenbury and El-Sayed (1984), Joshi *et al.* (1992) and Itoh *et al.* (1995). Females had higher plasma triglyceride concentration than the males.

El-Husseiny *et al.* (1980) observed a higher serum triglyceride concentration with cotton seed oil (5%) in rats, compared with other dietary oils (Olive oil, groundnut oil, soyabean oil, sunflower oil or maize oil). Conversely Adamopoulos *et al.* (1996) noticed a higher level of plasma triglyceride with olive oil and safflower oil (14 g/100 g level) in the diet of rats.

Klingenberg *et al.* (1995) during their study in pigs recorded a lower plasma triglyceride content in tallow fed group compared to sunflower oil fed group.

Ahrens *et al.* (1957) reported no significant change in lipid metabolism on feeding low level of additional fat in the diet of human beings. Kurup and Rajmohan (1994) conducted a study on human volunteers and confirmed that consumption of coconut oil will not elevate serum triglyceride level compared with groundnut oil. Thampan (1994) was of the opinion that coconut oil stimulate secretion of insulin in body.

2.1.3 Total cholesterol and lipoprotein cholesterol

Epidemiological studies have revealed that prevalence of hypercholesterolaemia and coronary heart disease are high in people with higher intake of dietary cholesterol as well as saturated fats. Cholesterol metabolism in poultry has been under investigation over years.

Smith and Hilker (1973), Morrissey and Donaldson (1977a) and Siegel *et al.* (1995) registered a higher plasma cholesterol content in Japanese quails fed diets containing exogenous cholesterol. A higher serum total cholesterol and lipoprotein cholesterol content in Japanese quails fed cholesterol in the diet was recorded by Verma *et al.* (1995).

Shapira *et al.* (1979) got a lower value for serum cholesterol after 48 hours of starvation in Japanese quails. Joshi *et al.* (1982) reported a lower plasma cholesterol in female quails than male quails. Poyraz (1988) could not notice any difference in plasma cholesterol concentration between male and female quails.

Rogel and Vohra (1983) failed to reduce serum cholesterol level by feeding oat bran and hulls in the semi purified diet with 0.5 per cent cholesterol in Japanese quails. While Hood (1991) observed that concentration of blood cholesterol in Japanese quail tend to decrease with diet containing beef tallow, safflower oil, linseed oil and fish oil, Sun and Shim (1994) could not observe any significant change in plasma cholesterol concentration with a diet containing fish oil, lard or sunflower oil (4%). Dietary onion and garlic caused no change in total cholesterol inplasma, while VLDL-C increased in both sexes of Japanese quails (Girishkumar, 1997). According to him no consistent effect due to feeding alliums on HDL-C was noticed, while LDL-C decreased in female quails.

Johnson *et al.* (1959) did not notice any significant difference in the plasma cholesterol content of laying chicken by feeding cholesterol in the ration, while Tanaka *et al.* (1989) observed a decrease in the concentration of cholesterol

fractions when cholesterol was fed along with pantethine. High levels of cholesterol and triglyceride in chicken diet increase LDL-cholesterol content (Allen and Wong, 1993). Similarly Castillo *et al.* (1994) found a significant elevation in free and ester cholesterol level in White Leghorn chickens by feeding cholesterol (2%) while in newly hatched chicks elevation occurred only in the level of ester cholesterol.

Treat *et al.* (1960) did not find any change in plasma total cholesterol concentration by feeding animal fat/ vegetable fat in the layer ration. However, sunflower oil (12%) unlike grease in the layer ration of chicken caused a reduction in serum cholesterol content (Daghir *et al.*, 1960). But feeding of soyabean oil and animal tallow (10%) in chicken produced only non-significant variation in the level (Marion *et al.*, 1960). Tanaka *et al.* (1981) reported an increase in serum cholesterol with fat free diet or tripalmitin diet in chicks compared to coconut oil diet.

Griminger and Fisher (1986) also noted an increase in plasma cholesterol concentration by feeding egg yolks to young male chickens. In the study of Castillo *et al.* (1994) coconut oil (10 or 20%) in the diet caused an elevation in plasma total cholesterol content in chicks after seven days of feeding.

Eventhough Basilov and Vargas (1989) did not find any significant influence of degree of saturation of dietary fat on the pattern of plasma lipoprotein cholesterol in fattening chickens, Rodriguez *et al.* (1993) recorded a change in composition of HDL fraction and an elevation of VLDL-C and LDL-C content by feeding coconut oil (20%) in *Gallus domesticus* chicks. However, Grimes *et al.* (1996) got a lower value for plasma total cholesterol, LDL-C and VLDL-C by feeding of saturated fat (prilled fat) than unsaturated fat (poultry fat) in young White Leghorn hens whereas in old hens lowering of HDL-C occurred in groups fed saturated fat.

Serum cholesterol was found to be lower in White Leghorn laying hens fed with sorbose (Furuse *et al.*, 1990) and with fish oil (Van Elswyk *et al.*, 1994) than in controls. Wang *et al.* (1993) registered a lower LDL-C content and higher HDL-C content in broiler chicks fed with diets containing barley oil (10%) than with maize oil. No significant difference was noticed by Fan *et al.* (1995) on serum cholesterol content of chicks fed with rice bran oil or maize oil.

A significant reduction was observed in serum LDL-C content on feeding apolar extracts of alfalfa in growing chicks (Yu *et al.*, 1994). A reduction in VLDL-C and LDL-C occurred by feeding garlic in chicken (Khalid *et al.*, 1995).

Kumar and Rawat (1975) could not notice any change in plasma cholesterol concentration between male and female birds. According to Yu *et al.* (1976) laying hens had higher VLDL-C and lower HDL-C content compared to nonlaying hen and rooster, whereas LDL-C content in rooster was significantly lower than the other two groups. Neill *et al.* (1977) observed a higher plasma cholesterol content at the onset of sexual maturity, which declined to the prelaying values later. Griffin *et al.* (1982) and Noble and Cocchi (1990) also recorded a higher VLDL-C content in laying chicken. A higher HDL-C in male juvenile meat type chickens than females was noticed by Peebles *et al.* (1996).

Latour *et al.* (1996b) reported a higher HDL-C as well as LDL-C in chicks from young broiler hens than from old hens. In another study Latour *et al.* (1996a) made a similar observation in the male juvenile meat type chicken infused with the hormone ACTH (8 IU/kg body weight).

Highest serum cholesterol was observed in rats fed with cotton seed oil (5%) in the diet than olive oil, groundnut oil, soyabean oil or sunflower seed oil by El-Husseiny *et al.* (1980) and with cholesterol (14 g/100 g of diet) than with olive oil and safflower oil by Adamopoulos *et al.* (1996). According to Vijayammal *et al.* (1982) rats fed on diets containing safflower oil (8%) had lower HDL-C as well as (VLDL+LDL)-C

than controls. But Vijayammal *et al.* (1982) got lower values for (LDL+VLDL)-C in coconut oil and groundnut oil fed (8%) rats than controls. Ventura *et al.* (1989) recorded higher LDL-cholesterol content with coconut oil (20%) than with fish oil containing diet. Baba *et al.* (1993) noticed a higher HDL-C content in rats maintained on a diet containing coconut oil, than with cocoa butter.

In the experiments conducted by Kobatake *et al.* (1989) it was observed that serum total cholesterol was reduced in rats fed on diets containing egg yolk phospholipid mixture and hydrogenated egg yolk phospholipid mixture. Choi *et al.* (1990) got a lower serum HDL-C content in spontaneously hypertensive rats fed on diets containing maize oil and beef tallow in the ratio of 1:1, beef tallow, grape seed oil, or soyabean oil. Klingenberg *et al.* (1995) could not notice any difference in plasma total cholesterol, LDL-C, VLDL-C and HDL-C by the incorporation of beef tallow or high oleic sunflower oil in the diet.

In case of rabbits also feeding of coconut oil (14% w/w) in the diet resulted in an increase in the HDL-C content (Carlson and Kolteke, 1991).

A study conducted by Kurup and Rajmohan (1994) revealed that consumption of coconut oil would not cause any harmful effects in human beings in comparison to the dietary groundnut

oil. The higher cholesterol value got in coconut oil fed group was due only to an elevation of HDL-C value which was beneficial to the body.

2.1.4 Phospholipid

Two important groups among the lipids that contain phosphorus are the phosphoglycerides and sphingomyelins. It is now well recognized that a relative increase in high density lipoprotein and phospholipids has a protective influence against atheroscelerosis. The plasma phospholipids stabilize the colloidal dispersion of cholesterol and there by prevent its deposition in the arterial wall.

Shapira *et al.* (1979) found that starving for 48 hours significantly reduced plasma phospholipid content in Japanese quails. An elevation of plasma phospholipid content in Japanese quails supplemented with onion or garlic in the feed was observed by Girishkumar (1997).

Geese fed with 10 per cent soyabean meal with methionine showed higher plasma lipid phosphorus content compared to those fed with control diet containing cooked maize, vitamins, salt and 1 per cent soyabean oil (Nir *et al.*, 1972), whereas feeding maize soyabean meal with 10 per cent fibre from various sources failed to reduce plasma phospholipid content

in growing White leghorn chicken (Siri *et al.*, 1992). Tanaka *et al.* (1989) observed that feeding pantethine with a basal diet in growing chicks significantly lowered plasma phospholipid concentration. Dietary palm oil (2%) in the biotin deficient chicks caused a significant increase in the concentration of blood phospholipid (Oloyo and Ogunmodede, 1993).

Clegg *et al.* (1976) observed a higher serum phospholipid content after diethyl stilbœstrol injection in laying hens. Yu *et al.* (1976) noticed a higher plasma phospholipid content during laying period in chicken. Neill *et al.* (1977) noticed a significant increase in the concentration of plasma phospholipid at the onset of sexual maturity, 50th and 100th egg in laying hen. Noble and Cocchi (1990) noted a higher plasma phospholipid content in laying chicken than the nonlaying chicken.

In the experimental study of Kim and Han (1985) male broiler chicks fed with soyabean protein and egg yolk recorded lower serum phospholipid content than those fed with casein and egg yolk. A positive correlation between phospholipids and triacylgycerol content in plasma of broilers fed on a diet supplemented by DL-α-tocopheryl acetate was noticed by Criseteg *et al.* (1993).

Supplementation of olive oil or maize oil (5%) in the diet of rats produced higher serum phospholipid concentration than with cotton seed oil, ground nut oil, soyabean oil or sunflower oil (El-Husseiny *et al.*, 1980). Kobatake *et al.* (1989) did not find any difference in concentration of serum phospholipid of rats fed on diets containing egg yolk phospholipid mixture from controls. However Liu-Liyun *et al.* (1995) registered a lower plasma phospholipid content in rats given diet containing eggs than those fed on basal diet without eggs. Low serum phospholipid content has been reported by Choi *et al.* (1990) in spontaneously hypertensive rats fed on diets containing maize oil and tallow 1:1 (control), beef tallow, grape seed oil or soyabean oil, whereas in the experiments of Kim and Chung (1992) butter (16%) in the diet produced higher plasma phospholipid concentration than with diets containing butter with olive oil, sardine and safflower oil. In rats with induced hypercholesterolaemia serum phospholipid concentration was reduced by feeding fish oil (Stangl *et al.*, 1993).

Raghuram and Rugmini (1995) reported that plasma phospholipid will stabilize the colloidal dispersion of cholesterol in human beings.

2.2 Lipid profile in liver

2.2.1 Total lipid

The lipid content in liver has significant correlation with dietary fat, body fat, liver weight and DNA concentration. Fat content in liver of birds increases significantly by the onset of sexual maturity.

A higher liver lipid content in oestrogenised quails was recorded by Nirmalan and George (1972). Experiments of Maurice and Jensen (1978) revealed that lipid content in liver was greater in Japanese quails fed on maize containing diets than with wheat containing diets. Fat content of liver of Japanese quail was reduced by starving (Shapira *et al.*, 1979) and by supplementing oat bran and oat hulls in the feed (Rogel and Vohra, 1983). Furuse *et al.* (1991) observed an increase in the liver lipid content upon sexual maturity in Japanese quails. Dietary γ-linolenic acid can replace the linoleic acid requirement in Japanese quails and can prevent liver lipid accumulation caused by linoleic acid deficiency (Murai *et al.*, 1996). Girishkumar (1997) recorded a higher value for total lipid content in liver of Japanese quails by feeding onion and garlic in the diet.

Chung *et al.* (1965) and Sim and Bragg (1978) observed a higher level of total lipid in liver of laying hen fed

hydrogenated coconut oil in the diet. Kruski and Narayan (1972) and Sim and Bragg (1978) got a higher value for total lipid in liver of laying hens by feeding a diet containing 1 per cent cholesterol. However, Kim and Han (1985) did not observe any elevation in liver lipid content of male broiler chick by feeding a diet with 0.2 per cent cholesterol either as egg yolk or crystalline cholesterol. Griminger and Fisher (1986) confirmed the influence of feeding egg yolk to increase the liver fat content of young male chickens.

Eventhough Vogtman and Clandinin (1974) did not find any change in the liver lipid content by feeding rapeseed oil (5 or 15%) or soyabean oil to broiler chicken, Scaife *et al.* (1994) found a reduction in liver lipid content with rapeseed oil than with soyabean oil or fish oil.

However, Phelteplace and Watkins (1990) were unable to confirm any influence of dietary oils on liver lipid content in chicken. March and Macmillan (1990) and Cherian *et al.* (1995) observed an inverse relationship between linoleic acid in the diet and total liver lipid content in laying hen.

A higher lipid content in the liver of laying chicken was reported by Pearce (1971 and 1974) and Theyer *et al.* (1973). Neill *et al.* (1977) and Leclercq (1984) also recorded a higher lipid content in liver of female chicken. Estrogenised chicks exhibited higher lipid content in liver (Bolden *et al.*, 1984).

Almann and Gibson (1965) and Muto and Gibson (1970) were able to notice that polyunsaturated fatty acids in the diet would suppress the lipid biosynthesis in the liver of laying hens. Kritchevsky and Tepper (1973) and Sreekumar and Kurup (1978) were of the opinion that triglyceride structure of fat was responsible for its influence in lipid metabolism in rats.

Pearce (1972) failed to notice any influence of dietary inositol on lipid content in liver of chicken. While, Lin *et al* (1993) found a lower lipid content in liver of biotin deficient ducks whereas Oloyo and Ogunmodede (1993) got a higher value for the total lipid content in liver of biotin deficient chicks. According to Oloyo and Ogunmodede (1993) supplementation of 2 per cent palm kernel oil in the diet reduced the concentration of liver lipid in chicks.

But Tanaka *et al.* (1983) reported a decrease in the hepatic lipogenesis of growing chicks by increasing the dietary metabolizable energy.

Akiba *et al.* (1994) observed feeding dietary fish meal in chicken caused a reduction in the lipid content in liver. Farnworth *et al.* (1983) conducted experiments on lipid metabolism of White Leghorn laying hens, after feeding them with different levels of dietary deoxyvalenol. Beyer and Jensen (1991) reported that dietary orotic acid reduced the lipid content in the liver of laying hen. Clark *et al.* (1990)

were of the opinion that feeding of unsaturated fatty acids will reduce lipid synthesis in tissues of laying hen.

Vijajammal (1982) observed a higher liver lipid content on feeding cholesterol in the diet of rats. Total lipid deposition in tissues of rats was reduced by dietary olive oil or maize oil (5%) than with cotton seed oil, groundnut oil, soyabean oil or sunflower oil (El-Husseiny *et al.*, 1980). Total lipid content of liver was significantly elevated in rats fed with cholesterol (Quazi *et al.*, 1983).

2.2.2 Triglyceride

The triglyceride content in liver is a balance between synthesis and secretion into blood. Triglyceride is stored in adipose tissue which can be mobilised on demand. The adipose tissue storage of fat is always under continuous turnover.

Reports about the influence of dietary oilson the liver triglyceride content of Japanese quail are scanty. Labate and Dam (1980) recorded a higher liver triglyceride content in Japanese quails fed diets supplemented with hydroxy methyl glytaryl coenzyme A (HMG-CoA). Furuse *et al.* (1991) reported that oestrogen could cause an increase in the liver triglyceride content in Japanese quails. Supplementation of γ-linolenic acid in the feed of Japanese quails from day old to four weeks of age completely prevented liver

triacylglycerol accumulation induced by the essential fatty acid free diet (Murai *et al.*, 1996). A higher liver triglyceride content in female Japanese quails by onion and garlic containing diet was observed by Girishkumar (1997).

Higher triglyceride content in liver was observed in pullets fed with beef tallow at 6.5 per cent level (Theyer *et al.*, 1973) and in chicks fed with the same at 10 per cent level (Ueda *et al.*, 1996).

According to Klopfenstein and Clegg (1980) liver triglyceride level was lower in cockerels fed with dietary oleic acid (5%) than with palmitic acid. Tanaka *et al.* (1981) got a higher liver triglyceride content in chicks fed on a fat free diet or tripalmitin diet than one with coconut oil and safflower oil. Naber and Biggert (1989) recorded a lower liver triglyceride content with safflower oil feeding in laying hens. An *et al.* (1995) got a lower value with linseed oil than safflower oil (3 or 4.5%) in growing chicks. Phelteplace and Watkins (1990) failed to observe any significant difference in liver triglyceride content by feeding different combinations of chicken fat and menhaden oil in broiler chicken. A higher value for liver triglyceride content was observed by a high fat diet in broiler chickens (Akiba *et al.*, 1994) and by cholesterol containing diet in chicks (Ueda *et al.*, 1995). According to Akiba *et al.* (1994)

feeding of fish oil resulted in lowering of liver triglyceride content of broiler chicken. Ueda *et al.* (1995) observed sodium cholate was effective in reducing the level of triglyceride in liver of chicks.

Leenstra (1986); Noble and Cocchi (1990) and Park and Cho (1990) observed a higher liver triglyceride content in laying chicken. Noble *et al.* (1988) studied the lipid metabolism in broiler birds during growth and egg laying.

Farnworth *et al.* (1983) recorded a higher liver triglyceride content in White Leghorn hens after feeding a diet contaminated with deoxyvalenol. Liver triglyceride content was increased by higher dietary metabolizable energy (Tanaka *et al.*, 1983) in growing chicks. Pikul *et al.* (1985) reported the liver triglyceride content during growth and egg laying in broiler birds.

Lower triglyceride deposition was noticed in tissues of male rats fed with olive oil or maize oil (5%) than with soyabean oil, ground nut oil and sunflower oil, while the cotton seed oil gave the greatest deposition of tissue triglyceride (El-Husseiny *et al.*, 1980). Chiang Mengtsan *et al.* (1995) did not find any effect on the liver triglyceride content of rats by feeding a diet containing fish oil (5% fish oil +5% lard) or lard alone. However, accumulation of liver triglyceride was observed (Nakasa *et al.*, 1995) in rats by

feeding per cent cholesterol and 12 per cent lard whereas a reduction of this elevated triglyceride content of liver occurred by feeding leaf extracts of *Eucommia ulmoides*.

2.2.3 Total cholesterol

Various experimental studies have demonstrated that cholesterol concentration of organs becomes elevated when cholesterol or cholesterol with fat are added in the diet. The liver and the ovary are the primary sites of cholesterol biosynthesis in the laying bird.

Studies related to the influence of dietary oils on the liver cholesterol content in Japanese quail are meagre. Morrissey and Donaldson (1977a) got a higher value for liver cholesterol content in Japanese quails by feeding a diet containing cholesterol. Labate and Dam (1980) did not find any change in the liver cholesterol content of Japanese quails by feeding hydroxy methyl glutaryl coenzyme A (HMG-CoA) in the diet. Liver cholesterol accumulation induced by feeding of essential fatty acid free diet was prevented by supplementation of γ-linolenic acid (0.4%) in the diet of Japanese quails (Murai *et al.*, 1996). Girishkumar (1997) could not observe any change in liver cholesterol content by feeding a diet containing onion or garlic (1%).

In chicken Treat *et al.* (1960) and Chung *et al.* (1965) noticed identical values for liver cholesterol concentration by the addition of different types of dietary fats. According to Chung *et al.* (1965) liver cholesterol in laying hens was significantly lower with the hydrogenated coconut oil diet than with the corn oil or lard diet when all were fed along with cholesterol. Coconut oil supplementation (10 or 20%) in the feed of neonatal chicks for seven days did not produce any change in liver cholesterol concentration as reported by Castilo *et al.* (1994).

Weiss *et al.* (1967) observed an elevation in hepatic synthesis of cholesterol on feeding of unsaturated fat in the diet of laying hens. An *et al.* (1995) obtained a lower liver cholesterol content in chicks fed on diets containing 3 per cent and 4.5 per cent linseed oil than those of chicks fed on diets containing safflower oil.

Addition of cholesterol to the high fat diet but not to the basal diet resulted in an elevated liver cholesterol level in laying hens (Chung *et al.*, 1965). A higher serum cholesterol level was recorded by the addition of cholesterol to the diet in roosters (Sutton *et al.*, 1984), in neonatal chicks (Castillo *et al.*, 1994) and in White Leghorn male chicken (Ueda *et al.*, 1995).

Theyer *et al.* (1973) did not notice any change in liver cholesterol concentration by the addition of 6.5 per cent tallow in the diet of hybrid pullets while, Ueda *et al.* (1996) got an elevated liver cholesterol content with beef tallow (10%) in the diet of chicks.

Farnworth *et al.* (1983) recorded the changes in liver cholesterol content in chicken after feeding a diet with deoxyvalenol.

Pikul *et al.* (1985) studied the lipid profile in various tissues of chicken while Noble *et al.* (1988) compared the lipid composition of liver and bile from broiler birds during growth and egg laying. Siri *et al.* (1992) failed to observe any change in liver cholesterol content by the addition of 10 per cent fibre to the diet of growing chicks. High protein barley flour elevated liver cholesterol level in laying hens when fed along with cholesterol as stated by Beyer and Jensen (1993). Oloyo and Ogunmodede (1993) recorded an elevated liver cholesterol level in biotin deficient chicks.

Sreekumar and Kurup (1978) observed a higher cholesterol content in liver of rats fed exogenous cholesterol. According to El-Husseiny *et al.* (1980) feeding of eight weeks old male rats with olive oil or maize oil (5%), resulted in less cholesterol deposition in tissues compared with groundnut oil, soyabean oil or sunflower seed oil. In this study cottonseed

oil gave the greatest deposition of tissue cholesterol. Chiang-Mengtsan (1995) recorded an elevated liver cholesterol content in rats fed a diet with fish oil than one containing lard. Kobatake *et al.* (1989) got a lower level of hepatic cholesterol in rats fed on diets containing egg yolk phospholipid mixture or hydrogenated egg yolk phospholipid mixture. Conversely, an elevated liver cholesterol content was also recorded in rats on a ration with cholesterol and egg (Liu-Liyun *et al.*, 1995) and with cholesterol and lard (Nakasa *et al.*, 1995).

2.2.4 Phospholipid

It is quite possible that increased phospholipids in tissues may reflect an attempt on the part of the body to effect the solubilization of hydrophobic cholesterol. Synthesis of phospholipids, essential components of lipoproteins is enhanced by unsaturated fats whereas dietary saturated fats are less readily utilized for the synthesis of phospholipids in the hen liver.

Very few studies are recorded about the liver phospholipid content of Japanese quails. Furuse *et al.* (1991) recorded an elevated liver phospholipid content in laying Japanese quails. Girishkumar (1997) could not observe any change in liver phospholipid content on feeding onion and garlic (1%) in the ration of male and female Japanese quails.

Ismail and Nair (1973) reported the liver phospholipid content in two months old Australorp and White Leghorn birds. Neill *et al.* (1977) observed an increase in the liver phospholipid content on the onset of sexual maturity in White Leghorn hens. Total phospholipid content in liver of Ross broiler breeder birds at 7, 20, 22 and 42 weeks of age was recorded by Noble *et al.* (1988). Oestrogen caused an elevation of liver phosholipid content in chicken (Noble and Cocchi, 1990).

According to Tanaka *et al.* (1981) chicks on a diet with coconut oil produced lower liver phospholipid content than those fed on a fat free diet or triplamitin diet. Reduction in the liver phospholipid content was produced by feeding safflower oil in the diet of laying hen (Naber and Biggert, 1989) and by biotin deficient diet in chicks (Oloyo and Ogunmodede, 1993).

Liver phospholipid concentration was not altered by the incorporation of deoxyvalenol in the diet of WLH laying hens eventhough that could increase total lipid and triglyceride content in liver (Farnworth *et al.*, 1983). Pikul *et al.* (1985) studied the lipid profile in various tissues of chicken. Dietary supplementation of garlic oil could not produce any effect on liver phospholipid content in chicken (Sklan *et al.*, 1992).

Sreekumar and Kurup (1978) got a lower liver phospholipid content in rats fed various vegetable oils in the diet than those fed cholesterol and dietary oil. Experiments of El-Husseiny *et al.* (1980) indicated that supplementation of olive oil or maize oil (5%) in the diet of male rats elevated the phospholipid concentration in tissues compared to supplementation with cotton seed oil, groundnut oil, soyabean oil or sufflower oil. Kobatake *et al.* (1989) failed to notice any significant difference in liver phospholipid content of rats fed on diet containing egg yolk phospholipid mixture, hydrogenated egg yolk phospholipid mixture or control diet. Chaing-Mengtsan *et al.* (1995) registered a lower liver phospholipid content in rats fed on a diet containing fish oil than with a diet containing lard.

2.3 Weight of the liver

There exists a specific relationship between the body weight and liver weight. As body weight increases during growth of the bird, there will be an increase in liver weight also. Diet has got a direct influence upon the liver weight. Reports state that there is a control factor that can regulate the growth of organs relative to the body size.

Morrissey and Donaldson (1977b) recorded a higher liver weight in Japanese quails fed a diet containing 10 per cent

fat and 1 per cent cholesterol. Starving for 48 hours considerably reduced liver weight in Japanese quails (Shapira *et al.*, 1979). The liver weight of Japanese quails by feeding palmitic, oleic or linoleic acid (3%) in the diet was reported by Vilchez *et al.* (1991). Oguz *et al.* (1996) could not observe any difference in liver weight in different strains of Japanese quails. Raji (1997) recorded the liver weight of Japanese quails at various ages and a reduction in the weight of the liver was observed by partial feed restriction.

According to Pearce and Johnson (1984) feed restriction reduced the liver weight of female chickens. Cheva Isarakul and Tangtaweewipat (1991) noted a higher liver weight in broilers fed sunflower seed in the diet than those fed with the control diet. Oruwari *et al.* (1993) could not observe any effect on the absolute liver weight of chicken fed a diet containing palm oil. Lard in the diet (3% and 7%) considerably reduced the liver weight of chicks as per the study of Latour *et al.* (1994). An *et al.* (1995) did not find any change in the liver weight of chicks fed with purified diets containing safflower oil, linseed oil (6%) or a combination of these at different levels.

2.4 Lipid profile in egg yolk

2.4.1 Total lipid

Reports indicate that the lipid content of the egg yolk is usually not significantly influenced by the dietary oil or sterol treatment. It is said that egg yolk is a major route of lipid elimination in the laying bird.

Lepore and Marks (1965) and Adachi *et al.* (1978) recorded the total lipid content of Japanese quail eggs. Bedulevich *et al.* (1970) and Miric *et al.* (1973) studied the composition of the Japanese quail eggs. Katsuya *et al.* (1973) had made a comparative study on the egg yolk lipid content of Japanese quail and hens. Yolk total lipid content of Japanese quails was unaltered by dietary supplementation of onion or garlic (Girishkumar, 1997). Studies on the influence of dietary oils on quail egg yolk lipids are meagre.

According to Treat *et al.* (1960), Marion and Edwards (1962) and Sim and Bragg (1978), the type and amount of dietary fat had no influence on the total lipid content of egg yolk in White Leghorn layers. Lipid content of chicken eggs was not influenced by the dietary oils upto 30 per cent (Reiser *et al.*, 1951) and upto 10 per cent level or with even 1 per cent cholesterol in diet (Chung *et al.*, 1965).

No difference in yolk total lipid content in chicken was observed by supplementing safflower oil or tallow at 5 per cent level (March and Macmillan, 1990), by fish oil (Hargis *et al.*, 1991) by high oleic, linoleic or linolenic acid (Jiang *et al.*, 1991) by linseed oil (Suzuki *et al.*, 1994), by herring meal (Nash *et al.*, 1995), by maize oil or corn oil (Takita *et al.*, 1995) in the diet.

Sodium metasilicate 1 per cent in the diet of laying hens was effective in elevating concentration of total lipids in egg yolk (Kiriliv *et al.*, 1992). Shafey (1996) observed that as age advances total lipid content in yolk increases.

2.4.2 Total cholesterol

A major route of cholesterol elimination in the hen is through the egg. Egg cholesterol level has been shown to vary with species of bird, breed or strain as well as age of the bird. The requirements of the embryo for cholesterol indicated that natural selection would oppose artificial selection to lower egg yolk cholesterol content.

Chand (1980) compared the yolk cholesterol content in various avian species. Baumgartner and Simeonova (1992) established the yolk cholesterol concentration in different lines of Japanese quails. Sun and Shim (1994) observed that

yolk cholesterol concentration in quail eggs was significantly higher with feeding lard or sunflower oil in the ration for four weeks unlike with fish oil. However, after seven weeks of feeding they could not notice any change in the concentration of yolk cholesterol. Verma *et al.* (1995) got a higher value for total cholesterol content in eggs of older quails than younger, irrespective of the dietary treatments (fish meal and cholesterol 1% or lard 10%). Hammad *et al.* (1996) failed to notice any consistent correlation between yolk and plasma total cholesterol and its fractions in Japanese quails at different ages. According to them dietary cholesterol failed to elevate yolk cholesterol concentration. Girishkumar (1997) could not observe any change in the yolk cholesterol concentration in Japanese quails by feeding a diet containing onion or garlic (1%).

Reiser *et al.* (1951), Edwrds *et al.* (1962), Chung *et al.* (1965), Hirata *et al.* (1986) and Meluzzi *et al.* (1996) reported that dietary fat had negligible influence on the total cholesterol content of egg yolk in chicken.

An elevation in yolk cholesterol deposition in White Leghorn birds was recorded by cholesterol feeding along with a high fat diet (corn oil, lard or hydrogenated coconut oil) by Chung *et al.* (1965) whereas high protein barley flour alongwith 1 per cent cholesterol in the diet of White Leghorn

birds increased yolk cholesterol deposition was observed by Beyer and Jensen (1993).

While Weiss *et al.* (1967) and Naber (1983) noted a higher cholesterol content in laying hens on unsaturated fat, Sim and Bragg (1978) and Grashorn (1994) got a lower egg cholesterol content with unsaturated fat (Safflower oil and Soyabean oil) in the diet, than with saturated fat (coconut oil). According to Piliang (1994) lower level of yolk cholesterol deposition was noticed in laying hen fed with unsaturated fat (palm oil) in the diet than with saturated fat (coconut oil).

Meluzzi *et al.* (1994) compared yolk cholesterol concentration of laying hens with feeding of commercial feed containing animal proteins or fats or diets with vegetable ingredients only and observed a higher yolk cholesterol concentration in the group on vegetable ingredients diet.

Non significant variation in yolk cholesterol deposition of laying hen was recorded by the dietary supplementation of vitamin A (Dua *et al.*, 1967 and Weiss *et al.*, 1967), niacin (Sing, 1972) and ascorbic acid (Nockels, 1973). Yolk cholesterol deposition was not altered by feeding of 10 per cent alfalfa meal containing varying levels of saponin to White Leghorn layers (Nakaue *et al.*, 1980).

Feeding of white Leghorn pullets with diet containing oat bran (30%) or cotton seed hull (3%) was effective in reducing yolk cholesterol concentration as stated by Lirette *et al.* (1993). Majumdas and Panda (1994) did not find any change in yolk cholesterol deposition in medium and high laying birds. According to Compo (1995) variation in the proportion of yolk had little influence on the cholesterol content of eggs in different breeds of hen.

Marks and Wasburn (1977) registered the inability to reduce egg yolk cholesterol levels markedly due to a physiological control mechanism which ultimately caused cessation of egg production when yolk cholesterol deposition was inadequate for embryo survival. Hargis (1988) reported attempts to improve egg yolk cholesterol which had met only marginal success.

2.5 Egg production

Egg production per unit body weight is high in quails compared to chicken and turkey. Quail eggs are considered to be highly nutritious and compare well with the eggs of chicken.

Egg weight in Japanese quails was found to be higher in groups fed on a diet containing corn oil (3%) while a lower egg weight was noticed by replacing the corn oil with

linolenic acid (Vilchez *et al.*, 1990). Vilchez *et al.* (1991) noticed a higher egg production and egg weight in Japanese quails fed on a diet containing palmitic acid (3%) than the one containing oleic or linoleic acid. According to Murai (1994) linoleic acid requirement for egg production in Japanese quail was about 0.7 per cent in the diet. Girishkumar (1997) could not observe any change in egg production on feeding a diet containing onion or garlic (1%) to Japanese quails.

According to Wilson *et al.* (1961) the age at first egg of Japanese quail was 35-42 days, whereas in the trial by Garret *et al.* (1972) first egg was laid on 35th day. Tiwari (1976) and Sreenivasaiah and Joshi (1988) recorded the age at first egg, 50 per cent production and peak production in Japanese quails. Narahari *et al.* (1986) got the first egg on 41st day of age while Philomina (1994) recorded it as 39-42 days of age.

Okamoto *et al.* (1989) registered the egg mass values of three lines of Japanese quail. Sreenivasaiah and Joshi (1988) recorded the egg production and egg weight of Japanese quails hatched during monsoon and winter season. Thomas *et al.* (1994) reported the monthly egg production, while Shrivastava *et al.* (1994) observed the weekly egg production in Japanese

quails. The weight of egg at 11 and 18 weeks old Japanese quail was noticed by Shrivastava *et al.* (1994).

Egg production and egg weight in chicken layers was not influenced by different levels of dietary fat (Atteh and Leeson, 1985) and different types of dietary fat (Grashorn, 1994, Prakash *et al.*, 1996). Grashorn (1994) used beef tallow, soyabean oil, coconut oil or fish oil in their study whereas Prakash *et al.* (1996) compared fish oil and sunflower oil. According to Karunajeewa *et al.* (1989) egg production, egg weight or egg mass in White Leghorn x Aushalorps hens were not affected by dietary oil extracted sunflower seed meal with or without sunflower oil.

Furuse *et al.* (1990) did not notice any difference in hen day egg production with different levels of dietary sorbose. Hen day egg production in laying hens was not influenced by different levels of dietary fibre and calcium (Piliang, 1990).

Egg weight was found to be increased, with safflower oil than with tallow (March and Macmillan, 1990), with soyabean oil than with tallow (Scholfyssek, 1991) and with soyabean oil than with coconut, linseed or maize oil (Halle, 1996). Piliang (1994) recorded a higher egg production and egg weight with unsaturated fat (palm oil 10%) in the diet than saturated fat (coconut oil). But Grimes *et al.* (1996) found that saturated fat (prilled fat) increased egg production and

decreased egg weight compared to unsaturated fat (poultry fat). Coconut oil (3%) in the diet produced lowest egg weight than with poultry fat, fish oil, tallow, maize oil or soyabean oil (Meluzzi *et al.*, 1996).

2.6 Feed consumption

Feeding commences at the moment quail chicks hatch out. Coturnix females appear to be very sensitive to the disturbances in management, even in the change in composition of the ration.

Wilson *et al.* (1961) reported the total feed consumed by a quail to put on the adult body size as 496 g. Christaki *et al.* (1994) recorded the feed consumption of Japanese quails at various ages. The average feed consumption of Japanese quails at one, two, three, four, five, six weeks of age and in adults (10-12 weeks) was recorded by Panda *et al.* (1990). According to Vilchez *et al.* (1990) substitution of linolenic acid (3%) for corn starch in a semipurified low fat basal mix depressed feed consumption in Japanese quails. Feed intake of Japanese quail hens were higher when they were fed on a diet with palmitic acid (3%) than on diets with oleic or linoleic acid at the same level (Vilchez *et al.*, 1991). The sex difference in feed consumption of Japanese quails was observed by Panda (1990) and Raji (1997).

Feed consumption was greater in broilers fed a diet, with maize oil than with soyabean oil (Zollitsch *et al.*, 1992) with animal fat than with rape seed oil (Atteh *et al.*, 1989 and Scaife *et al.*, 1994) with palm oil than with a control diet (Panja *et al.*,1995). Kumar and Panchauri (1989) noticed that feed consumption was significantly greater with a diet containing olive oil (2%) in pullets than the control diet containing normal saline.

Feed intake was not different between groups fed with animal fat or coconut oil in laying hens (Grashorn, 1994), safflower oil or linseed oil in chicks (An *et al.*, 1995), sunflower oil or fish oil in layers (Prakash *et al.*, 1996).

2.7 Body weight

There are several reports about the body weight in quails stating that female quails attain sexual maturity at an early date i.e. at an age of six weeks, whereas males attain adult size by a later date.

Japanese quails fed groundnut oil in the finisher diet exhibited higher body weight than those fed with beef tallow (Shrivastav and panda, 1993). Sun and Shim (1994) did not find any significant difference in growth rate of Japanese quails fed basal diets containing fish oil, lard or safflower oil (4%) for four to seven weeks of age. Girishkumar (1997)

failed to observe any change in body weight gain in Japanese quails due to dietary supplementation of onion and garlic.

Wilson *et al.* (1961), Tiwari and Panda (1978) and Brah *et al.* (1992) recorded the body weight of Japanese quails at various ages. Panda (1990) observed the body weight of Japanese quails at zero, one, two, three, four, five and six weeks old and adult (10-12 weeks) Japanese quails. Brah *et al.* (1992) noted the body weight of Japanese quails upto six weeks of age. Christaki *et al.* (1994) studied the effect of sunflower seed meal on the body weight gain of Japanese quails. Body weight of Japanese quails under partial feed restriction was reported by Raji (1997).

The body weight of Japanese quails at sexual maturity was reported by Jues and Houghes (1978), Ahuja *et al.* (1978), Sato *et al.* (1981) and Sachedev and Ahuja (1986). Influence of hatching season on body weight was studied by Sreenivasaiah and Joshi (1988). The body weight of Japanese quails at first egg was reported by Philomina (1994).

Olomu and Baracos (1991) could not observe any difference in the growth rate of White Leghorn chicks on feeding a diet containing 6 per cent (w/w) added fat consisting of various proportions of animal tallow and flax seed oil. Menkin *et al.* (1992) and Scaife *et al.* (1994) recorded a higher body weight in broilers fed animal fat than vegetable oils.

No difference in body weight of chicks was observed in groups fed on safflower oil or linseed oil or a combination of these at different levels by An *et al.* (1995) and in groups fed on diets containing 5% tallow, maize oil, soyabean oil, animal and vegetable fat blend, rape seed oil or a diet without supplemental fat by Leeson and Atteh (1995). According to Rupic *et al.* (1995) chickens fed on diets supplemented with fat at 10.5% levels from different sources (free long chain fatty acids, animal fat, sunflower oil and soyabean oil) exhibited higher body weight than those fed fat at 4.5% level in the diet.

2.8 Feed efficiency

Feed efficiency is an important production parameter which determines the profitability of poultry farming. Feed efficiency for broilers is calculated on body weight gain basis whereas in layers it is calculated on the basis of egg production.

Jues and Houghes (1978) and Christaki *et al.* (1994) recorded the feed efficiency of six-week old coturnix quail. While Torges and Wegner (1984) reported the feed efficiency value of five-week old male and six-week old female Japanese quail. Narahari *et al.* (1986) noted the feed efficiency of female Japanese quails between five and eight weeks of age.

Feed conversion efficiency of three lines of male and female Japanese quails upto 10 weeks of age was recorded by Okamoto *et al.* (1989). Feed conversion efficiency varies with different levels of dietary manganese in Japanese quails (Shukla *et al.*, 1993).

Feed conversion efficiency during the first three weeks of age in quails hatched during winter was significantly higher than those hatched during summer (Chopra and Singh, 1992). Shrivastav and Panda (1993) observed better feed conversion efficiency in Japanese quails fed groundnut oil in the diet (2.5 and 5%) than with beef tallow. Girishkumar (1997) could not observe any change in feed conversion efficiency in Japanese quails fed diet containing onion and garlic.

Reddy *et al.* (1991) failed to observe any significant effect of dietary garlic oil (0.02%) on feed efficiency in single comb White Leghorns pullets. For optimum feed conversion efficiency and egg production half of the sesame oil meal in the diet of laying hens could be replaced by untreated mustard oil meal (Das and Ali, 1993) and soyabean oil meal and groundnut oil meal can be supplemented with fish meal (Mandlekkar and Thatte, 1993) in laying hens.

Materials and Methods

3. MATERIALS AND METHODS

3.1 Experimental design

Seventy two (thirty six males and thirty six females) four week old, clinically healthy, Japanese quail chicks (*Coturnix coturnix japonica*) of the same strain (egg type) and hatch were selected, at random, from the Kerala Agricultural University Poultry Farm, Mannuthy and reared under standard farm conditions.

After recording the initial body weight (fourth week of age) of the individual birds, they were divided into three main groups (24 birds in each group; G-I, G-II and G-III) and each main group was again divided into two subgroups comprising of 12 males (subgroup M) and 12 females (subgroup F) viz., M-I, F-I, M-II, F-II, M-III, F-III (Table 1).

Birds in each subgroup were wing banded and housed in six separate compartments (90x45x30 cm in size) of the battery brooder. Feed and fresh clean water were provided *adlibitum*. The birds were reared on standard quail grower ration (vide table 2 and 3) upto sixth week of age. Gingelly oil, coconut oil and sunflower oil were incorporated at 2 per cent level in the ration of groups GI, GII and GIII respectively.

After sixth week of age the birds were provided with standard adult quail ration (Panda, 1990) vide Table 2.1 and 3.1. Gingelly oil, coconut oil and sunflower oil were incorporated at 2 per cent level in the ration of groups G-I, G-II and G-III respectively. The birds were maintained at a photoperiod of 16 hours.

3.1.1 Body weight

Individual body weight of birds was recorded at the initial stage of the experiment, at weekly intervals and at the time of sacrifice.

3.1.2 Feed consumption and egg production

Daily feed consumption of each subgroup of birds were recorded. The birds were observed for the onset of egg laying. Rate of egg production of the birds in each subgroup and the weight of egg were daily recorded. The eggs collected from the three groups on the last day of 14th, 15th and 16th week were stored in separate labelled bottles at -20°C for the assay of lipid parameters.

3.2 Biochemical studies

3.2.1 Collection of samples

At the 10th week of age after fasting for 14 hours the male birds in each subgroup (M-I, M-II and M-III) were sacrificed by decapitation. Blood was collected into labelled clean, dry centrifuge tubes using heparin as anticoagulant (0.2 mg/ml of blood). The liver collected quickly from the individual birds were weighed and stored in separate labelled, dry vials at -20°C for the biochemical analyses. Plasma was separated from the blood by centrifugation at 500 g for 10 minutes and stored in clean, dry, labelled vials at -20°C. At the end of 16th week of age, after recording the body weight and 14 hours of fasting, the female birds in subgroups (F-I, F-II and F-III) were sacrificed for collection of blood and liver and samples were stored as in the case of males for the different biochemical analyses.

3.2.2 Biochemical assay on plasma

3.2.2.1 Total lipid

Total lipids in plasma was estimated by the method of Folch *et al.* (1956).

Principle

Plasma lipids are soluble in organic solvent systems like chloroform - methanol. Methanol can precipitate off the protein from the plasma and lipids alone are extracted. The dissolved lipid is quantified after evaporation of the solvent.

Procedure

One ml of plasma was added dropwise to 5 ml of methanol in a glass stoppered test tube. Then 2.5 ml of chloroform was added and mixed. This mixture was incubated at 55°C for 15 minutes. At the end, another 5 ml chloroform was added, so that the proportion of chloroform to methanol was 2:1. It was filtered using a fat free filter paper. After filtration and washing the residue three times with chloroform: methanol in the ratio of 2:1, combined filtrate was washed with 0.7 per cent potassium chloride solution (20% of total volume of extract). The aqueous upper phase was removed, and the lower layer was washed each time with 5 ml of chloroform:methanol: 0.7 per cent potassium chloride solution (3:48:47). The washed lower layer of chloroform was evaporated at vacuum, at 45°C. The residue was dried by keeping it in an incubator (at 55°C) for half an hour. It was then placed in a desiccator for four hours and weighed to a constant weight.

Calculation

$$\text{Total lipid (mg/dl)} = \frac{A-B}{V} \times 100$$

where

A = Weight of test tube + lipid residue

B = Weight of the test tube

V = Volume of plasma taken

3.2.2.2 Triglyceride

Plasma triglyceride was estimated by GPO-PAP method

The estimation was done by employing the kit supplied by Ranbaxy laboratories, Nehru place, New Delhi 110019.

Principle

Serum triglycerides are hydrolysed to glycerol and free fatty acids by lipase. In the presence of ATP and glycerokinase, the glycerol is converted to glycerol phosphate. The glycerol-3-phosphate is then oxidised by glycerol-3-phosphate oxidase to yield hydrogen peroxide. The hydrogen peroxide reacts in the presence of peroxidase with ESPAS (N-ethyl N-sulfo propyl-m-anisidine) and 4-amino antipyrine to form a coloured complex. The intensity of the

colour developed is proportional to triglycerides concentration and is measured photometrically at 546 nm.

Procedure

The buffer solution was mixed with the enzymatic solution and stored at 4°C. This was the chromogen reagent. One ml of this chromogen reagent was pipetted out into three test tubes labelled 'test', 'standard' and 'blank'. Plasma (0.25 ml) was diluted to 2 ml with normal saline. From this, 0.02 ml was added to the test and 0.02 ml of the standard triglyceride solution (containing triglyceride 200 mg/dl) was added to the 'standard'. All the tubes were mixed well and were incubated in a waterbath at 37°C for 10 minutes. Two ml of distilled water was added to all the test tubes and mixed well. The absorbance of the 'test' and 'standard' was read against the reagent blank in a spectrophotometer at a wavelength of 546 nm.

Calculations

$$\text{Triglyceride concentration (mg/dl)} = \frac{U}{S} \times \frac{C}{V} \times 8 \times 100$$

where

U = reading of test

S = reading of standard

C = concentration of standard (200 mg/dl) i.e. 0.04 mg/0.02 ml

V = volume of plasma (0.02 ml)

8 = dilution factor

100 = Conversion factor to express the concentration in decilitre

3.2.2.3 Total cholesterol

Total plasma cholesterol was estimated by employing cholesterol kit supplied by Ranbaxy laboratories Ltd., Nehru place, New Delhi - 110 019.

Principle

Cholesterol esters are hydrolysed by cholesterol esterase to cholesterol and fatty acids. Free and liberated cholesterol are oxidised by cholesterol oxidase to cholest-4-en-3-one and hydrogen peroxide is liberated. The hydrogen peroxide produced couples with 4-amino antipyrine and phenol in the presence of peroxidase to form a coloured compound. The intensity of the colour developed is proportional to cholesterol concentration and is measured photometrically at a wavelength of 500 nm.

Procedure

Buffer solution was mixed with the enzyme solution and stored at 4°C. This formed the chromogen reagent. One ml of

this chromogen reagent was pipetted out into the three test tubes labelled 'test', 'standard' and 'blank'. Plasma (0.02 ml) was added to the 'test' using a micropipette and 0.02 ml of the 'standard' solution of cholesterol (200 mg/dl) was added to standard. The tubes were mixed well and incubated at 37°C for 10 minutes. Two ml of distilled water was added to all the three tubes and mixed well. Absorbance of the 'test' and 'standard' was read against the reagent blank in a spectrophotometer at the wavelength of 500 nm.

Calculation

$$\text{Cholesterol (mg/dl)} = \frac{U}{S} \times \frac{C}{V} \times 100$$

where

U = reading of unknown

S = reading of standard

C = concentration of standard (200 mg/dl) i.e., 0.04 mg/0.02 ml

V = volume of plasma taken (0.02 ml)

100 = Conversion factor to express it in decilitre

3.2.2.4 Lipoprotein cholesterol

3.2.2.4.1 High density lipoprotein cholesterol (HDL-C)

High density lipoprotein cholesterol (HDL-C) in plasma was estimated by employing HDL-C kit supplied by Ranbaxy laboratories.

Principle

Chylomicrons, very low density lipoproteins (VLDL) and low density lipoproteins (LDL) of plasma are precipitated using buffered polyethylene glycol (PEG-6000). After centrifugation, high density lipoproteins (HDL) are in the supernatent. The cholesterol in the HDL fraction is estimated by an enzymatic method using cholesterol esterase, cholesterol oxidase, peroxidase, 4 amino antipyrine and phenol.

Procedure

Chromogen reagent was prepared by mixing buffer solution supplied in the kit with enzyme solution and stored at 4°C. Precipitating reagent (0.3 ml) was pipetted out into a test tube and 0.3 ml of plasma was added and centrifuged for 20 minutes at 200 g to obtain a clear supernatent. One ml of chromogen reagent was added into three test tubes marked them as 'test', 'standard' and 'blank'. The supernatent from the centrifuged tube (0.2 ml) was added to the 'test'. 'Standard'

solution (0.2 ml) with a concentration of 50 mg/dl was added to the test tube marked 'standard'. All the tubes were mixed well and incubated in a waterbath at 37°C for 10 minutes. Two ml of distilled water was added to all the test tubes and mixed well. The absorbance of the 'test' and 'standard' was read against the reagent blank in a spectrophotometer at the wavelength of 500 nm.

Calculation

$$\text{HDL-C concentration (mg/dl)} = \frac{U}{S} \times \frac{C}{V} \times 100$$

where

U = reading of test

S = reading of standard

C = concentration of standard (0.1 mg/0.2 ml)

V = volume of plasma in the sample (0.01 ml)

100 = Conversion factor to express it in decilitre

3.2.2.4.2 Very low density lipoprotein cholesterol (VLDL-C) and low density lipoprotein cholesterol (LDL-C)

(VLDL-C + LDL-C) was calculated using the formula given below.

(VLDL-C + LDL)-C in mg/dl = (Total plasma cholesterol)-(HDL-C)

3.2.2.5 Phospholipid

Plasma phospholipid was estimated as explained by Varley (1975).

Principle

The lipid extract was digested with sulphuric acid and hydrogen peroxide to oxidise the phosphorus to inorganic phosphate which gives a blue colour on reaction with ammonium molybdate, sodium bisulphite and metol. This is measured photometrically. The phospholipid content is expressed in terms of lecithin (mg/dl) by multiplying the inorganic phosphorus concentration with 25 (conversion factor to convert phosphorus into lecithin).

Procedure

Reagents

1. Ammonium molybdate solution. Ammonium molybdate (7.5 g) dissolved in 200 ml of distilled water, 100 ml of 10 N sulphuric acid was added and made up the volume to 400 ml with distilled water.

2. Metol (D-dimethyl amino phenol sulphate) one gram in 100 ml of 3 per cent solution of sodium bisulphate.

3. Standard phosphate solution. Potassium dihydrogen phosphate (0.2197 g) was dissolved in distilled water, made up the volume to a litre with distilled water and two drops of chloroform was added.

Lipid extract of plasma was made as described in the estimation of total lipid in plasma. One ml of the lipid extract of the plasma was taken in a graduated test tube and evaporated to dryness. It was digested with sulphuric acid: phosphoric acid mixture (in the ratio of 2:1 with the addition of two drops of nitric acid and 1 drop of hydrogen peroxide). It was cooled and one ml of ammonium molybdate solution was added followed by the addition of 1 ml of metol solution.Allowed to stand for 30 minutes. One ml of the standard phosphate solution was evaporated to dryness. It was digested with per chloric acid: sulphuric acid digestion mixture. Ammonium molybdate solution and metol solution were added as in the case of the test. Blank was prepared in the same way by taking 1 ml of distilled water instead of the unknown/standard solutions.. After 30 minutes, the readings were taken in a spectrophotometer at a wavelength of 680 nm, adjusting the instrument to zero with the blank.

Calculation

$$\text{Phospholipid in plasma, expressed as mg\% of lecithin} = \frac{U}{S} \times \frac{0.025 \times 8 \times 100 \times 25}{V}$$

where

U = reading of test

S = reading of standard

0.025 = concentration of standard

V = volume of plasma in the extract

8 = Total volume of chloroform extract made

25 = Conversion factor to convert phosphorus into lecithin

3.2.3 Biochemical assay on liver

3.2.3.1 Total lipid

Total lipid in liver was estimated as per Folch method (1956).

Liver tissue (500 mg) was taken and the homogenate was prepared in a Potter Elvehjem type homogenizer, using chloroform: methanol mixture in the ratio of 2:1. The volume of the homogenate was made upto 10 ml. This was kept in a waterbath at 55°C for 15 minutes. It was then filtered using a fat free filter paper into a weighed test tube. Chloroform: methanol (2:1) mixture was added to the residue and again

incubated and filtered. This was repeated three times in order to completely dissolve the lipid in the solvent. Total lipid was estimated from the extract as in the case of plasma.

Calculation

$$\text{Total lipid (g\%)} = \frac{A-B}{W} \times 100$$

where

A = Weight of test tube + lipid residue

B = Weight of the empty test tube

W = Weight of liver taken

The residue was dissolved and made upto 8 ml with chloroform and kept in a deep freezer at -20°C for further estimations.

3.2.3.2 Triglyceride

Liver triglyceride was estimated by the method of Van Handel and Zilversmith (1957).

Principle

Triglyceride is measured after hydrolysis by estimating its glycerol content. The glycerol is oxidised to formaldehyde which is measured photometrically with

chromotropic acid. Zeolite is used to adsorb the interfering substances.

Procedure

Reagents

1. Fat solvents: Redistilled technical grade chloroform kept in dark bottle was used.

2. Doucil: Doucil was activated by heating for four hours at 125°C and kept in a closed bottle for upto 2 weeks.

3. Alcoholic potassium hydroxide (0.4 per cent): Reagent grade potassium hydroxide (2 g) was dissolved in 100 ml 95 per cent redistilled ethyl alcohol. This stock solution (10 ml) was diluted to 50 ml with 95 per cent alcohol on the day of use.

4. Sulphuric acid (0.2 N): Three ml of concentrated sulphuric acid was diluted to 500 ml with distilled water.

5. Sodium metaperiodate (0.05 M): Sodium metaperiodate (1.07 g) was dissolved in 100 ml of distilled water. This was prepared fresh.

6. Sodium arsenate (0.5 M): Sodium arsenate (6.45 g) was dissolved in a few ml of distilled water and was made upto 100 ml. The solution was prepared fresh.

7. Chromotropic acid: Two grams of chromotropic acid (or 2.24 g of the sodium salt) was dissolved in 200 ml of distilled water, 600 ml of concentrated sulphuric acid was added separately to 300 ml of distilled water and was cooled in ice. The diluted sulphuric acid was added to the chromotropic acid solution. This was stored in a dark bottle in a refrigerator and was prepared fresh every two weeks. (The solution is discarded when the colour deepens or the absorbance value of the blank increases).

8. Triglyceride standard solution: Triolein (0.58) was dissolved in chloroform and made upto 100 ml in a glass stoppered volumetric flask. The stock standard was diluted 1 to 100 ml with chloroform on the day of use. The stock standard was kept in a deep freezer in order to prevent the evaporation of chloroform. Evaporation of chloroform was checked periodically.

Lipid extract of the liver was prepared as described under the estimation of total lipid.

Zeolite (1.2 g) was placed in a glass stoppered test tube, 1 ml of chloroform was added and shaken well. One ml of the lipid extract of the liver was placed on the top of zeolite and mixed thoroughly. Four ml of chloroform was added. The tube was shaken vigorously for 30 seconds and then intermitently for 30 minutes. It was then filtered through a fat free filter paper and 0.5 ml of the filtrate was taken in two test tubes. One ml of the working standard solution was taken into two labelled test tubes. One ml of chloroform was taken as the blank and labelled. All the tubes were evaporated to dryness. Alcoholic potassium hydroxide (0.5 ml) solution was added to one of the unknown tubes and one of the standards (labelled as saponified sample and saponified standard). Ethanol (0.5 ml) was added to all the other three tubes (one of the unknown tubes and standards and blank which form the unsaponified sample, unsaponified standard and blank) the tubes were kept in a waterbath at 65°C for 15 minutes. Sulphuric acid (0.2 N, 0.5 ml) was added to all the tubes and mixed. The tubes were placed in a gently boiling waterbath for about 15 minutes to remove the alcohol. The tubes were cooled and the glycerol content was estimated using the procedure of Lambert and Neish (1950). Periodate solution (0.1 ml) was added from a graduated pipette. After 10 minutes the oxidation was stopped by the addition of 0.1 ml of sodium arsenate. A yellow colour of iodine appeared and vanished in a few minutes. After three minutes, 5 ml of chromotropic acid

reagent was added and mixed. The tubes were heated for half an hour at 100°C in a thermostatically controlled water bath in the absence of excessive light. After cooling the optical density was determined at a wavelength of 570 nm adjusting the instrument to zero with the reagent blank.

Calculation

$$\text{Triglyceride (g\%)} = \frac{\text{ST-UT}}{\text{SS-US}} \times \frac{0.045 \times 4 \times 100}{w \times 0.05}$$

where

ST = reading of saponified unknown

UT = reading of unsaponified unknown

SS = reading of saponified standard

US = reading of unsaponified standard

0.045 = concentration of standard (mg)

W = weight of liver tissue taken (g)

4 = volume of chloroform extract prepared (ml)

0.05 = volume of chloroform extract taken (ml)

3.2.3.3 Total cholesterol

Liver cholesterol was estimated by the method of Zak (1957).

Principle

A solution of cholesterol in acetic acid produces a red colour when treated with ferric chloride and sulphuric acid. The colour produced is estimated photometrically.

Procedure

Reagents

1. Stock ferric chloride solution. Ferric chloride (840 mg) was dissolved in a few ml of glacial acetic acid and was diluted to 100 ml with acetic acid.

2. Ferric chloride precipitating reagent: Stock ferric chloride solution was diluted 1 in 10 ml with glacial acetic acid.

3. Ferric chloride blank: Stock ferric chloride solution (1.7 ml) was diluted to 20 ml with glacial acetic acid.

4. Cholesterol stock standard: Pure dry cholesterol (100 g) was dissolved in 100 ml of glacial acetic acid.

5. Working standard: Cholesterol stock standard (2 ml) was mixed with 1.7 ml of stock ferric chloride solution and diluted to 20 ml with glacial acetic acid.

6. Final standard: Prepared by mixing 2 ml of the working standard with 4 ml of the ferric chloride blank solution just before use.

Liver tissue (0.5 g) was homogenised in Potter Elvejhem type of homogeniser, in normal saline and final volume is made upto 20 ml. This homogenate (0.1 ml) was added to 6 ml of ferric chloride precipitating reagent, mixed and filtered through a dry Whatman No.42 filter paper and the filtrate was collected in a test tube. Three ml each of the filtrate, final standard (0.1 mg/3 ml) and ferric chloride blank were taken in separate labelled test tubes, 2 ml of concentrated sulphuric acid was added slowly to each tube and was mixed by gentle shaking. The solutions were cooled, and readings were taken in a spectrophotometer at a wavelength of 500 nm, setting the instrument to zero with the blank solution.

Calculation

$$\text{Total cholesterol (g\%)} = \frac{U}{S} \times \frac{0.1 \times 20 \times 100}{w \times 0.05}$$

where

U = reading of test

S = reading of standard

0.1 = concentration of standard (0.1 mg/3 ml)

w = weight of liver taken in g

0.05 = volume of tissue homogenate taken

20 = volume of homogenate prepared

3.2.3.4 Phospholipid

Liver phospholipid was estimated as explained by Varley (1975).

Lipid extract of the liver was prepared as described in the estimation of total lipid. One ml of the lipid extract of the liver was taken in a graduated test tube. The liver phospholipid was estimated as in the case of estimation of plasma phospholipids.

$$\text{Phospholipid expressed as lecithin (g\%)} = \frac{U}{S} \times \frac{0.025 \times 8 \times 100 \times 25}{W \times V}$$

where

U = reading of unknown

S = reading of standard

0.025 = concentration of standard (mg)

W = weight of liver taken in g for extraction of lipids

V = volume of chloroform extract taken (ml)

8 = volume of chloroform extract made (ml)

25 = conversion factor to convert the lipid phosphorus into lecithin

3.2.4 Biochemical assay on egg yolk

3.2.4.1 Total lipid

Total lipid in egg yolk was estimated as per Folch method (1956).

The homogenate was prepared as explained in the estimation of total lipid (Folch *et al.*, 1956). One ml of the yolk homogenate was added to 5 ml of methanol in a glass stoppered test tube. Five ml of chloroform was added to the test tube. The test tube was incubated at 55°C for 15 minutes in a waterbath. Again 5 ml of chloroform was added to the test tube so that the ratio of chloroform to methanol became 2:1 the solution was mixed well and filtered through a fat free filter paper. The total lipid was estimated from the extract as in the case of plasma.

$$\text{Total lipid (g\%)} = \frac{A-B}{W} \times 20 \times 100$$

where

A = weight of test tube + lipid residue

B = weight of test tube

20 = Total volume of homogenate made

W = Weight of yolk in g

3.2.4.2 Total cholesterol

Yolk cholesterol was estimated by the method of Zak (1957).

The egg yolk was completely separated from the albumen, with the yolk membrane intact, using a filter paper, weight of the yolk was recorded and the homogenate was prepared in normal saline using the Potter Elvehjem type homogenzer. The final volume of the homogenate was made up to 20 ml.

This homogenate (0.05 ml) was added to 6 ml of ferric chloride precipitating reagent. The estimation of yolk total cholesterol was done as per the estimation of liver cholesterol.

Calculations

$$\text{Cholesterol (g\%)} = \frac{U}{S} \times \frac{0.1 \times 20 \times 100}{0.025 \times W}$$

where

U = reading of unknown

S = reading of standard

0.1 = concentration of standard

0.025 = volume of homogenate present in the test solution (0.025 ml/3 ml percipitating reagent)

W = weight of yolk in g

20 = volume of homogenate prepared

3.3 Statistical analysis

The results recorded from the study were analysed statistically (Snedecor and Cochran, 1973). Comparison was made among the values in the three groups in adult male and female birds separately and also between the sex. Avoiding the extreme values only ten values were taken for comparison of biochemical parameters in plasma, liver and egg yolk. The significance was tested at $P \leq 0.01$ and $P \leq 0.05$ levels.

Table 1. Design of the experiment

Sex	Male			Female		
Duration of the experiment in weeks	4 to 10			4 to 16		
Groups	I	II	III	I	II	III
Subgroups	M-I	M-II	M-III	F-I	F-II	F-III
No. of birds	12	12	12	12	12	12

I : Control group (Ration with gingelley oil)

II&III: Experimental groups

(II - Ration with coconut oil and
III- Ration with sunflower oil)

M : Male Japanese quails

F : Female Japanese quails

NB: Avoiding the extreme values, 10 values were selected from each group for statistical analysis of the data in plasma, liver and egg yolk.

Table 2. Composition of quail grower ration parts/100 kg

Sl. No.	Ingredients	Control group	Experimental groups	
		G I	G II	G III
1.	Yellow maize	37	37	37
2.	Groundnut oil cake	32	32	32
3.	Gingelley oil cake	12	12	12
4.	Rice polish	9	9	9
5.	Unsalted dried fish	5	5	5
6.	Mineral mixture*	2	2	2
7.	Salt	0.5	0.5	0.5
8.	Shell grit	0.5	0.5	0.5
9.	Vegetable oil (fat)	2.0 (gingelley oil)	2.0 (coconut oil)	2.0 (sunflower oil)
	Total	100.0	100.0	100.0

For every 100 kg feed added the following vitamins:

Rovibe 75 g, Rovimix 25 g, Choline chloride 50 g

1. Rovibe (Roche products limited)
Guaranteed potency per gram. Vit B1-4 mg, B6-8 mg, B12-40 mg, Niacin 60 mg, Calcium pantothenate 40 mg and Vit. E - 40 IU

2. Rovimix A B_2 D_3 (Roche products limited)

Guaranteed potency per gram

Vit.A-40,000 IU, B2-20 mg, D3-5000 IU

*3. Poultry min (Aries Agro-Vet Industries Private Limited)
Contained calcium (min)-32.00%, Phosphorus (min)-6%
Copper (min)-100 ppm, Cobalt (min)-60 ppm,
Manganese (min)-2700 ppm, Iodine 100 ppm,
Zinc-2600 ppm, Iron 0.1% and Magnesium 1000 ppm

Table 2.1 Composition of quail adult ration parts/100 kg

Sl. No.	Ingredients	G I	G II	G III
1.	Yellow maize	38	38	37
2.	Groundnut oil cake	38	38	38
3.	Gingelley oil cake	5	5	5
4.	Fish meal	5	5	5
5.	Rice polish	5	5	5
6.	Salt	0.5	0.5	0.5
7.	Shell meal	3.5	3.5	3.5
8.	Mineral mixture*	3.0	3.0	3.0
9.	Vegetable oil (fat)	2.0 (gingelley oil)	2.0 (coconut oil)	2.0 (sunflower oil)
	Total	100.0	100.0	100.0

For every 100 kg feed added the following vitamins:

Rovibe 75 g, Rovimix 25 g, Choline chloride 50 g

*1. Poultry min (Aries Agro-Vet Industries Private Limited) Contained calcium (min)-32.00%, Phosphorus (min)-6% Copper (min)-100 ppm, Cobalt (min)-60 ppm, Manganese (min)-2700 ppm, Iodine 100 ppm, Zinc-2600 ppm, Iron 0.1% and Magnesium 1000 ppm

2. Rovibe (Roche products limited) Guaranteed potency per gram. Vit B1-4 mg, B6-8 mg, B12-40 mg, Niacin 60 mg, Calcium pantothenate 40 mg and Vit. E - 40 IU

3. Rovimix A B_2 D_3 (Roche products limited)

Guaranteed potency per gram

Vit.A-40,000 IU, B2-20 mg, D3-5000 IU

Table 3. Chemical composition of quail grower ration

Sl. No.	Parameters	G I	G II	G III
1.	Crude protein (%)	24.21	24.21	24.21
2.	Ether extract (%)	8.68	8.68	8.68
3.	Crude fibre (%)	5.30	5.30	5.30

ME = 2800 KCal/kg

Table 3.1 Chemical composition of quail adult ration

Sl. No.	Parameters	G I	G II	G III
1.	Crude protein (%)	22.30	22.30	22.30
2.	Ether extract (%)	9.79	9.79	9.79
3.	Crude fibre (%)	3.84	3.84	3.84

ME = 2900 KCal/kg

4. RESULTS

The results obtained in the present study in Japanese quails under different dietary oil treatments are presented under the following main headings.

4.1 Influence of dietary oils on lipid profile in plasma of Japanese quails

4.2 Influence of dietary oils on lipid profile in liver of Japanese quails

4.3 Influence of dietary oils on weight of the liver in Japanese quails

4.4 Influence of dietary oils on lipid profile in egg yolk of Japanese quails

4.5 Influence of dietary oils on production performance of Japanese quails

4.6 Influence of dietary oils on feed consumption of Japanese quails

4.7 Influence of dietary oils on body weight of Japanese quails

4.8 Influence of dietary oils on feed efficiency of Japanese quails

4.1 Influence of dietary oils on lipid profile in plasma of Japanese quails

4.1.1 Total lipid

The mean plasma total lipid content observed in male Japanese quails under the three dietary oil treatments (M-I, M-II and M-III) were 700.600 ± 29.598, 714.400 + 48.838 and 698.700 + 13.708 mg/dl respectively (Table 4.1, 4.2, 4.3 4.4 and Fig.1.1). The corresponding values in female quails in F-I, F-II and F-III groups were 1405.700 ± 91.019, 1468.100 ± 126.595 and 1488.300 ± 150.167 mg/dl respectively (Table 4.6, 4.7, 4.8, 4.9 and Fig.1.3). From the analysis of variance it was revealed that there was no significant difference in plasma total lipid content among the groups in both male and female quails (Table 4.5, 4.10). The highest plasma total lipid content was observed in male birds of coconut oil fed group (M-II) and the lowest concentrations was in the sunflower oil fed group (M-III), whereas, the highest plasma total lipid content in female birds was observed in sunflower oil fed group (F-III) and the lowest value was in the gingelley oil fed group (F-I).

The mean plasma total lipid content in all the groups was significantly higher ($P \leq 0.01$) in female quails than the male quails (Table 4.11). The overall mean value for plasma total lipid recorded in male and female quails were 704.567 ± 18.934 and 1454.033 ± 69.931 mg/dl respectively (Table 4.12 Fig.1.5).

Female quails had significantly higher plasma total lipid content than the males (Table 4.12).

4.1.2 Triglyceride

The mean values for plasma triglyceride content observed in male Japanese quails in the gingelley oil fed group (M-I group - control), coconut oil fed group, (M-II group) and sunflower oil fed group, (M-III group) were 143.401 ± 11.203, 140.301 ± 12.857 and 124.651 ± 6.182 mg/dl respectively (Tables 4.1, 4.2, 4.3, 4.4 and Fig.1.1). Corresponding values in female japanese quails were 744.328 ± 51.630, 772.604 ± 72.235 and 778.547 ± 83.379 mg/dl respectively (Tables 4.6, 4.7, 4.8, 4.9 and Fig.1.3). From the analysis of variance it was observed that there was no significant difference in plasma triglyceride content among the gingelley oil fed group (control), coconut oil and sunflower oil fed groups (treatments) in both male and female quails (Tables 4.5, 4.10).

In the male quails highest plasma triglyceride content was observed in the gingelley oil fed group (M-I group) and the lowest value was in the sunflower oil fed group (M-III group). In the female quails the highest plasma triglyceride content was in the sunflower oil fed group (F-III group) and the lowest value was in the gingelley oil fed group (F-I group) (Table 4.4).

From the `t' test it was observed that the female quails of all the dietary oil groups had significantly higher ($P \leq 0.01$) plasma triglyceride content than the male quails (Table 4.11). The over all mean value recorded in the male and female quails were 136.118 ± 6.030 and 765.160 ± 39.273 mg/dl respectively (Table 4.12). Female birds showed significantly higher ($P \leq 0.01$) plasma triglyceride content (765.160 ± 39.273 mg/dl) than male birds (Table 4.12) (Fig.1.5).

4.1.3 Total cholesterol

The mean value for plasma total cholesterol content in M-I, M-II and M-III were 204.740 ± 8.512, 201.406 ± 14.821 and 229.125 ± 8.781 mg/dl respectively (Tables 4.1, 4.2, 4.3, 4.4 and Fig.1.1). The corresponding values in the female Japanese quails were 113.212 ± 6.811, 132.256 ± 11.513 and 139.413 ± 12.813 mg/dl respectively (Tables 4.6, 4.7, 4.8, 4.9 and Fig.1.3). There was no significant difference in the plasma total cholesterol content in three different dietary oil fed groups, in both sexes (Table 4.5, 4.10). The highest concentration of plasma total cholesterol was recorded in the male and female quails of the sunflower oil fed group (M-III and F-III groups) and the lowest value in males was of the coconut oil fed group (M-II group) and in females the lowest value was for the gingelley oil fed group (F-I group) vide Tables 4.4, 4.9 .

The overall mean plasma total cholesterol content recorded in the adult male and female quails were 211.757 ± 6.592 and 128.294 ± 6.302 mg/dl respectively (Table 4.12, Fig.1.5). From the t test it was observed that male quails of each group had significantly higher ($P \leq 0.01$) mean value for plasma total cholesterol than the female quails (Table 4.11). The overall mean plasma total lipid content in male quails was significantly higher ($P \leq 0.01$) than that of female quails (Table 4.12).

4.1.4 Lipoprotein cholesterol

4.1.4.1 HDL-cholesterol

The mean values for HDL-cholesterol content in plasma observed in the male japanese quails in the gingelley oil fed group (M-I group-control), coconut oil fed group, (M-II group) and sunflower oil fed group, (M-III group) were 162.075 ± 8.342, 158.454 ± 14.315 and 182.639 ± 9.622 mg/dl respectively (Tables 4.1, 4.2, 4.3, 4.4 and Fig.1.2). The corresponding values in the female Japanese quails were 25.266 ± 1.106, 25.392 ± 0.841 and 26.377 ± 1.195 mg/dl respectively (Tables 4.6, 4.7, 4.8, 4.9 and Fig.1.4). From the analysis of variance it was deduced that there was no significant difference in cholesterol content among the gingelley oil fed group (control), coconut oil and sunflower oil fed groups (treatments) in both male and female quails (Table 4.5, 4.10).

The highest concentration of plasma HDL-cholesterol in male and female Japanese quails was observed in the sunflower oil fed group (M-III and F-III group) and the lowest was in the coconut oil fed group (M-II and F-II groups). The HDL-C content in male birds of each group was significantly higher ($P \leq 0.01$) than that of female birds (Tables 4.11 and 4.12 and Fig.1.6).

The overall mean concentrations of HDL-C recorded in the male and female quails were 167.719 ± 6.471 and 25.678 ± 0.597 mg/dl respectively). From the `t' test significant difference ($P \leq 0.01$) was observed in the concentration of HDL-cholesterol of male and female quails (Table 4.12 Fig.1.6). The overall mean HDL-C content in male quails was significantly higher ($P \leq 0.01$) than that of female quails.

4.1.4.2 (VLDL + LDL)-cholesterol

The mean plasma (VLDL + LDL)-cholesterol content observed in male quails of groups I, II and III were 42.666 ± 2.374, 42.952 ± 2.789, 46.496 ± 1.189 mg/dl respectively (Tables 4.1, 4.2, 4.3, 4.4 and Fig.1.2). The female quails had the values 87.945 ± 5.853, 106.864 ± 10.789, 113.036 ± 12.032 mg/dl respectively (Tables 4.6, 4.7, 4.8, 4.9 and Fig.1.4). The mean value for plasma (VLDL + LDL)-cholesterol content did not differ significantly between the control (gingelley oil fed group) and treatments (coconut oil fed and sunflower oil fed

groups) in both male and female Japanese quails (Table 4.5, 4.10). The highest value for plasma (VLDL + LDL)-C content was observed in sunflower oil fed group and the lowest value in gingelley oil fed group in both male and female quails (Tables 4.4 and 4.9).

The overall mean value recorded in male and female quails were 44.038 ± 1.280, 102.615 ± 5.873 mg/dl respectively (Table 4.12, Fig.1.6). The plasma (VLDL + LDL)-C content was significantly higher ($P \leq 0.01$) in female quails than male quails of each group (Table 4.11). The value was significantly ($P \leq 0.01$) higher in adult female quails than that in male quails (Table 4.12).

4.1.5 Phospholipid

The mean plasma phospholipid content observed in the male Japanese quails in the gingelley oil group (M-I control), coconut oil fed group (M-II group) and sunflower oil fed group (M-III group) were 345.003 ± 16.952, 364.973 ± 30.253 and 337.209 ± 11.760 mg/dl respectively (Tables 4.1, 4.2, 4.3, 4.4 and Fig.1.1). The corresponding values in the female birds were 539.638 ± 35.300, 548.138 ± 44.901 and 553.446 ± 54.732 mg/dl respectively (Tables 4.6, 4.7, 4.8, 4.9 and Fig.1.3). From the analysis of variance it was found that there was no significant difference in the plasma phospholipid content between the different dietary oil fed groups of both male and

female Japanese quails (Tables 4.5, 4.10). The highest phospholipid content was in male quails of the coconut oil fed group (M-II group) and the lowest value was in the sunflower oil group (M-III group) vide Table 4.4 . The highest plasma phospholipid content in female birds was in the sunflower oil fed group (F-III) and the lowest was in the gingelley oil fed group (F-I) vide Table 4.9.

The female quails of all the groups had significantly higher ($P \leq 0.01$) plasma phospholipid content than male quails (Table 4.11). The overall mean values recorded in the male and female quails were 349.061 ± 11.976 and 547.074 ± 25.465 mg/dl respectively (Table 4.12, Fig.1.5). The female quails had significantly higher ($P \leq 0.01$) plasma phospholipid content than the male quails.

Table 4.1 Lipid profile in plasma of adult male Japanese quails M-I (gingelley oil fed group - control)

Sl. No.	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+ LDL)-C mg/dl	Phospholipid mg/dl
1.	593	108.060	198.389	164.266	34.123	280.150
2.	699	126.036	200.806	161.942	38.864	365.090
3.	708	128.358	212.890	173.318	39.572	358.895
4.	794	210.903	189.930	132.745	57.185	383.258
5.	793	147.352	240.483	196.051	44.432	396.380
6.	763	163.863	181.672	136.459	45.213	409.658
7.	760	146.106	226.989	182.135	44.854	379.265
8.	494	85.405	156.849	126.095	30.754	246.513
9.	706	177.297	195.890	146.607	49.283	324.243
10.	699	140.630	243.505	201.075	42.375	306.575
Mean ±SE	700.600± 29.598	143.401± 11.203	204.740± 8.512	162.075± 8.342	42.666± 2.374	345.003± 16.952

Table 4.2 Lipid profile in plasma of adult male Japanese quails M-II (coconut oil fed group - treatment)

Sl. No.	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+ LDL)-C mg/dl	Phospholipid mg/dl
1.	969	220.522	186.707	125.162	61.545	551.305
2.	812	177.612	218.933	168.049	50.884	407.030
3.	722	142.952	188.318	144.043	44.275	383.380
4.	509	106.799	120.443	83.276	37.167	275.998
5.	761	153.894	213.897	169.663	44.234	384.735
6.	852	148.287	221.349	177.732	43.617	473.718
7.	696	134.268	232.226	190.768	41.458	321.670
8.	539	91.892	158.219	125.943	32.276	282.730
9.	509	83.000	179.452	148.277	31.175	240.700
10.	775	143.784	294.521	251.629	42.892	328.460
Mean ±SE	714.400± 48.838	140.301± 12.857	201.406± 14.821	158.454± 14.315	42.952± 2.789	364.973± 30.253

Table 4.3 Lipid profile in plasma of adult male Japanese quails M-III (sunflower oil fed group - treatment)

Sl. No.	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+LDL)-C mg/dl	Phospholipid mg/dl
1.	690	130.224	226.989	179.731	47.258	325.560
2.	770	143.657	258.610	209.363	49.247	359.143
3.	625	99.171	231.621	190.836	40.785	287.928
4.	740	144.942	224.371	176.092	48.279	362.355
5.	735	130.017	206.445	158.157	48.288	390.243
6.	706	119.626	233.434	189.237	44.197	345.065
7.	668	113.084	230.614	183.720	46.894	316.635
8.	678	118.380	232.628	187.114	45.514	319.626
9.	716	153.358	171.198	117.930	53.268	383.395
10.	659	94.054	275.342	234.108	41.234	282.135
Mean ±SE	698.700± 13.708	124.651± 6.182	229.125± 8.781	182.629± 9.622	46.496± 1.189	337.209± 11.760

Table 4.4 Lipid profile in plasma under the influence of dietary oils in adult male Japanese quails (Mean±SE)

Groups	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+LDL)-C mg/dl	Phospholipid mg/dl
M-I	700.600± 29.598	143.401± 11.203	204.740± 8.512	162.075± 8.342	42.666± 2.374	345.003± 16.952
M-II	714.400± 48.838	140.301± 12.857	201.406± 14.821	158.454± 14.315	42.952± 2.789	364.973± 30.253
M-III	698.700± 13.708	124.651± 6.182	229.125± 8.781	182.629± 9.622	46.496± 1.189	337.209± 11.760

Table 4.5 Analysis of variance for the comparison of lipid profile in plasma in adult male Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total lipid	Between treatment	2	1468.467	734.233	0.064 NS
	Within treatment	27	310420.900	11497.070	
Triglyceride	Between treatment	2	2020.248	1010.124	0.921 NS
	Within treatment	27	29616.633	1096.912	
Total cholesterol	Between treatment	2	4580.214	2290.107	1.861 NS
	Within treatment	27	33233.302	1230.863	
HDL-C	Between treatment	2	3399.957	1699.978	1.389 NS
	Within treatment	27	33040.051	1223.706	
(VLDL-DLDL)C	Between treatment	2	91.062	45.531	0.920 NS
	Within treatment	27	1335.911	49.478	
Phospholipid	Between treatment	2	4101.303	2050.652	0.459 NS
	Within treatment	27	120694.170	4470.154	

NS - Non-significant

Table 4.6 Lipid profile in plasma of adult female Japanese quails F-I (gingelley oil fed group - control)

Sl. No.	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+LDL)-C mg/dl	Phospholipid mg/dl
1.	1533	779.618	152.036	30.493	121.543	585.223
2.	1704	892.994	115.837	25.550	90.287	677.421
3.	1368	710.828	113.122	24.801	88.321	530.350
4.	970	500.637	85.973	23.397	62.576	372.962
5.	1070	561.783	99.548	22.907	76.641	397.293
6.	1313	714.839	111.600	23.062	88.538	503.258
7.	1126	569.032	108.000	24.646	83.354	437.548
8.	1476	811.613	110.800	22.253	88.547	568.419
9.	1818	975.484	146.400	32.619	113.781	677.226
10.	1679	926.452	88.800	22.936	65.864	646.678
Mean ±SE	1405.700± 91.019	744.328± 51.630	113.212± 6.811	25.266± 1.106	87.945± 5.853	539.638± 35.300

Table 4.7 Lipid profile in plasma of adult female Japanese quails F-II (coconut oil fed group - treatment)

Sl. No.	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+ LDL)-C mg/dl	Phospholipid mg/dl
1.	1031	515.924	104.977	21.413	83.564	399.045
2.	1785	942.675	110.407	22.683	87.724	713.439
3.	1894	1011.465	174.661	27.425	147.236	688.312
4.	1847	1040.764	162.896	27.668	135.228	624.554
5.	1045	551.592	92.308	24.981	67.327	389.904
6.	1768	940.127	148.416	25.788	122.628	661.592
7.	1117	579.618	90.498	23.174	67.327	435.223
8.	1002	503.871	112.000	23.842	88.158	375.306
9.	1293	654.194	131.200	26.937	104.263	494.291
10.	1900	985.806	195.200	30.011	165.189	699.709
Mean ±SE	1468.100± 126.595	772.604± 72.235	132.256± 11.513	25.392± 0.841	106.864± 10.789	548.138± 44.901

Table 4.8 Lipid profile in plasma of adult female Japanese quails F-III (Sunflower oil fed group - treatment)

Sl. No.	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+LDL)-C mg/dl	Phospholipid mg/dl
1.	1868	998.726	155.656	26.528	129.128	694.076
2.	1097	583.439	88.688	23.014	65.674	412.993
3.	1850	949.045	173.756	28.521	145.235	708.058
4.	1978	1042.038	185.520	36.147	149.373	730.478
5.	1016	512.102	107.692	24.210	83.482	386.274
6.	1008	518.471	93.213	23.925	69.288	385.891
7.	1052	522.293	110.407	24.684	85.723	408.662
8.	1997	1105.806	199.200	26.653	102.547	671.709
9.	1029	522.581	116.800	25.175	91.625	363.871
10.	1987	1030.968	163.200	24.911	138.289	772.452
Mean ±SE	1488.300± 150.167	778.547± 83.379	139.413± 12.813	26.377± 1.195	113.036± 12.032	553.446± 54.732

Table 4.9 Lipid profile in plasma under the influence of dietary oils in adult female Japanese quails (mean±SE)

Groups	Total lipid mg/dl	Triglyceride mg/dl	Total cholesterol mg/dl	HDL-C mg/dl	(VLDL+LDL)-C mg/dl	Phospholipid mg/dl
F-I	1405.700± 91.019	744.328± 51.630	113.212± 6.811	25.266± 1.106	87.945± 5.853	539.638± 35.300
F-II	1468.100± 126.595	772.604± 72.235	132.256± 11.513	25.392± 0.841	106.864± 10.789	548.138± 44.901
F-III	1488.300± 150.167	778.547± 83.379	139.413± 12.813	26.377± 1.195	113.036± 12.032	553.446± 54.732

Table 4.10 Analysis of variance for the comparison of lipid profile in plasma in adult female Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total lipid	Between treatment	2	37081.867	18540.933	0.119 NS
	Within treatment	27	4217467.100	156202.485	
Triglyceride	Between treatment	2	6685.887	3342.944	0.068 NS
	Within treatment	27	1335200.486	49451.870	
Total cholesterol	Between treatment	2	3668.152	1834.076	1.603 NS
	Within treatment	27	30884.263	1143.862	
HDL-C	Between treatment	2	7.394	3.697	0.329 NS
	Within treatment	27	302.973	11.221	
(VLDL+DLDL)C	Between treatment	2	3418.635	1709.317	1.736 NS
	Within treatment	27	26590.192	984.822	
Phospholipid	Between treatment	2	970.355	485.178	0.023 NS
	Within treatment	27	563219.791	20859.992	

NS - Non-significant

Table 4.11 Comparison of lipid profile in plasma -between groups of both sexes under the influence of dietary oils in adult Japanese quails

Parameters	t value		
	Groups		
	M1 Vs F1	M2 Vs F2	M3 Vs F3
Total lipid	7.367**	5.554**	5.236**
Triglyceride	11.374**	8.617**	7.821**
Total cholesterol	8.395**	3.684**	5.775**
HDL-C	16.256**	9.279**	16.114**
(VLDL+DLDL)-C	7.168**	5.734**	5.503**
Phospholipid	4.156**	3.383**	3.862**

Table 4.12 Comparison of lipid profile in plasma between sex under the influence of dietary oils in adult Japanese quails

Sex	Total lipid mg/dl	Trigly-ceride mg/dl	Total chole-sterol mg/dl	HDL-C mg/dl	(VLDL+ LDL)-C mg/dl	Phospho-lipid mg/dl
Male	704.567± 18.934	136.118± 6.030	211.757± 6.592	167.719± 6.471	44.038± 1.280	349.061± 11.976
Female	1454.033± 69.931	765.160± 39.273	128.294± 6.302	25.678± 0.597	102.615± 5.873	547.074± 25.465
t value	10.344**	15.831**	9.151**	21.854**	9.744**	7.036**

** - Significant at 1% level

Fig. 1.1 LIPID PROFILE IN PLASMA UNDER THE INFLUENCE OF DIETARY OILS IN ADULT MALE JAPANESE QUAILS

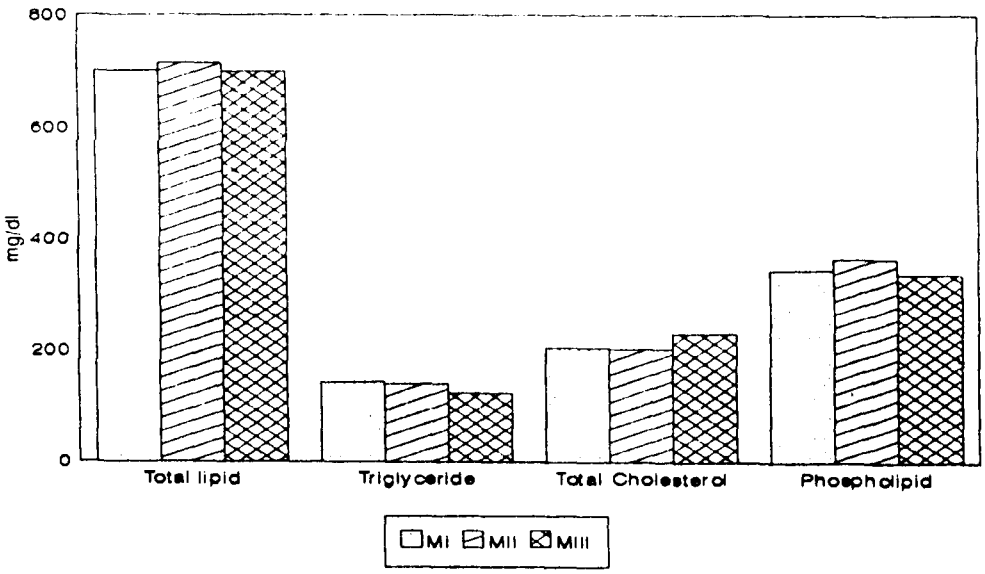


Fig.1.2 TOTAL CHOLESTEROL AND LIPOPROTEIN CHOLESTEROL IN PLASMA UNDER THE INFLUENCE OF DIETARY OILS IN ADULT MALE JAPANESE QUAILS

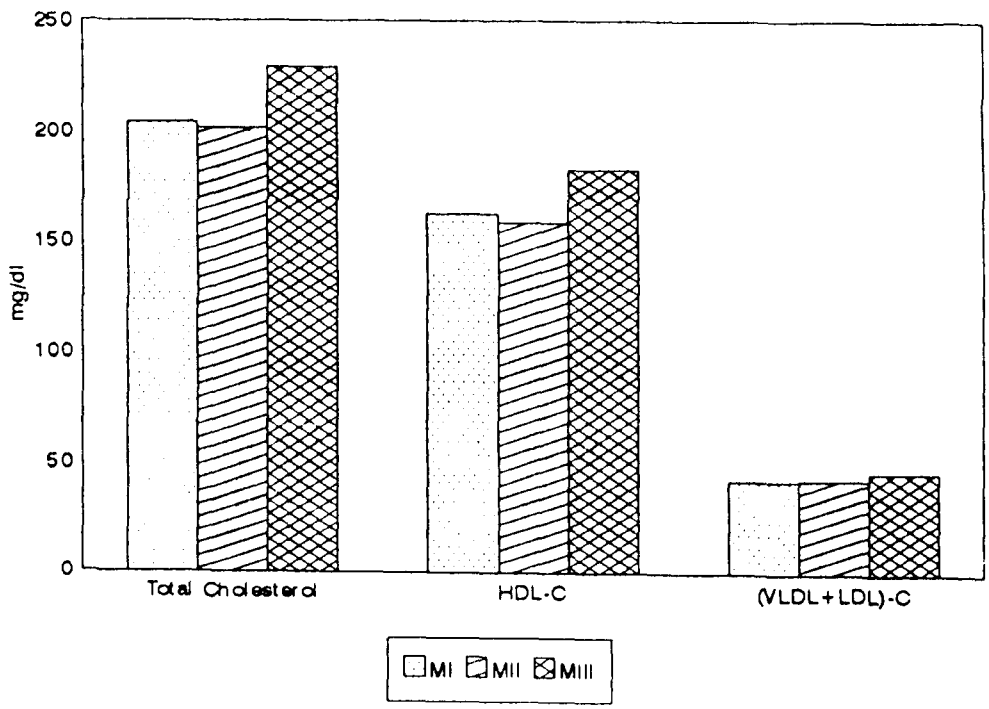


Fig.1.3 LIPID PROFILE IN PLASMA UNDER THE INFLUENCE OF DIETARY OILS IN ADULT FEMALE JAPANESE QUAILS

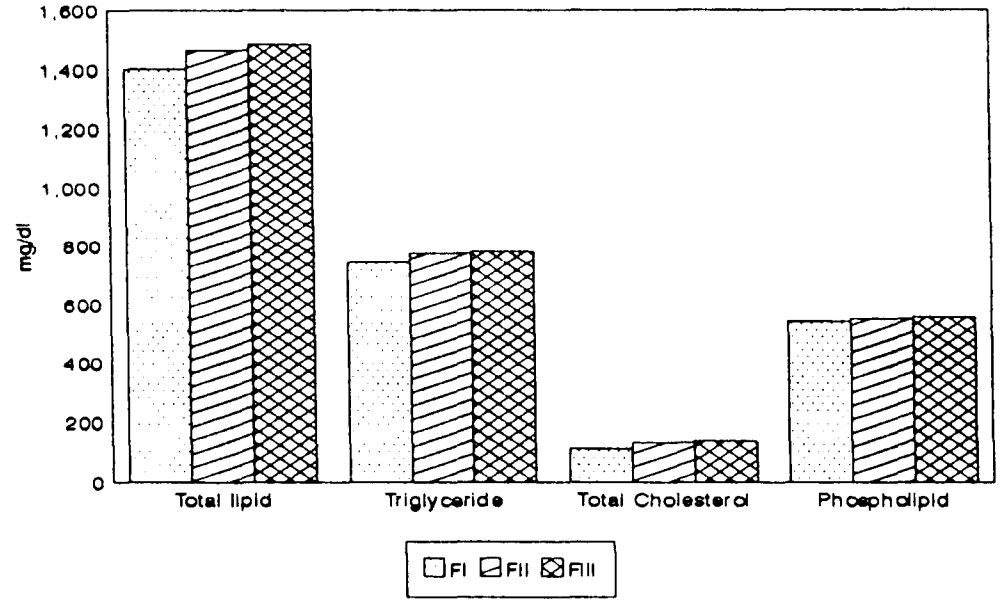


Fig. 1.4 TOTAL CHOLESTEROL AND LIPOPROTEIN CHOLESTEROL IN PLASMA UNDER THE INFLUENCE OF DIETARY OILS IN ADULT FEMALE JAPANESE QUAILS

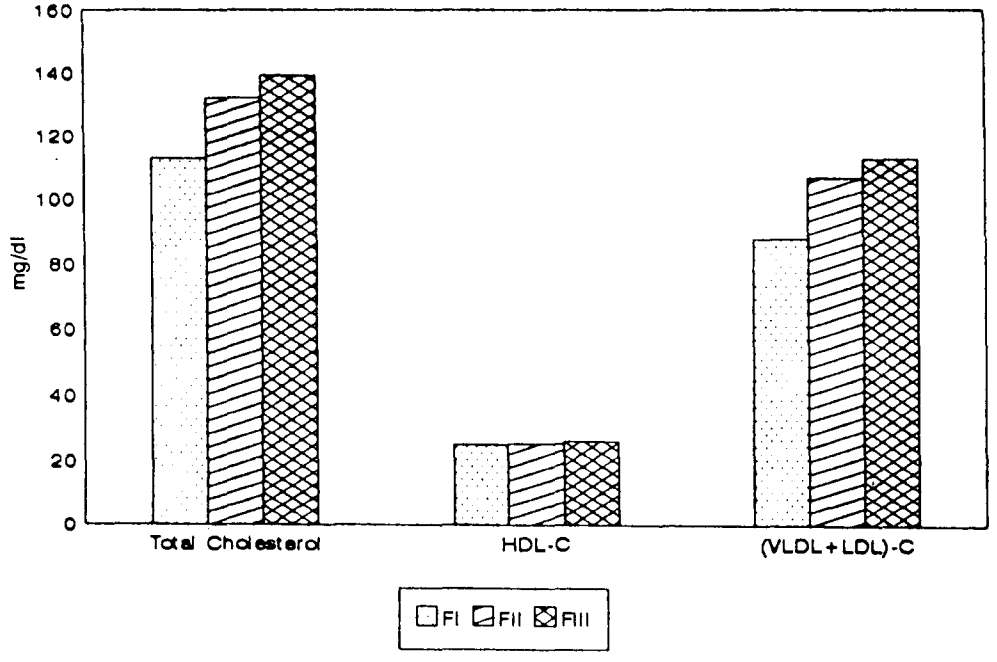


Fig.1.5 LIPID PROFILE IN PLASMA UNDER THE INFLUENCE OF DIETARY OILS IN ADULT JAPANESE QUAILS

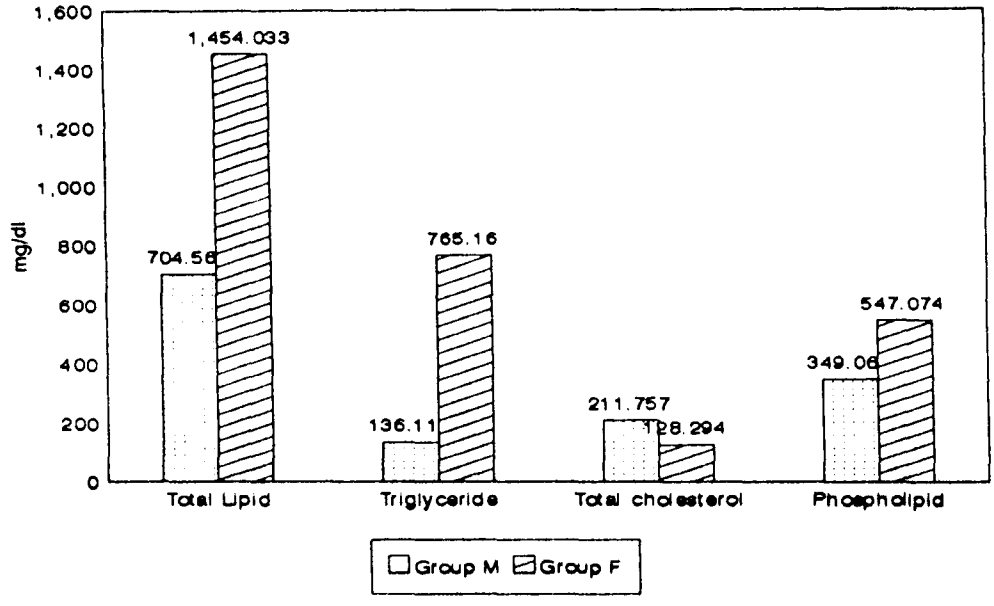
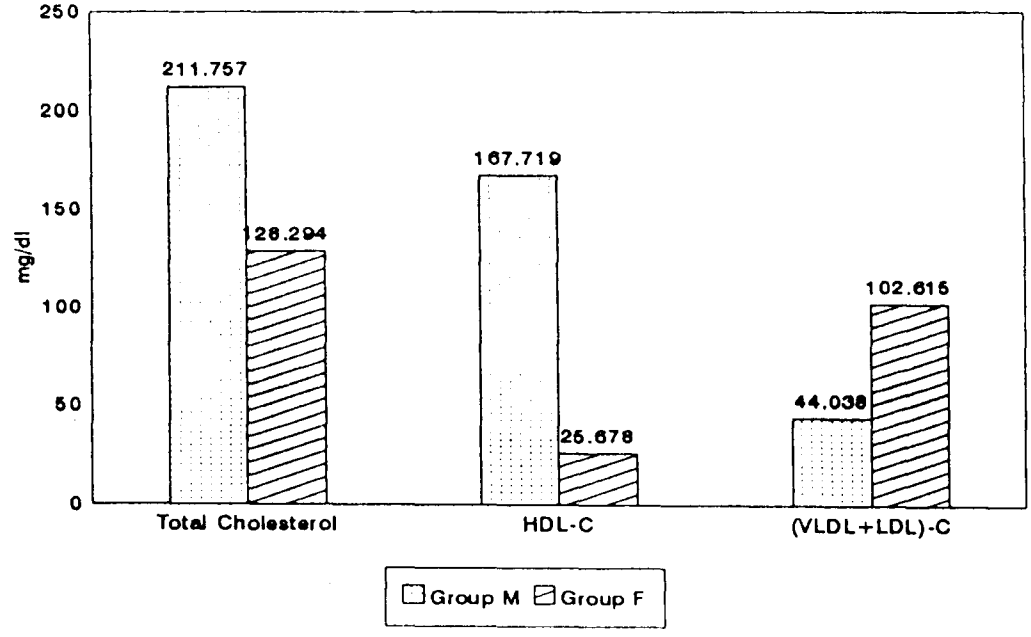


Fig.1.6 TOTAL CHOLESTEROL AND LIPOPROTEIN CHOLESTEROL IN PLASMA UNDER THE INFLUENCE OF DIETARY OILS IN ADULT JAPANESE QUAILS



4.2 Influence of dietary oils on lipid profile in liver of Japanese quails

4.2.1 Total lipid

The mean values for liver total lipid observed in the male Japanese quails in the gingelley oil fed M-I group (control), coconut oil fed M-II group and sunflower oil fed M-III group (treatments) were 5.659 ± 0.180, 5.379 ± 0.177 and 5.062 ± 0.164 g per cent respectively (Tables 5.1, 5.2, 5.3, 5.4, and Fig.2.1). The liver total lipid content in female quails were 11.087 ± 0.218, 10.405 ± 0.158 and 10.209 ± 0.196 g per cent respectively (Tables 5.7, 5.8, 5.9, 5.10 Fig.2.2). From the analysis of variance (Table 5.5) no significant difference was noticed between the different groups of males. Among the female birds gingelley oil fed group (F-I) had significantly higher ($P \leq 0.01$) liver total lipid content than coconut oil fed, F-II and sunflower oil fed F-III groups (Table 5.11, 5.12). The highest liver total lipid in both male and female quails was recorded in the gingelley oil fed groups (M-I and F-I) and the lowest value was in the sunflower oil fed groups (M-III and F-III) vide Tables 5.4 and 5.10. There was no significant difference between the values in the coconut oil fed group (M-II, F-II) and sunflower oil fed group (M-III, F-III) in both sexes (Table 5.5, 5.12).

The liver total lipid content was significantly higher ($P \leq 0.01$) in female quails than the male quails of each group

(Table 5.13, 5.14). The mean value observed for male and female quails were 5.367 ± 0.107 and 10.567 ± 0.127 g per cent respectively (Table 5.14 Fig.2.3). From the `t' test the total liver lipid content was found significantly ($P \leq 0.01$) higher in female quails than male quails (Table 5.14, Fig.2.3).

4.2.2 Triglyceride

The mean liver triglyceride content in male Japanese quails of gingelley oil (M-I), coconut oil (M-II) and sunflower oil (M-III) fed groups were 2.222 ± 0.101, 2.145 ± 0.050 and 2.049 ± 0.050 g per cent respectively (Tables 5.1, 5.2, 5.3, 5.4 and Fig.2.1). The values in females were 6.974 ± 0.158, 6.746 ± 0.142 and 6.564 ± 0.139 g per cent respectively (Tables 5.7, 5.8, 5.9, 5.10 and Fig.2.2). Irrespective of whether male or female the values were highest in gingelley oil fed group (M-III, F-III). Liver triglyceride content did not differ significantly between the groups in both sexes (Table 5.5, 5.11).

There was significant ($P \leq 0.01$) influence of sex on the liver triglyceride content in all the groups (Table 5.13) female birds showed significantly higher values (6.761 ± 0.087 g%) than male quails. The overall mean liver triglyceride content observed in male and female quails were

2.139 ± 0.041 and 6.761 ± 0.087 g per cent respectively (Table 5.14, Fig.2.3).

4.2.3 Total cholesterol

The mean total cholesterol content in the liver of male Japanese quails of the gingelley oil fed group, (M-I group - control) and coconut oil fed group (M-II) and sunflower oil fed group (M-III group) were 1.507 ± 0.230, 1.412 ± 0.098 and 1.473 ± 0.113 g per cent respectively (Tables 5.1, 5.2, 5.3, 5.4 and Fig.2.1). The corresponding values in the female birds were 2.401 ± 0.158, 1.990 ± 0.148 and 2.022 ± 0.129 g per cent respectively (Table 5.7, 5.8, 5.9, 5.10 and Fig.2.2). From the statistical analysis (ANOVA) it was seen that there was no significant difference between the different dietary oil fed groups of both male and female quails (Table 5.5, 5.11). The highest total cholesterol content in liver was observed in the gingelley oil fed group (M-I, F-I) and the lowest value in the coconut oil fed group (M-II, F-II) in both male and female quails.

Significantly higher ($P \leq 0.01$) liver cholesterol content was recorded in female quails, when compared to male quails in all the three groups (Table 5.13). The overall mean values for the total cholesterol content in male and female quails were 1.464 ± 0.087 and 2.137 ± 0.089 g per cent respectively

(Table 5.14). Female quails had significantly ($P \leq 0.01$) higher value than male quails (Fig.2.3).

4.2.4 Phospholipid

The mean values of phospholipid content in liver in male quails of gingelley oil (M-I), coconut oil (M-II) and sunflower oil (M-III) fed groups were 1.788 ± 0.075, 1.673 ± 0.151 and 1.358 ± 0.110 g per cent respectively (Tables 5.1, 5.2, 5.3, 5.4 and Fig.2.1). In both male and female birds gingelley oil fed group (M-I and F-I) had the highest phospholipid content and the lowest value was observed in sunflower oil fed group (M-III and F-III) (Tables vide 5.4, 5.10). Statistical analysis revealed that there was no significant difference in male quails between gingelley oil fed group (M-I) and coconut oil fed group (M-II) and also between coconut oil fed group and sunflower oil fed group (M-III) in male quails. It was found that there was significant ($P \leq 0.05$) difference between (M-I) gingelley oil fed group and (M-III) sunflower oil fed group (Table 5.5, 5.6).

The values obtained in group F-I, F-II and F-III were 1.544 ± 0.113, 1.536 ± 0.085 and 1.446 ± 0.104 g per cent respectively (Tables 5.7, 5.8, 5.9, 5.10, Fig.2.2). There was no significant difference in liver phospholipid content among groups in female quails (Table 5.11). Among the female birds

the sunflower oil fed group had the lowest phospholipid content and highest in gingelley oil fed group (Table 5.10, Fig.2.2).

There was no significant difference in the liver phospholipid content between male and female quails of different groups (Table 5.13). The overall mean value observed for liver phospholipid in male and female quails were 1.604 ± 0.073 and 1.509 ± 0.056 g per cent respectively (Table 5.14 Fig.2.3). The over all mean values of liver phospholipid content of male and female quails were not significantly different. The male birds had higher value than the female birds.

Table 5.1 Lipid profile in liver of adult male Japanese quails M-I (gingelley oil fed group - control)

Sl. No.	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
1.	6.780	1.478	3.482	1.680
2.	4.889	1.942	1.126	1.541
3.	5.894	2.468	1.289	2.020
4.	5.971	2.614	1.422	1.802
5.	4.964	2.298	1.059	1.497
6.	5.801	2.148	1.783	1.754
7.	5.284	2.228	1.145	1.678
8.	5.315	2.484	1.115	1.596
9.	5.691	2.212	1.213	2.141
10.	6.001	2.344	1.432	2.170
Mean ±SE	5.659± 0.180	2.222± 0.101	1.507± 0.230	1.788± 0.075

Table 5.2 Lipid profile in liver of adult male Japanese quails M-II (coconut oil fed group - treatment)

Sl. No.	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
1.	5.314	1.898	1.589	1.586
2.	4.881	2.102	1.573	1.070
3.	4.804	2.124	1.137	1.428
4.	5.961	2.285	1.616	1.943
5.	4.781	2.284	1.177	1.098
6.	4.626	1.932	1.181	1.377
7.	5.614	2.184	1.400	1.897
8.	5.883	2.412	1.213	2.109
9.	6.014	2.214	2.080	1.615
10.	5.914	2.014	1.149	2.608
Mean ±SE	5.379± 0.177	2.145± 0.050	1.412± 0.098	1.673± 0.151

Table 5.3 Lipid profile in liver of adult male Japanese quails M-III (sunflower oil fed group - treatment)

Sl. No.	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
1.	4.983	2.218	1.405	1.180
2.	5.394	1.891	1.417	1.852
3.	4.287	2.144	0.930	0.967
4.	4.635	1.898	1.157	1.444
5.	5.281	2.181	1.750	1.086
6.	4.374	2.228	1.017	1.002
7.	4.898	1.944	1.529	1.313
8.	5.794	1.798	1.910	1.943
9.	5.225	2.192	1.620	1.178
10.	5.748	1.998	1.993	1.614
Mean ±SE	5.062± 0.164	2.049± 0.050	1.473± 0.113	1.358± 0.110

Table 5.4 Lipid profile in liver under the influence of dietary oils in adult male Japanese quails (mean±SE)

Group	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
M-I	5.659± 0.180	2.222± 0.101	1.507± 0.230	1.788± 0.075
M-II	5.379± 0.177	2.145± 0.050	1.412± 0.098	1.673± 0.151
M-III	5.062± 0.164	2.049± 0.050	1.473± 0.113	1.358± 0.110

Table 5.5 Analysis of variance for the comparison of lipid profile in liver in adult male Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total lipid	Between treatment	2	1.785	0.892	2.936 NS
	Within treatment	27	8.208	0.304	
Triglyceride	Between treatment	2	0.149	0.075	1.423 NS
	Within treatment	27	1.415	0.052	
Total cholesterol	Between treatment	2	0.046	0.023	0.093 NS
	Within treatment	27	6.766	0.251	
Phospholipid	Between treatment	2	0.991	0.496	3.666 *
	Within treatment	27	3.651	0.135	

* - Significant at 5% level
NS - Non-significant

Table 5.6 Comparison of phospholipid content in liver under the influence of dietary oils between groups in adult male Japanese quails

Group	CD value
M-I Vs M-II	0.337
M-I Vs M-III	0.337*
M-II Vs M-III	0.337

* - Significant at 5% level

Table 5.7 Lipid profile in liver of adult female Japanese quails F-I (gingelley oil fed group - control)

Sl. No.	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
1.	12.386	6.820	3.485	1.900
2.	10.414	6.920	2.003	1.367
3.	10.963	7.104	2.792	0.919
4.	10.594	7.106	1.842	1.411
5.	11.691	7.046	2.812	1.618
6.	11.586	7.821	2.538	1.073
7.	10.473	6.177	2.101	1.958
8.	10.598	6.372	2.125	1.990
9.	11.653	7.621	2.216	1.686
10.	10.511	6.753	2.092	1.523
Mean ±SE	11.087± 0.218	6.974± 0.158	2.401± 0.158	1.544± 0.113

Table 5.8 Lipid profile in liver of adult female Japanese quails F-II (coconut oil fed group - treatment)

Sl. No.	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
1.	10.181	6.479	1.675	1.878
2.	10.794	7.382	1.880	1.406
3.	10.861	6.654	2.691	1.374
4.	10.485	6.427	2.099	1.818
5.	10.371	6.948	1.483	1.786
6.	10.486	6.189	2.933	1.184
7.	9.613	6.643	1.702	1.138
8.	9.971	6.670	1.653	1.501
9.	9.975	6.438	1.990	1.517
10.	11.314	7.632	1.796	1.753
Mean ±SE	10.405± 0.158	6.746± 0.142	1.990± 0.148	1.536± 0.085

Table 5.9 Lipid profile in liver of adult female Japanese quails F-III (sunflower oil fed group - treatment)

Sl. No.	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
1.	11.535	7.322	2.380	1.693
2.	9.987	6.399	1.746	1.682
3.	10.574	7.027	2.508	0.778
4.	10.361	6.863	2.004	1.337
5.	10.775	6.147	2.585	1.808
6.	9.901	6.574	1.732	1.565
7.	9.871	6.895	1.218	1.390
8.	10.118	6.011	2.155	1.794
9.	9.514	6.216	1.959	1.113
10.	9.675	6.182	1.928	1.297
Mean ±SE	10.209± 0.196	6.564± 0.139	2.022± 0.129	1.446± 0.104

Table 5.10 Lipid profile in liver under the influence of dietary oils in adult female Japanese quails (mean±SE)

Group	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
F-I	11.087± 0.218	6.974± 0.158	2.401± 0.158	1.544± 0.113
F-II	10.405± 0.158	6.746± 0.142	1.990± 0.148	1.536± 0.085
F-III	10.209± 0.196	6.564± 0.139	2.022± 0.129	1.446± 0.104

Table 5.11 Analysis of variance for the comparison of lipid profile in liver in adult female Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total lipid	Between treatment	2	4.245	2.122	5.755 **
	Within treatment	27	9.956	0.369	
Triglyceride	Between treatment	2	0.846	0.423	1.953 NS
	Within treatment	27	5.844	0.216	
Total cholesterol	Between treatment	2	1.044	0.522	2.431 NS
	Within treatment	27	5.796	0.215	
Phospholipid	Between treatment	2	2.060	0.030	0.288 NS
	Within treatment	27	2.795	0.104	

** - Significant at 1% level
NS - Non-significant

Table 5.12 Comparison of total lipid content in liver under the influence of dietary oils between groups in adult female Japanese quails

Group	CD value
F-I Vs F-II	0.557**
F-I Vs F-III	0.557
F-II Vs F-III	0.557**

** - Significant at 1% level

Table 5.13 Comparison of lipid profile in liver between groups of both sexes under the influence of dietary oils in adult Japanese quails

Parameters	t value		
	Groups		
	M-I Vs F-I	M-II Vs F-II	M-III Vs F-III
Total lipid	19.239**	21.122**	20.094**
Triglyceride	25.244**	30.298**	30.330**
Total cholesterol	3.197**	3.261**	3.172**
Phospholipid	1.762NS	0.798NS	0.580NS

** - Significant at 1% level
NS - Non-significant

Table 5.14 Comparison of lipid profile in liver between sex under the influence of dietary oils in adult Japanese quails

Group	Total lipid (g%)	Triglyceride (g%)	Total cholesterol (g%)	Phospholipid (g%)
Male	5.367± 0.107	2.139± 0.041	1.464± 0.087	1.604± 0.073
Female	10.567± 0.127	6.761± 0.087	2.137± 0.089	1.509± 0.056
t value	31.185**	47.459**	5.378**	1.052NS

** - Significant at 1% level
NS - Non-significant

Fig.2.1 LIPID PROFILE IN LIVER UNDER THE INFLUENCE OF DIETARY OILS IN ADULT MALE JAPANESE QUAILS

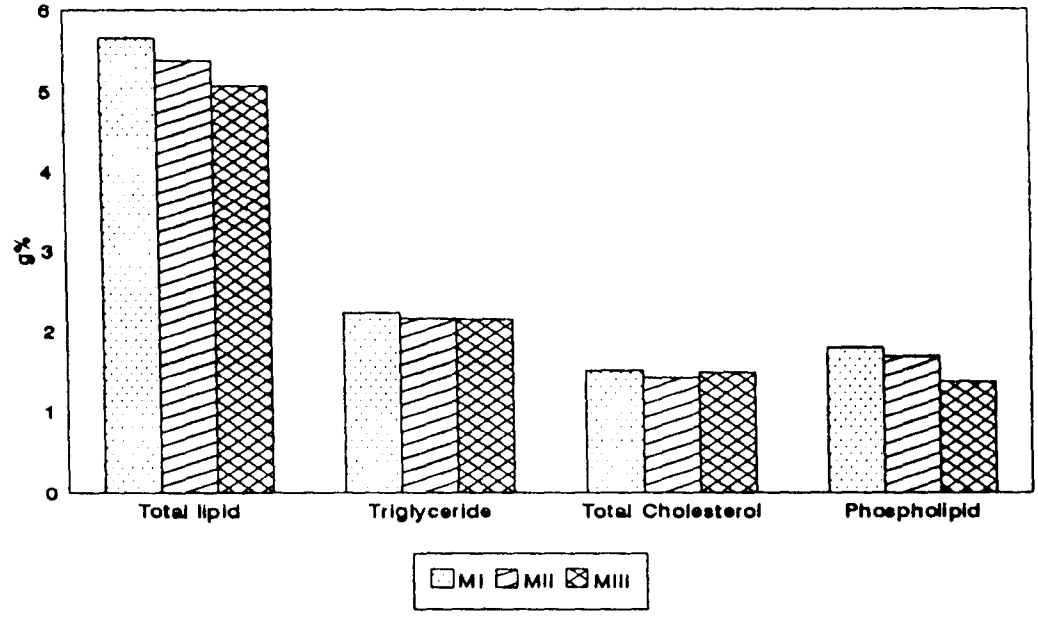


Fig.2.2 LIPID PROFILE IN LIVER UNDER THE INFLUENCE OF DIETARY OILS IN ADULT FEMALE JAPANESE QUAILS

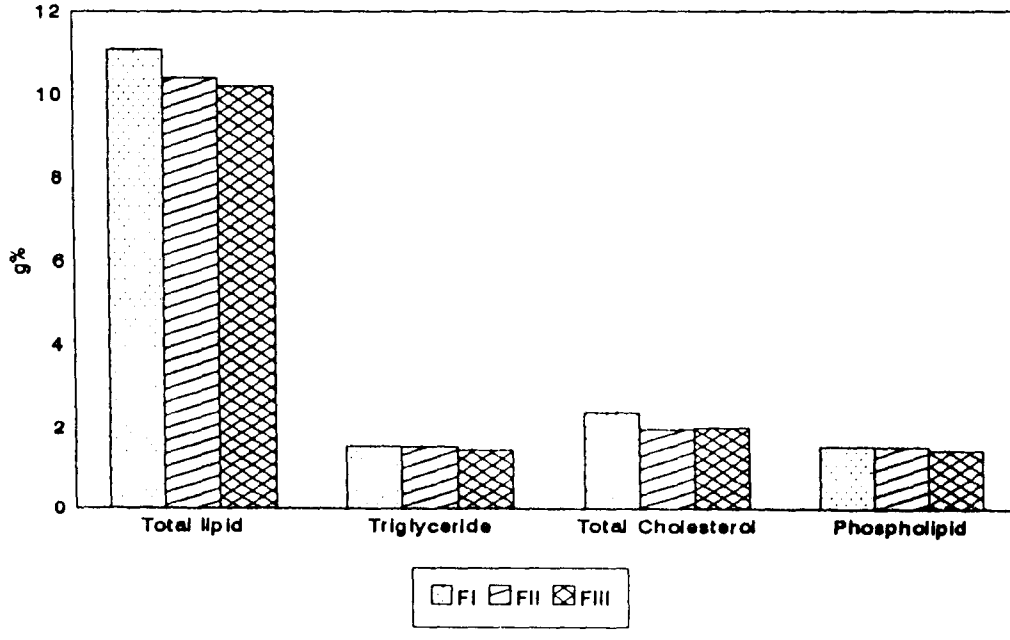
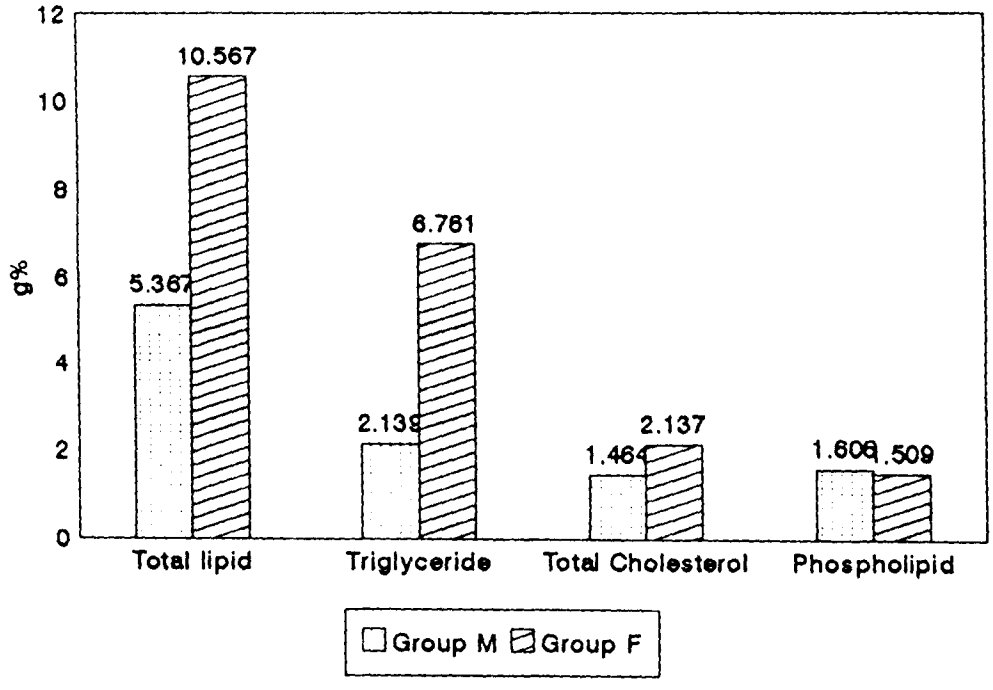


Fig.2.3 LIPID PROFILE IN LIVER UNDER THE INFLUENCE OF DIETARY OILS IN ADULT JAPANESE QUAILS



4.3 Influence of dietary oils on weight of the liver in Japanese quails

The mean value for liver weight in male quails of groups M-I, M-II and M-III were 2.517 ± 0.142, 2.482 ± 0.230 and 2.290 ± 0.088 g respectively (Tables 6.1, 6.4 and Fig.3.1). The corresponding values in female quails were 5.951 ± 0.499, 5.132 ± 0.531 and 6.709 ± 0.866 g respectively (Tables 6.2, 6.4 and Fig.3.1). The mean value in male birds was highest in gingelley oil fed group and was lowest in sunflower oil fed group. Among females the value was highest in sunflower oil group (F-III) and lowest in coconut oil group (F-II).

There was significant influence of sex on the liver weight under different dietary oil treatments. The overall mean value for liver weight in male and female quails were 2.430 ± 0.933 and 5.930 ± 0.383 respectively. The liver weight of male quails in each group were significantly lower ($P \leq 0.01$) than that of female quails (Table 6.3, 6.4).

Table 6.1 Weight of the liver under the influence of dietary oils in adult male Japanese quails (g)

Sl. No.	M-I	M-II	M-III
1.	2.878	1.930	2.101
2.	2.944	3.516	2.074
3.	2.285	2.250	2.698
4.	2.630	3.880	2.183
5.	2.946	2.204	2.422
6.	2.089	2.505	2.790
7.	2.101	2.120	2.275
8.	2.797	2.347	1.911
9.	1.653	1.422	2.196
10.	2.844	2.644	2.252
Mean±SE	2.517±0.142	2.482±0.230	2.290±0.088

Table 6.2 Weight of the liver under the influence of dietary oils in adult female Japanese quails (g)

Sl. No.	F-I	F-II	F-III
1.	5.402	3.404	5.797
2.	4.284	5.191	4.511
3.	4.272	4.441	11.071
4.	6.180	7.016	6.823
5.	6.296	4.448	4.637
6.	9.552	8.518	4.832
7.	4.660	5.960	5.232
8.	5.442	5.458	6.050
9.	7.094	3.388	5.814
10.	6.323	3.496	12.320
Mean±SE	5.951±0.499	5.132±0.531	6.709±0.866

Table 6.3 Analysis of variance for the comparison of the weight of liver under the influence of dietary oils in adult Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Weight of liver (male)	Between treatment	2	0.297	0.149	0.551 NS
	Within treatment	27	7.292	0.270	
Weight of liver (female)	Between treatment	2	12.436	6.218	1.456 NS
	Within treatment	27	115.287	4.270	

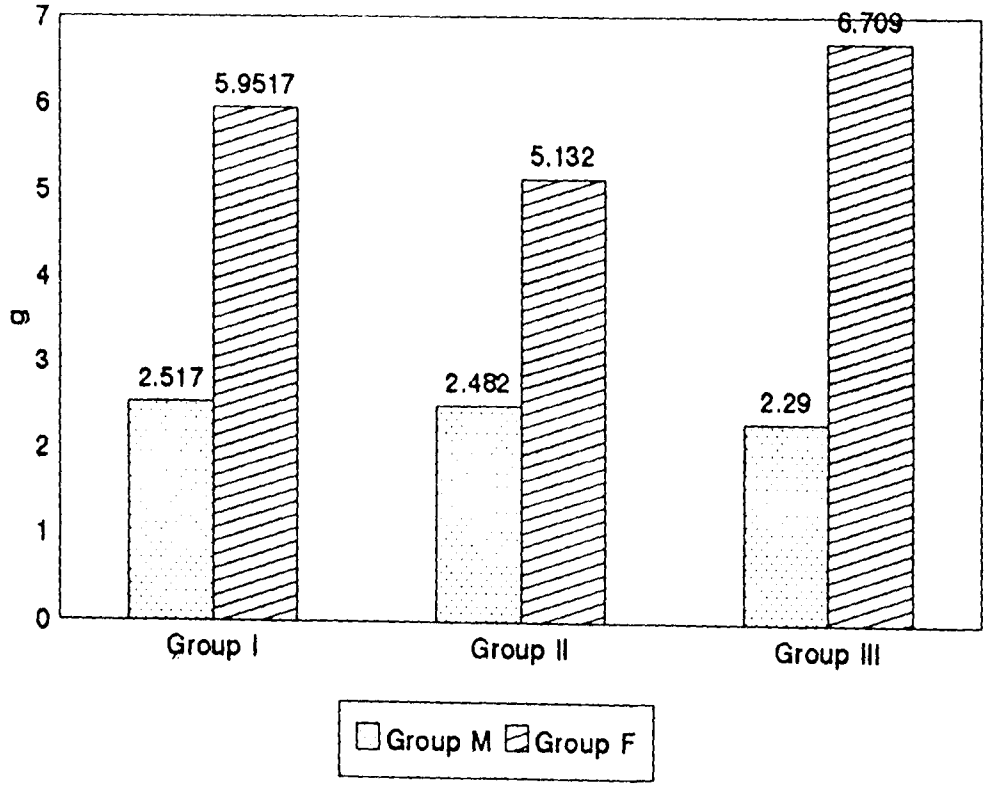
NS - Non-significant

Table 6.4 Comparison of the weight of liver under the influence of dietary oils between sex in adult Japanese quails

Sex	Groups			Overall mean±SE
	G-I	G-II	G-III	
Male	2.517±0.142	2.482±0.230	2.290±0.088	2.430±-0.933
Female	5.951±0.499	5.132±0.531	6.709±0.866	6.930±0.383
t value	6.613**	4.573**	5.079**	8.870**

** - Significant at 1% level

Fig.3.1 WEIGHT OF THE LIVER UNDER THE INFLUENCE OF DIETARY OILS IN ADULT JAPANESE QUAILS



4.4 Influence of dietary oils on lipid profile in egg yolk of Japanese quails

4.4.1 Total lipid

The mean yolk total lipid content observed on the last day of 14th week of age in the gingelley oil fed group, (F-I-control) and coconut oil fed group (F-II) and sunflower oil fed group (F-III) were 23.794 ± 0.746, 23.634 ± 0.847 and 23.192 ± 0.992 g per cent respectively (Tables 7.1, 7.4 and Fig.4.1). The corresponding values on the last day of 15th week were 27.889 ± 0.588, 26.538 ± 0.939 and 26.445 ± 0.720 g per cent respectively (Tables 7.2, 7.4 and Fig.4.1). The total lipid content of eggs on the last day of 16th week of age were 31.962 ± 1.457, 30.073 ± 1.388 and 32.768 ± 1.805 g per cent respectively (Tables 7.3, 7.4 and Fig.4.1). Statistical analysis ('t'test) revealed that there was no significant difference among the different dietary oil groups in the total lipid content of eggs in each week (Table 7.5).

The overall mean value for total lipid content in yolk observed in the gingelley oil fed group (F-I), coconut oil fed group (F-II) and sunflower oil fed group (F-III) were 27.882 ± 0.835, 26.748 ± 0.777 and 27.466 ± 1.019 g per cent respectively (Table 7.13). The mean values were not different significantly between the groups (Table 7.15). The mean yolk total lipid content was highest in the gingelley oil fed group (F-I) and lowest in the coconut oil fed group (F-II) vide

Table 7.13. In all the three groups the mean value for total lipid was significantly highest ($P \leq 0.01$) at the 16th week, (Table 7.14). The overall mean value for total lipid content at 14th, 15th and 16th week of age were 23.540 ± 0.485, 26.957 ± 0.441 and 31.601 ± 0.894 g per cent respectively (Table 7.14). The difference in total lipid content of egg yolk was highly significant between each week (Table 7.15, 7.16).

4.4.2 Total cholesterol

The mean yolk total cholesterol content observed on the last day of 14th week of age in the gingelley oil fed (F-I - control) and coconut oil fed group (F-II group) and sunflower oil group (F-III group) were 2.322 ± 0.094, 2.225 ± 0.101 and 2.257 ± 0.104 g per cent respectively (Tables 7.7, 7.10 and Fig.4.2). The corresponding values on the last day of 15th week of age was 2.693 ± 0.120, 2.613 ± 0.088 and 2.553 ± 1.101 g per cent respectively (Tables 7.8, 7.10 and Fig.4.2). The values on the last day of 16th week were 2.830 ± 0.154, 2.538 ± 0.120 and 2.527 ± 0.164 g per cent respectively (Tables 7.9, 7.10 and Fig.4.2). The statistical analysis (t test) revealed that there was no significant difference in yolk total cholesterol content between different dietary oil treatments at 14th, 15th and 16th week of age (Table 7.11). The lowest total yolk cholesterol content in the 15th and 16th week of age was for the sunflower oil fed group (F-III). The highest total cholesterol content was recorded in the

gingelley oil fed group (F-I) in the 14th, 15th and 16th week of age whereas the lowest value in 14th week of age was for coconut oil fed group (F-II) vide Tables 7.7, 7.8, 7.9.

The overall mean value for yolk cholesterol in gingelley oil fed group (F-I), coconut oil fed group (F-II) and sunflower oil fed group (F-III) were 2.615 ± 0.080, 2.459 ± 0.066 and 2.446 ± 0.075 g% respectively (Table 7.13). The values were not significantly different among groups. In all the three groups the mean value for egg yolk total cholesterol content was lowest in the 14th week. The overall mean values for yolk cholesterol content in 14th, 15th and 16th week of age were 2.268 ± 0.056, 2.620 ± 0.059 and 2.632 ± 0.086 g per cent respectively (Table 7.14). The mean value was significantly ($P \leq 0.01$) higher at 15th week, when compared to 14th week (Tables 7.14, 7.15, 7.16). Similarly the value for total cholesterol was significantly higher ($P \leq 0.01$) at 16th week when compared to 14th week (Tables 7.14, 7.15, 7.16). But there was no significant difference between 15th and 16th weeks of age (Table 7.15).

Table 7.1 Total lipid content in egg yolk under the influence of dietary oils in Japanese quails at 14th week of age

Sl. No.	F-I (g%)	F-II (g%)	F-III (g%)
1.	27.315	23.434	21.198
2.	23.571	23.208	25.840
3.	25.725	19.602	20.123
4.	24.161	20.116	27.865
5.	25.551	20.690	19.657
6.	23.820	25.630	19.808
7.	22.738	25.847	23.687
8.	24.864	24.773	27.879
9.	20.774	26.835	22.601
10.	19.417	26.205	23.256
Mean±SE	23.794±0.746	23.634±0.847	23.192±0.992

Table 7.2 Total lipid content in egg yolk under the influence of dietary oils in Japanese quails at 15th week of age

Sl. No.	F-I (g%)	F-II (g%)	F-III (g%)
1.	26.341	24.633	26.196
2.	26.987	24.032	24.477
3.	28.962	25.766	23.030
4.	26.379	24.319	26.408
5.	28.093	30.775	30.584
6.	28.691	27.746	24.600
7.	30.720	22.751	27.935
8.	24.418	29.433	25.565
9.	28.579	25.005	26.457
10.	29.722	30.922	29.198
Mean±SE	27.889±0.588	26.538±0.939	26.445±0.720

Table 7.3 Total lipid content in egg yolk under the influence of dietary oils in Japanese quails at 16th week of age

Sl. No.	F-I (g%)	F-II (g%)	F-III (g%)
1.	31.807	30.048	35.918
2.	28.047	27.271	33.673
3.	29.389	24.827	29.518
4.	29.420	29.805	27.693
5.	31.336	26.819	40.820
6.	30.473	28.790	40.720
7.	32.408	28.740	37.047
8.	32.020	40.945	28.046
9.	44.488	31.275	29.802
10.	30.231	32.206	24.443
Mean±SE	31.962±1.457	30.073±1.388	32.768±1.805

Table 7.4 Total lipid content in egg yolk under the influence of dietary oils in Japanese quails (mean±SE)

Weeks	F-I (g%)	F-II (g%)	F-III (g%)
14	23.794±0.746	23.634±0.847	23.192±0.992
15	27.889±0.588	26.538±0.939	26.445±0.720
16	31.962±1.457	30.073±1.388	32.768±1.805

Table 7.5 Analysis of variance for the comparison of total lipid content in egg yolk under the influence of dietary oils in Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total lipid 14th week	Between treatment	2	1.945	0.973	0.129 NS
	Within treatment	27	203.254	7.528	
Total lipid 15th week	Between treatment	2	13.065	6.533	1.123 NS
	Within treatment	27	157.065	5.817	
Total lipid 16th week	Between treatment	2	38.281	19.141	0.785 NS
	Within treatment	27	658.631	24.394	

NS - Non-significant

Table 7.6 Comparison of total lipid content in egg yolk under the influence of dietary oils between weeks in each group of Japanese quails

Weeks	t value		
	F-I	F-II	F-III
14 Vs 15	4.312**	2.298*	2.651*
14 Vs 16	4.990**	3.957**	4.644**
15 Vs 16	2.591*	2.108*	3.250*

* - Significant at 5% level
** - Significant at 1% level

Table 7.7 Total cholesterol content in egg yolk under the influence of dietary oils in Japanese quails at 14th week of age

Sl. No.	F-I (g%)	F-II (g%)	F-III (g%)
1.	2.278	2.128	2.040
2.	2.140	2.149	1.513
3.	2.257	2.564	2.663
4.	1.963	2.225	2.269
5.	2.679	2.166	2.479
6.	2.710	2.105	2.531
7.	2.801	1.843	2.126
8.	2.303	2.172	2.152
9.	2.108	1.943	2.360
10.	1.984	1.952	2.433
Mean±SE	2.322±0.094	2.225±0.101	2.257±0.104

Table 7.8 Total cholesterol content in egg yolk under the influence of dietary oils in Japanese quails at 15th week of age

Sl.No.	F-I (g%)	F-II (g%)	F-III (g%)
1.	2.889	2.802	2.653
2.	2.232	2.406	2.954
3.	3.042	2.602	2.342
4.	2.804	2.875	2.939
5.	2.878	2.362	2.374
6.	2.422	3.228	2.439
7.	3.176	2.600	2.286
8.	2.741	2.475	2.035
9.	2.785	2.320	2.996
10.	1.966	2.463	2.512
Mean±SE	2.693±0.120	2.613±0.088	2.553±0.101

Table 7.9 Total cholesterol content in egg yolk under the influence of dietary oils in Japanese quails at 16th week of age

Sl.No.	F-I (g%)	F-II (g%)	F-III (g%)
1.	2.029	3.099	2.176
2.	2.529	2.965	2.180
3.	3.393	2.491	2.640
4.	2.325	2.571	3.567
5.	2.594	2.130	2.399
6.	2.879	1.794	2.360
7.	3.265	2.748	3.330
8.	3.470	2.720	2.085
9.	2.625	2.405	2.483
10.	3.184	2.460	2.052
Mean±SE	2.830±0.154	2.538±0.120	2.527±0.164

Table 7.10 Total cholesterol content in egg yolk under the influence of dietary oils in Japanese quails (mean±SE)

Week	F-I (g%)	F-II (g%)	F-III (g%)
14	2.322±0.094	2.225±0.101	2.257±0.104
15	2.693±0.120	2.613±0.088	2.553±0.101
16	2.830±0.154	2.538±0.120	2.527±0.164

Table 7.11 Analysis of variance for the comparison of total cholesterol content in egg yolk under the influence of dietary oils in Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total cholesterol 14 week	Between treatment	2	0.050	0.025	0.248 NS
	Within treatment	27	2.701	0.100	
Total cholesterol 15 week	Between treatment	2	0.098	0.049	0.453 NS
	Within treatment	27	2.937	0.109	
Total cholesterol 16 week	Between treatment	2	0.591	0.295	1.350 NS
	Within treatment	27	5.907	0.219	

NS - Non-significant

Table 7.12 Comparison of total cholesterol content in egg yolk under the influence of dietary oils between weeks in each group of Japanese quails

Weeks	t value		
	Group		
	F-I	F-II	F-III
14 Vs 15	2.420 *	2.895 **	2.036 **
14 Vs 16	2.795 *	1.994	1.390
15 Vs 16	0.705	0.498	0.132

* - Significant at 5% level
** - Significant at 1% level

Table 7.13 Lipid profile in egg yolk under the influence of dietary oils in Japanese quails (mean±SE)

Group	Total lipids (g%)	Total cholesterol (g%)
F-I	27.882 ± 0.835	2.615 ± 0.080
F-II	26.748 ± 0.777	2.459 ± 0.066
F-III	27.466 ± 1.019	2.446 ± 0.075

Table 7.14 Lipid profile in egg yolk under the influence of dietary oils in Japanese quails - 14th to 16th week

Week	Total lipids (g%)	Total cholesterol (g%)
14	23.540 ± 0.485	2.268 ± 0.056
15	26.957 ± 0.441	2.620 ± 0.059
16	31.601 ± 0.894	2.632 ± 0.086

Table 7.15 Analysis of variance for the comparison of lipid profile in egg yolk under the influence of dietary oils in Japanese quails

Character	k value	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total lipid	2	Factor A	2	982.231	491.115	39.0406**
	4	Factor B	2	19.735	9.868	0.7844NS
	6	AB	4	33.557	8.389	0.6669
	7	Error	81	1018.949	12.580	
Total cholesterol	2	Factor A	2	2.565	1.283	8.9985**
	4	Factor B	2	0.534	0.267	1.8729NS
	6	AB	4	0.205	0.051	0.3596
	7	Error	81	11.545	0.143	

** - Significant at 1% level
NS - Non-significant

Table 7.16 Comparison of total cholesterol content in egg yolk under the influence of dietary oils between weeks in each group of Japanese quails

Weeks	CD value	
	Total lipid	Total cholesterol
14 Vs 15	2.415 **	0.257 **
14 Vs 16	2.415 **	0.257 **
15 Vs 16	2.415 **	-

** - Significant at 1% level

Fig.4.1 TOTAL LIPID IN EGG YOLK UNDER THE INFLUENCE OF DIETARY OILS IN JAPANESE QUAILS

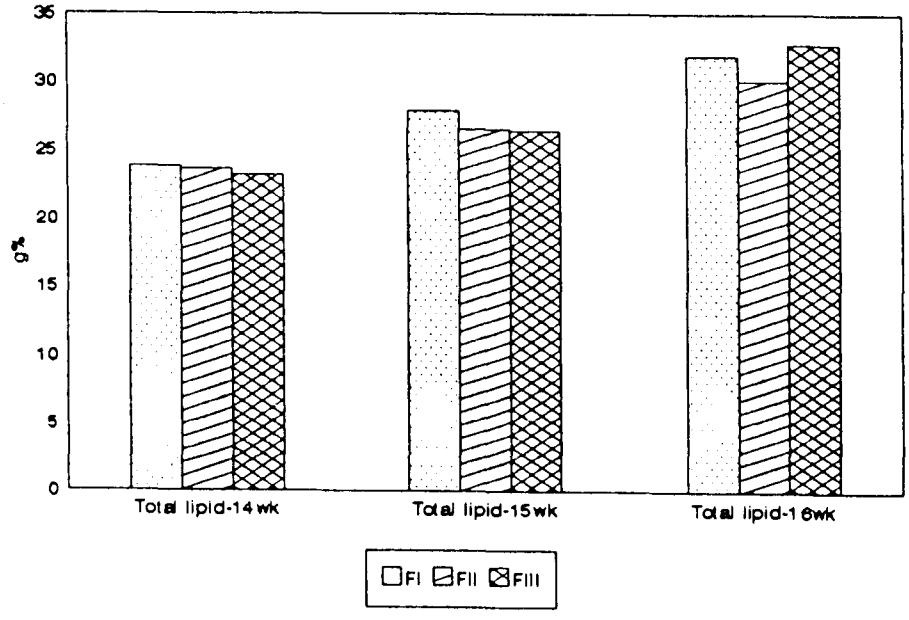
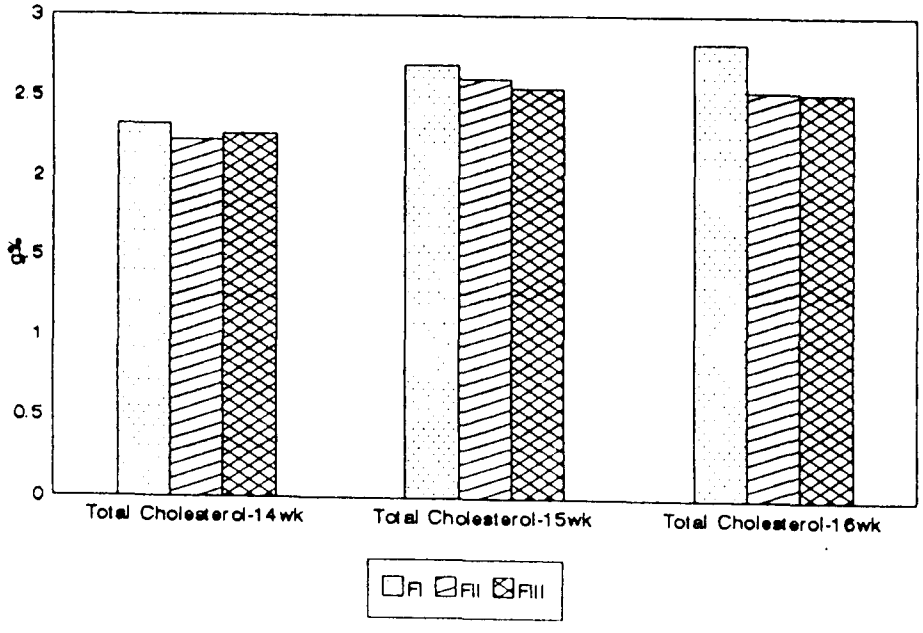


Fig.4.2 TOTAL CHOLESTEROL IN EGG YOLK UNDER THE INFLUENCE OF DIETARY OILS IN JAPANESE QUAILS



4.5 Influence of dietary oils on production performance of Japanese quails

4.5.1 Egg production

The number of eggs produced in each week by the three groups and the overall egg production in each week are presented in Tables 8.1 and 8.2. There was significantly ($P \leq 0.05$) higher egg production (64.600 ± 5.850) in (F-II) coconut oil fed group than (F-I) gingelley oil fed group (Tables 8.1, 8.4, 8.6). Analysis of the data on the influence of dietary oils on the egg production did not show any significant difference between F-I and F-III as well as F-II and F-III groups. The average number of eggs produced per week in groups I, II and III were 60.300 ± 5.904, 64.600 ± 5.850 and 62.800 ± 5.450 respectively (Table, 8.1, 8.2). There was significant increase in egg production between sixth and seventh and also between seventh and eight week (Table 8.5). Egg production decreased at 13th week when compared to 12th week (Tables 8.3, 8.4, 8.5 and Fig.5.1).

4.5.2 Hen day/hen housed production

The hen day production and hen housed production was the same in all the three groups of the Japanese quails since there was no mortality. The mean value for hen day/hen housed production in groups F-I, F-II and F-III were 71.784 ± 7.028, 76.905 ± 6.964 and 74.760 ± 6.487 per cent respectively

(Tables 8.1, 8.2 and Fig.5.4). The mean values for henday/hen housed production in each week is presented in Table 8.3. The mean value was significantly ($P \leq 0.05$) higher in coconut oil group F-II compared to gingelley oil group F-I (Tables 8.2, 8.4, 8.6) the value was not significantly different between gingelley oil fed group and sunflower oil fed group as well as coconut oil fed group compared with sunflower oil fed group. There was significant ($P \leq 0.01$) increase in hen day/hen housed production when compared between sixth and seventh week and also between seventh and eighth week (Table 8.5). There was a significant decrease ($P \leq 0.01$) in the values between 12th and 13th week of age (Table 8.4, 8.5).

4.5.3 Egg weight

The average egg weight in each week and the overall mean egg weight in each week are presented in Tables 8.1, 8.3). Significantly ($P \leq 0.01$) higher value was recorded in F-III when compared with F-II group (Tables 8.4, 8.6). Significant difference in the egg weight was not observed between sunflower oil (F-III) group and gingelley oil (F-I) group and also between coconut oil (F-II) and gingelley oil (F-I) fed groups. The lowest value was in coconut oil fed group (F-II). Egg weight of Japanese quails in group I, II and III were 9.950 ± 0.169 g, 9.719 ± 0.154 g and 10.214 ± 0.242 g respectively (Table 8.2). There was significant increase in egg weight in the seventh week compared to sixth week and also

in 13th week compared to 12th week (Table 8.4, 8.5 and Fig.5.2).

4.5.4 Egg mass

The weekly egg mass of each group is presented in Tables 8.1, 8.3 and Fig.5.3. Statistical analysis revealed that there was no significant difference in the egg mass values between the groups (Table 8.6). The mean value observed for weekly egg mass of group F-I, F-II and F-III were 607.300 ± 61.397, 631.200 ± 58.888 and 648.000 ± 61.016 g respectively (Table 8.2). The sunflower oil fed group showed the highest value and the gingelley oil fed group the lowest value (Table 8.2). There was a significant increase ($P \leq 0.01$) in overall egg mass at seventh week compared to sixth, and at eight week compared to seventh (Table 8.4, 8.5) week

Table 8.1 Egg production under the influence of dietary oils in Japanese quails

Age in weeks	Groups											
	F-I				F-II				F-III			
	Egg number	Average egg weight (g)	Egg mass (g)	Hen day/ hen housed production (%)	Egg number	Average egg weight (g)	Egg mass (g)	Hen day/ hen housed production (%)	Egg number	Average egg weight (g)	Egg mass (g)	Hen day/ hen housed production (%)
6	11	8.545	94	13.10	16	9.125	146	19.05	16	9.125	146	19.05
7	50	9.420	471	59.52	52	9.288	483	61.90	56	9.714	544	66.67
8	73	9.465	691	86.90	72	9.541	687	85.71	73	10.123	739	86.90
9	71	9.704	689	84.52	74	9.554	707	88.10	70	9.386	657	83.33
10	72	9.972	718	85.71	76	9.474	720	90.48	64	9.906	634	76.19
11	65	10.354	673	77.38	74	9.514	704	88.10	70	10.543	738	83.33
12	71	9.929	705	84.52	74	9.514	704	88.10	71	9.803	696	84.52
13	63	11.253	709	75.00	64	10.500	672	76.19	70	11.214	785	85.33
14	67	10.238	686	79.76	72	10.278	740	85.71	65	11.123	723	77.38
15	60	10.616	637	71.43	72	10.403	749	85.71	73	11.205	818	86.90
Mean± SE	60.300± 5.904	9.950± 0.169	607.300± 61.397	71.784± 7.028	64.600± 5.850	9.719± 0.154	631.200± 58.888	76.905± 6.964	62.800± 5.450	10.214± 0.242	648.000± 61.016	74.760± 6.487

NB: No. of quails in each group = 12

Egg mass = Egg weight x egg number

$$\text{Hen day egg production} = \frac{\text{Total number of eggs produced over the period}}{\text{Total number of hen days}} \times 100$$

$$\text{Hen housed production} = \frac{\text{Number of eggs produced over the period}}{\text{Number of hens housed in the beginning of the period}} \times 100$$

Table 8.2 Weekly egg production under the influence of dietary oils in Japanese quails (mean±SE)

Groups	Egg number	Hen day/hen housed production (%)	Egg weight (g)	Egg mass (g)
F-I	60.300± 5.904	71.784± 7.028	9.950± 0.169	607.300± 61.397
F-II	64.600± 5.850	76.905± 6.964	9.719± 0.154	639.200± 58.888
F-III	62.800± 5.450	74.760± 6.487	10.214± 0.242	648.000± 61.016

Table 8.3 Overall weekly egg production under the influence of dietary oils in Japanese quails

Age in weeks	Egg number	Hen day/hen housed production (%)	Egg weight (g)	Egg mass (g)
6	14.333± 1.667	17.067± 1.983	8.932± 0.192	128.667± 17.333
7	52.667± 1.763	62.697± 2.098	9.474± 0.125	499.333± 22.600
8	72.667± 0.333	86.503± 0.396	9.710± 0.207	705.667± 16.706
9	71.667± 1.202	85.317± 1.631	9.548± 0.091	684.333± 14.621
10	70.667± 3.527	84.127± 4.200	9.784± 0.155	690.667± 28.339
11	69.667± 2.603	82.937± 3.100	10.137± 0.316	705.000± 18.770
12	72.000± 0.999	85.713± 1.193	9.749± 0.122	701.667± 2.848
13	65.667± 2.185	78.173± 2.600	10.989± 0.244	722.000± 33.261
14	68.000± 2.081	80.950± 2.477	10.546± 0.288	716.333± 15.940
15	68.333± 4.176	81.347± 4.970	10.741± 0.239	734.667± 52.738

Table 8.4 Analysis of variance for egg production under the influence of dietary oils in Japanese quails

Character	k value	Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Egg number	1	Replication	9	8660.033	962.226	74.6340**	
	2	Factor A	2	93.267	46.633	3.6171*	
	3	Error	18	232.067	12.893		
Hen day/ hen housed production	1	Replication	9	12271.636	1363.515	74.6352**	0.0000
	2	Factor A	2	132.274	66.137	3.6202*	0.0477
	3	Error	18	328.843	18.269		
Egg weight	1	Replication	9	10.938	1.215	15.1643**	0.0000
	2	Factor A	2	1.228	0.614	7.6582**	0.0390
	3	Error	18	1.443	0.080		
Egg mass	1	Replication	9	955160.833	106128.981	61.0505**	0.0000
	2	Factor A	2	8366.467	4183.233	2.4064NS	0.1185
	3	Error	18	31290.867	1738.381		

* - Significant at 5% level
** - Significant at 1% level

Table 8.5 Comparison of egg production under the influence of dietary oils between weeks in Japanese quails

Weeks	CD value			
	Egg number	Hen day/ hen housed production (%)	Egg weight (g)	Egg mass (g)
6 Vs 7	6.159 **	7.332 **	0.485 **	71.524 **
7 Vs 8	6.159 **	7.332 **	-	71.524 **
12 Vs 13	6.159 **	7.332 **	0.485 **	-

** - Significant at 1% level

Table 8.6 Comparison of egg production under the influence of dietary oils between groups in Japanese quails

Groups	CD value			
	Egg number	Hen day/ hen housed production (%)	Egg weight (g)	Egg mass (g)
F-I Vs F-II	3.373*	4.016*	-	-
F-II Vs F-III		-	0.265**	-

No significant difference in egg mass among groups

* - Significant at 5% level
** - Significant at 1% level

Table 8.7 Egg production at various ages under the influence of dietary oils in Japanese quails

Parameters	Groups		
	F-I	F-II	F-III
Age at first egg in days	41	38	38
Above 50% production in weeks	7	7	7
Peak production in weeks	8	10	8

Fig.5.1 WEEKLY EGG PRODUCTION UNDER THE INFLUENCE OF DIETARY OILS IN JAPANESE QUAILS

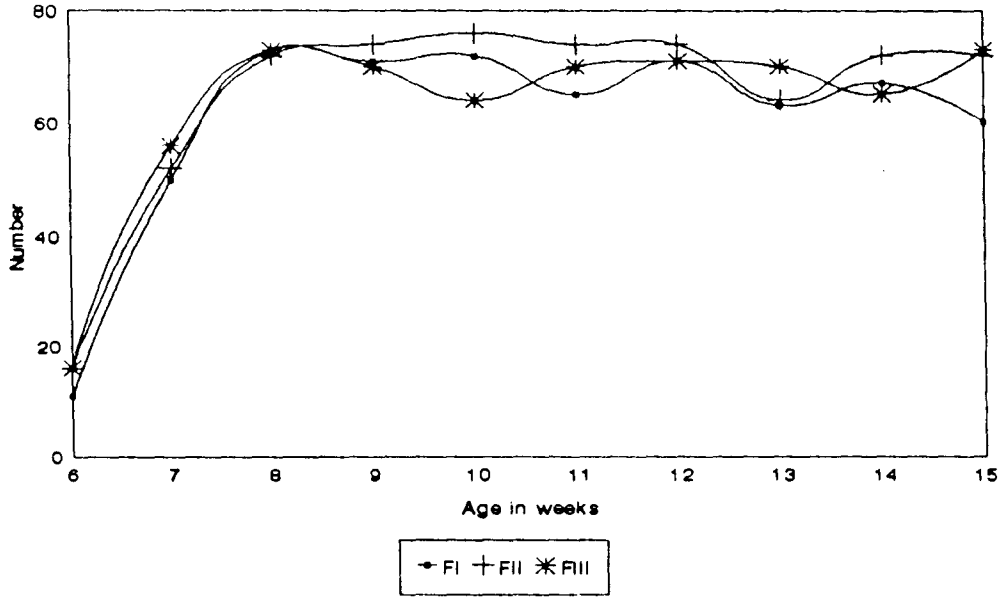


Fig.5.2 MEAN EGG WEIGHT UNDER THE INFLUENCE OF DIETARY OILS IN JAPANESE QUAILS

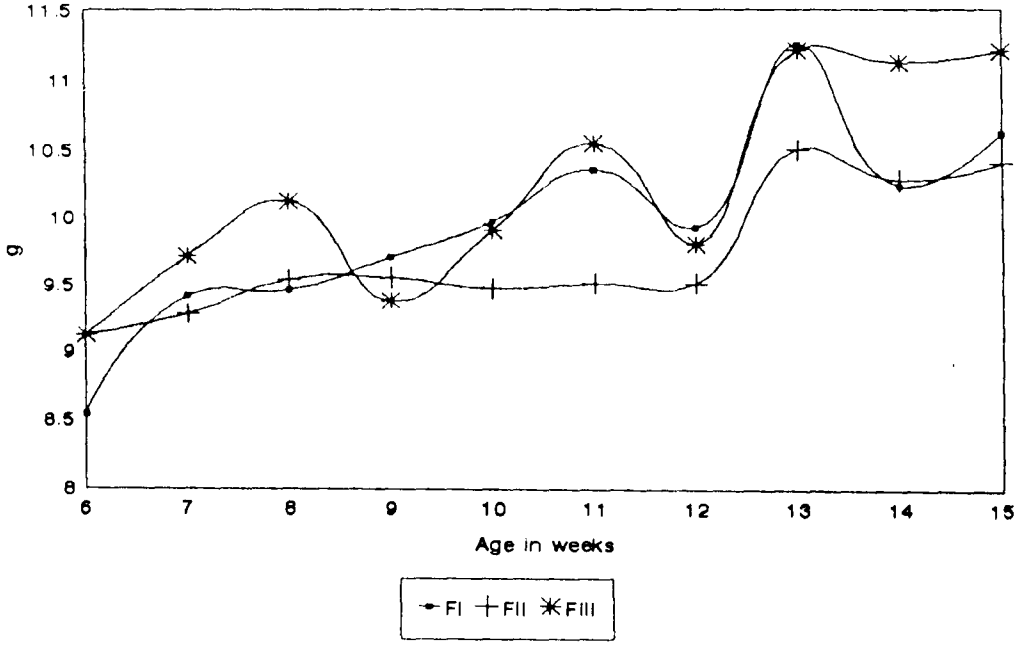


Fig.5.3 WEEKLY EGG MASS UNDER THE INFLUENCE OF DIETARY OILS IN JAPANESE QUAILS

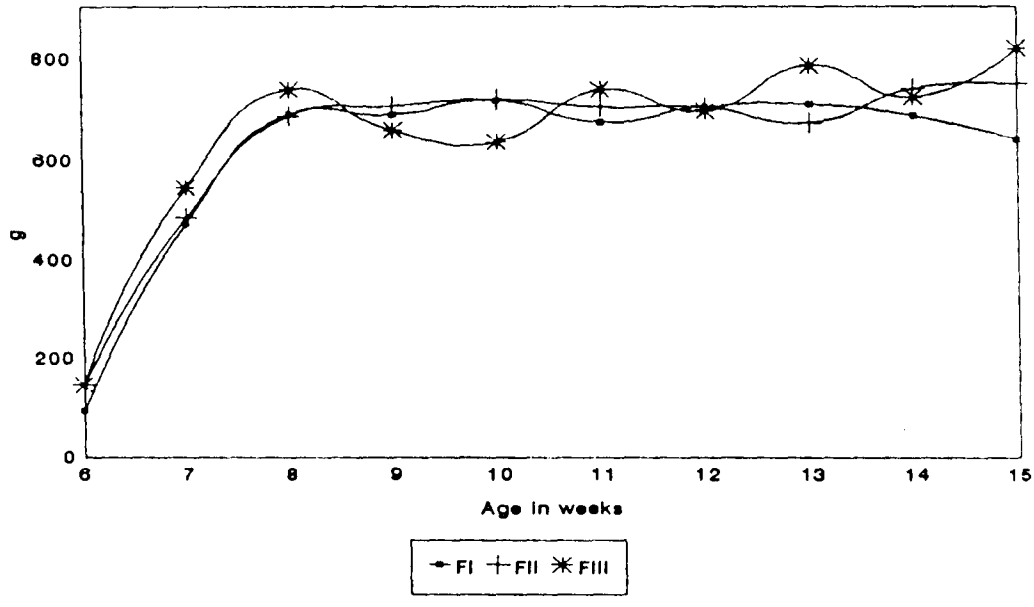
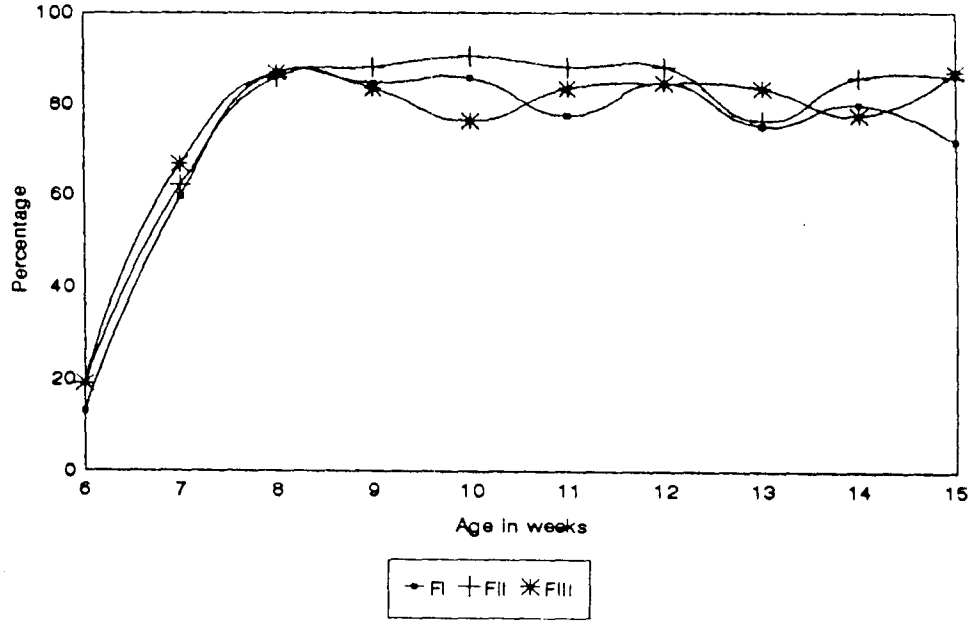


Fig.5.4 HEN DAY/HEN HOUSED PRODUCTION UNDER THE INFLUENCE OF DIETARY OILS IN JAPANESE QUAILS



4.6 Influence of dietary oils on feed consumption of Japanese quails

The average feed consumption observed in the male Japanese quails of the gingelley oil fed group M-I group (control) and coconut oil fed group M-II and sunflower oil fed group M-III (treatment) were 17.598 ± 0.186, 18.224 ± 0.340 and 18.240 ± 0.273 g/bird/day respectively (Table 9.1 and Fig.6.1). The corresponding values in the female quails (F-I, F-II and F-III) were 25.292 ± 0.704, 24.442 ± 0.675 and 24.537 ± 0.723 g/bird/day respectively (Table 9.2 and Fig.6.2). Statistical analysis (ANOVA) revealed that there was no significant difference between groups, in both male and female quails (Table 9.3). Among the male quails the mean value was highest in the sunflower oil fed group (M-III) and lowest in the gingelley oil fed group (M-I). Among the females the highest value was in the gingelley oil fed group (F-I) and the lowest in the coconut oil fed group (F-II) (Table 9.2).

However, feed consumption of both male and female quails varied significantly between weeks (Table 9.3, 9.4). There was significant increase in feed intake in male birds and female birds at fifth week of age when compared to that at fourth week of age. Feed intake decreased significantly ($P \leq 0.05$) in males at seventh week compared to sixth week, and at ninth week compared to eight week (Table 9.5).

The feed intake of female birds were significantly higher than that in male birds at each week (Table 9.5).

Table 9.1 Feed consumption under the influence of dietary oils in male Japanese quails (g/bird/day)

Age in weeks	Groups		
	M-I	M-II	M-III
4	17.451	17.287	18.167
5	18.395	19.236	18.287
6	17.196	19.439	19.752
7	17.326	17.543	17.864
8	18.196	18.543	18.297
9	17.164	17.257	17.543
10	17.456	18.257	17.769
Mean±SE	17.598±0.186	18.224±0.340	18.240±0.273

Table 9.2 Feed consumption under the influence of dietary oils in female Japanese quails (g/bird/day)

Age in weeks	Groups		
	F-I	F-II	F-III
4	19.511	19.250	19.166
5	21.166	22.333	22.166
6	22.583	23.500	20.750
7	26.166	22.682	22.833
8	25.250	24.083	23.500
9	26.250	22.583	26.166
10	26.416	24.333	26.333
11	27.416	25.583	26.500
12	27.416	24.750	26.583
13	27.000	26.333	25.000
14	26.666	27.416	26.083
15	26.500	27.000	26.333
16	27.451	27.896	27.568
Mean±SE	25.292±0.704	24.442±0.675	24.537±0.723

Table 9.3 Analysis of variance for the feed consumption under the influence of dietary oils in male and female Japanese quails

Character	k value	Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Feed intake male	1	Replication	6	5.877	0.980	3.2633**	0.0385
	2	Factor A	2	1.877	0.939	3.1268NS	0.0807
	3	Error	12	3.602	0.300		
Feed intake female	1	Replication	12	202.848	16.904	14.7073**	0.0000
	2	Factor A	2	5.637	2.819	2.4523	0.1074
	3	Error	24	27.585	1.149		

** - Significant at 1% level

Table 9.4 Comparison of feed consumption under the influence of dietary oils between weeks in male and female Japanese quails

Age in weeks	CD value	
	Male	Female
4 Vs 5	0.974 *	1.806 **
6 Vs 7	0.974 *	
8 Vs 9	0.974 *	

* - Significant at 5% level
** - Significant at 1% level

Table 9.5 Comparison of feed consumption between sex under the influence of dietary oils in Japanese quails (mean ± SE)

Sex	Weeks												
	4	5	6	7	8	9	10	11	12	13	14	15	16
Male	17.635± 0.270	18.639± 0.299	18.796± 0.804	17.579± 0.156	18.345± 0.103	17.321± 0.114	17.827± 0.233						
Female	19.309± 0.103	21.888± 0.364	22.277± 0.808	23.893± 1.136	24.277± 0.514	24.999± 1.208	25.694± 0.680	26.166± 0.292	26.250± 0.787	26.111± 0.587	26.722± 0.385	26.611± 0.200	27.638± 0.133
t value	** 5.783	** 6.884	* 3.052	* 5.502	** 11.306	* 6.325	** 10.930						

* - Significant at 5% level
** - Significant at 1% level

Fig.6.1 DAILY FEED CONSUMPTION UNDER THE INFLUENCE OF DIETARY OILS IN MALE JAPANESE QUAILS

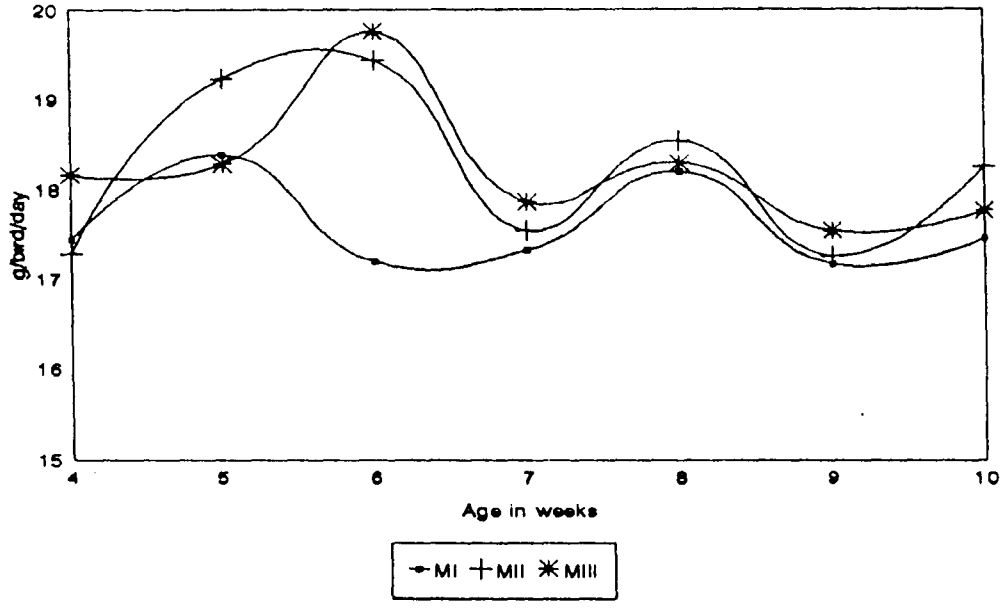
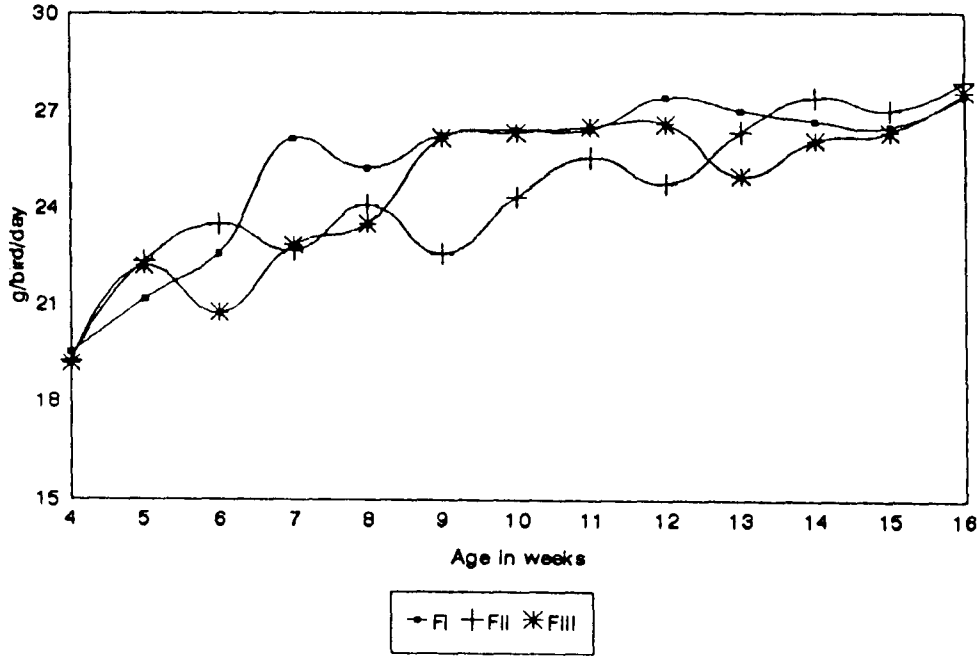


Fig.6.2 DAILY FEED CONSUMPTION UNDER THE INFLUENCE OF DIETARY OILS IN FEMALE JAPANESE QUAILS



4.7 Influence of dietary oils on body weight of Japanese quails

The body weights of individual male and female Japanese quails under three dietary oil treatments are presented in Table 10.1 and 10.2.

There was no significant difference in body weight between the groups in males in each week except at sixth week of age (Table 10.9). At sixth week of age the mean body weight of male Japanese quails in sunflower oil group (F-III) was significantly lowest (115.800 ± 1.391 g) than that of gingelley oil fed group; M-I (123.700 ± 2.055 g) and coconut oil fed group M-II (120.600 ± 1.517 g) vide table 10.7 and the initial body weight of male Japanese quails (4th week of age) for M-I, M-II and M-III were 70.800 ± 1.170, 69.400 ± 1.328, 70.600 ± 1.359 g respectively (Table 10.7). The mean body weight of Japanese quails at 10th week of age (adult) in the control, (M-I group gingelley oil fed group) and treatments, (M-II group coconut oil fed group) and (M-III group sunflower oil fed group) were 148.500 ± 3.510, 147.400 ± 3.20 and 146.000 ± 3.478 g respectively (Table 10.7 and Fig.7.1). Male birds of gingelley oil fed group and coconut oil fed group showed significant increase in body weight from fourth to sixth week of age and also between seventh and eighth week of age. But in sunflower oil fed group the increase in body weight was significant ($P \leq 0.01$) from fourth to eighth week of

age. The increase in body weight was not significant between sixth and seventh week in males of gingelley oil fed group (123.700 ± 2.055 g and 127.700 ± 1.739 g) and coconut oil fed group (120.600 ± 1.517 g and 124.200 ± 1.486 g) and also between eighth to tenth week of age in all the three groups. The overall mean body weight of male birds increased significantly ($P \leq 0.01$) at each week upto 10th week (Table 10.14).

There was no significant difference in the body weights among the groups from fourth to sixth week of age in females. The mean body weight of female quails of gingelley oil fed group was significantly lower than that of coconut oil fed group from seventh to 13th week of age and sunflower oil fed group from seventh to 12th week and at 15th week of age. At 13th week of age females of coconut oil fed group (F-II) showed significantly ($P \leq 0.05$) higher body weight (178.200 ± 3.668 g) compared to gingelley oil fed group F-I (165.400 ± 4.047 g) and sunflower oil fed group F-III (160.400 ± 6.672 g) vide table 10.8.

At 14th and 16th week of age body weight of sunflower oil fed group F-III (189.200 ± 4.458 g and 192.400 ± 3.636 g) showed significantly higher ($P \leq 0.01$) body weight than that of gingelley oil fed group F-I (163.400 ± 4.300 g and 175.200 ± 4.047 g). At 14th week of age the mean body weight of female birds of sunflower oil fed group F-III was significantly

higher than that of coconut oil fed group F-II and it is also higher than the body weight of sunflower oil fed group at 13th week of age (160.400 ± 6.672 g). There was no significant difference in the mean body weight between gingelley oil fed group F-I (165.400 ± 4.047 g) and sunflower oil fed group F-III (160.400 ± 6.672 g) at 13th week and also no significant difference was observed at 16th week of age between the mean body weights in coconut oil fed group F-II (187.600 ± 4.363) and sunflower oil fed group F-III (192.400 ± 3.636 g), and also between gingelley oil fed group F-I (175.200 ± 4.047 g), and coconut oil fed group, F-II (187.600 ± 4.363 g) at 16th week of age (Table 10.8). There was significant increase in body weight from fourth to seventh week, between seventh and eight week. There was an increase in the overall mean body weight from fourth to eighth and from 13th to 15th week of age. The body weights of female birds were more or less constant from eighth to 16th week of age in each group and it was also noticed that there was no significant variation in the overall mean body weight of females between eighth to 13th week of age.

Table 10.1 Body weight of male Japanese quails of M-I group (gingelley oil fed group - control) in grams

Sl No.	4	5	6	7	8	9	10
1	70	98	126	128	140	148	156
2	66	88	118	126	134	138	142
3	68	90	126	128	138	146	158
4	74	108	120	121	126	134	144
5	72	104	124	128	132	136	138
6	66	108	128	130	138	142	143
7	74	98	126	128	138	144	152
8	68	90	112	118	122	126	130
9	74	118	121	132	140	148	154
10	76	118	136	138	148	162	168
Mean ±SE	70.800 ±1.170	102.000 ±3.510	123.700 ±2.055	127.700 ±1.39	135.600 ±2.371	142.400 ±3.099	148.500 ±3.510

Table 10.2 Body weight of male Japanese quails of M-II group (coconut oil fed group - treatment) in grams

Sl No.	4	5	6	7	8	9	10
1	76	108	120	122	124	126	136
2	70	100	120	132	152	164	166
3	76	108	130	132	140	148	164
4	66	94	114	120	132	140	148
5	68	88	114	116	128	138	144
6	66	88	120	122	134	138	146
7	64	100	124	128	138	138	140
8	66	90	118	122	134	136	140
9	70	104	122	126	130	134	138
10	72	100	124	126	140	150	152
Mean ±SE	69.400 ±1.328	98.000 ±2.434	120.600 ±1.517	124.200 ±1.486	135.200 ±2.466	141.200 ±3.320	147.400 ±3.320

Table 10.3 Body weight of male Japanese quails of M-III group (sunflower oil fed group - treatment) in grams

Sl No.	4	5	6	7	8	9	10
1	74	98	110	120	134	138	152
2	76	108	118	128	142	144	148
3	68	98	112	122	138	144	148
4	68	98	120	128	148	154	158
5	64	98	116	120	128	136	140
6	74	96	110	116	122	132	132
7	66	92	112	116	126	138	138
8	68	108	120	136	136	138	142
9	76	100	120	128	146	158	164
10	72	106	120	128	138	144	148
Mean ±SE	70.600 ±1.359	100.200 ±1.707	115.800 ±1.391	124.200 ±2.023	135.800 ±2.687	142.600 ±2.561	146.000 ±3.478

Table 10.4 Body weight of female Japanese quails of F-I group (gingelley oil fed group - control) in grams

Sl. No.	Weeks												
	4	5	6	7	8	9	10	11	12	13	14	15	16
1	76	110	138	164	168	172	172	158	154	170	148	170	160
2	70	88	122	136	138	148	152	140	138	140	146	154	166
3	80	110	130	160	162	178	178	182	168	166	170	164	168
4	76	116	130	160	176	168	164	158	146	160	170	184	184
5	78	106	134	158	160	168	148	170	154	172	154	172	190
6	72	106	138	166	178	182	180	182	176	168	180	176	168
7	70	96	122	138	180	166	148	154	158	174	156	160	184
8	70	82	110	134	162	168	170	168	170	182	188	166	198
9	78	118	128	142	162	172	160	170	164	174	162	162	164
10	74	110	146	150	152	158	154	158	138	148	160	154	170
Mean ±SE	74.400 ±1.170	104.200 ±3.731	129.800 ±3.225	150.800 ±3.889	163.800 ±4.016	168.000 ±3.035	162.600 ±3.994	164.000 ±4.110	156.600 ±4.174	165.400 ±4.047	163.400 ±4.300	166.200 ±3.004	175.200 ±4.047

Table 10.5 Body weight of female Japanese quails of F-II group (coconut oil fed group - treatment) in grams

Sl. No.	Weeks												
	4	5	6	7	8	9	10	11	12	13	14	15	16
1	78	116	146	186	190	196	192	190	190	178	188	200	206
2	80	114	152	168	174	182	178	172	168	168	158	170	170
3	74	102	136	156	190	178	178	180	178	190	146	188	190
4	72	108	124	158	188	190	182	182	192	194	190	200	204
5	81	110	140	152	174	186	176	168	170	164	168	172	186
6	76	122	148	164	180	172	174	180	164	168	160	174	168
7	78	114	136	184	184	184	178	170	168	180	176	182	188
8	60	96	124	164	164	170	168	168	168	174	180	180	182
9	78	110	148	162	164	154	154	162	166	170	172	152	178
10	70	94	124	166	174	182	192	188	192	196	188	196	204
Mean ±SE	74.700 ±1.960	108.600 ±2.814	137.800 ±3.446	166.000 ±3.510	178.200 ±3.099	179.400 ±3.731	177.200 ±3.478	176.000 ±2.940	175.600 ±3.636	178.200 ±3.668	172.600 ±4.648	183.800 ±3.636	187.600 ±4.363

Table 10.6 Body weight of female Japanese quails of F-III group (sunflower oil fed group - treatment) in grams

Sl. No.	Weeks												
	4	5	6	7	8	9	10	11	12	13	14	15	16
1	74	116	156	160	178	176	168	184	188	150	212	194	194
2	80	104	136	164	180	178	168	166	172	148	188	200	194
3	70	104	120	164	174	178	174	180	168	130	182	174	180
4	78	118	142	174	180	168	178	170	168	148	174	188	190
5	74	98	132	164	168	166	166	170	170	134	168	176	190
6	78	118	134	164	168	182	174	172	155	134	184	168	174
7	78	108	144	180	184	188	192	198	192	168	194	214	210
8	76	108	140	178	200	192	188	186	190	154	202	208	208
9	76	104	126	166	168	178	178	170	180	174	182	182	184
10	80	112	140	184	186	178	182	188	148	202	206	198	200
Mean ±SE	76.400 ±0.980	109.000 ±2.150	137.000 ±3.162	169.800 ±2.656	178.600 ±3.162	178.400 ±2.498	176.800 ±2.751	178.400 ±3.288	173.100 ±4.648	160.400 ±6.672	189.200 ±4.458	190.200 ±4.806	192.400 ±3.636

Table 10.7 Body weight under the influence of dietary oils in male Japanese quails in grams (mean±SE)

Groups	Age in weeks						
	4	5	6	7	8	9	10
M-I	70.800 ±1.170	102.000 ±3.510	123.700 ±2.055	127.700 ±1.739	135.600 ±2.371	142.400 ±3.099	148.500 ±3.510
M-II	69.400 ±1.328	98.000 ±2.434	120.600 ±1.517	124.200 ±1.486	135.200 ±2.466	141.200 ±3.320	147.400 ±3.320
M-III	70.600 ±1.359	100.200 ±1.707	115.800 ±1.391	124.200 ±2.023	135.800 ±2.687	142.600 ±2.561	146.000 ±3.478

Table 10.8 Body weight under the influence of dietary oils in female Japanese quails in grams (mean±SE)

Groups	Age in weeks												
	4	5	6	7	8	9	10	11	12	13	14	15	16
F-I	74.400 ±1.170	104.200 ±3.731	129.800 ±3.225	150.800 ±3.889	163.800 ±4.016	168.000 ±3.035	162.600 ±3.994	164.000 ±4.110	156.600 ±4.174	165.400 ±4.047	163.400 ±4.300	166.200 ±3.004	175.200 ±4.047
F-II	74.700 ±1.960	108.600 ±2.814	137.800 ±3.446	166.000 ±3.510	178.200 ±3.099	179.400 ±3.731	177.200 ±3.478	176.000 ±2.940	175.600 ±3.636	178.200 ±3.668	172.600 ±4.648	183.800 ±3.636	187.600 ±4.363
F-III	76.400 ±0.980	109.000 ±2.150	137.000 ±3.162	169.800 ±2.656	178.600 ±3.162	178.400 ±2.498	176.800 ±2.751	178.400 ±3.288	173.100 ±4.648	160.400 ±6.672	189.200 ±4.458	190.200 ±4.806	192.400 ±3.636

Table 10.9 Comparison of body weight under the influence of dietary oils in male Japanese quails

Groups	Age in weeks						
	4	5	6	7	8	9	10
M-I Vs M-II	0.790	0.939	1.216	1.535	0.116	0.264	0.227
M-I Vs M-III	0.111	0.462	3.202*	1.308	0.055	0.049	0.505
M-II Vs M-III	0.627	0.743	2.336*	0.000	0.164	0.334	0.291

* Significant at 5% level

Table 10.10 Comparison of body weight under the influence of dietary oils in female Japanese quails

Weeks	t value												
	4	5	6	7	8	9	10	11	12	13	14	15	16
F-I Vs F-II	0.130	0.940	1.700	2.894**	2.831*	2.366*	2.826*	2.371*	3.441**	2.347*	1.452	3.719**	2.090
F-I Vs F-III	1.300	1.111	1.596	4.025**	2.887**	2.646*	3.029**	2.735*	2.648*	0.639	4.157**	4.225**	3.166**
F-II Vs F-III	0.773	0.112	0.171	0.862	0.090	0.222	0.090	0.543	0.424	2.335*	2.573*	1.060	0.846

* - Significant at 5% level
** - Significant at 1% level

Table 10.11 Comparison of body weight under the influence of dietary oils between weeks in male Japanese quails

Weeks	t value		
	M-I	M-II	M-III
4 Vs 5	8.454 **	10.341 **	13.573 **
5 Vs 6	5.351 **	7.900 **	7.127 **
6 Vs 7	1.490	1.699	3.419
7 Vs 8	2.693 *	3.812 **	3.440 **
8 Vs 9	1.746	1.450	1.829
9 Vs 10	1.301	1.325	0.786

* - Significant at 5% level
** - Significant at 1% level

Table 10.12 Comparison of body weight under the influence of dietary oils between weeks in female Japanese quails

Weeks	t value		
	F-I	F-II	F-III
4 Vs 5	7.593 **	9.875 **	13.770 **
5 Vs 6	5.188 **	6.580	7.322 **
6 Vs 7	4.153 **	5.740 **	7.945 **
7 Vs 8	2.318 *	2.601 *	2.127 *
8 Vs 9	0.832	0.247	0.049
9 Vs 10	1.108	0.430	0.432
10 Vs 11	0.249	0.262	0.373
11 Vs 12	1.264	0.085	0.932
12 Vs 13	1.515	0.505	1.561
13 Vs 14	0.338	0.946	3.580
14 Vs 15	0.533	1.896	0.152
15 Vs 16	1.786	0.669	0.364

* - Significant at 5% level
** - Significant at 1% level

Table 10.13 Comparison of body weight between sex under the influence of dietary oils in each group in each week in Japanese quails

Groups	Age in weeks						
	4	5	6	7	8	9	10
M-I Vs F-I	** 2.168	0.429	** 3.503	** 5.408	** 6.039	** 5.900	* 2.719
M-II Vs F-II	* 2.229	* 2.855	** 4.582	** 10.966	** 10.820	** 7.653	** 6.195
M-III Vs F-III	** 3.447	** 3.207	** 6.149	** 13.631	** 10.293	** 10.011	** 6.961

* - Significant at 5% level
** - Significant at 1% level

Table 10.14 **Comparison of overall body weight between sex under the influence of dietary oils in Japanese quails** MEAN ± SE

Sex	Weeks												
	4	5	6	7	8	9	10	11	12	13	14	15	16
Male	70.300 ±0.730	100.100 ±1.497	120.000 ±1.113	125.400 ±1.022	135.500 ±1.405	142.100 ±1.679	147.300 ±1.917						
Female	74.000 ±1.314	104.700 ±1.697	134.100 ±2.044	162.500 ±2.409	175.300 ±2.501	174.200 ±2.300	172.100 ±2.629	172.800 ±2.266	168.433 ±2.799	168.000 ±3.104	175.067 ±3.185	180.067 ±2.874	185.067 ±2.611
t value	* 2.484	* 2.051	** 6.047	** 14.166	** 13.864	** 11.271	** 7.639						

* - Significant at 5% level
** - Significant at 1% level

Table 10.15 Analysis of variance for the comparison of overall body weight under the influence of dietary oils between weeks-male and female Japanese quails

Character	k value	Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Body weight male	2	Factor A	6	131189.981	21864.997	366.6053**	0.0000
	4	Factor B	2	217.610	108.805	1.8243	0.1642
	6	AB	12	317.390	26.449	0.4435	
	7	Error	189	11272.300	59.642		
Body weight female	2	Factor A	12	392540.492	32711.708	176.4223**	0.0000
	4	Factor B	2	5901.174	2950.587	15.9132	0.0000
	6	AB	24	6712.892	279.704	1.5085	0.0610
	7	Error	351	65081.400	185.417		

** - Significant at 1% level

Table 10.16 Comparison of overall body weight of Japanese quails under the influence of dietary oils between weeks

Weeks	CD value	
	Male	Female
4 Vs 5	3.908 **	5.820 **
5 Vs 6	3.908 **	5.820 **
6 Vs 7	3.908 **	5.820 **
7 Vs 8	3.908 **	5.820 **
8 Vs 9	3.908 **	
9 Vs 10	3.908 **	
13 Vs 14		5.820 **

** - Significant at 1% level

Fig.7.1 BODY WEIGHT UNDER THE INFLUENCE OF DIETARY OILS IN MALE JAPANESE QUAILS

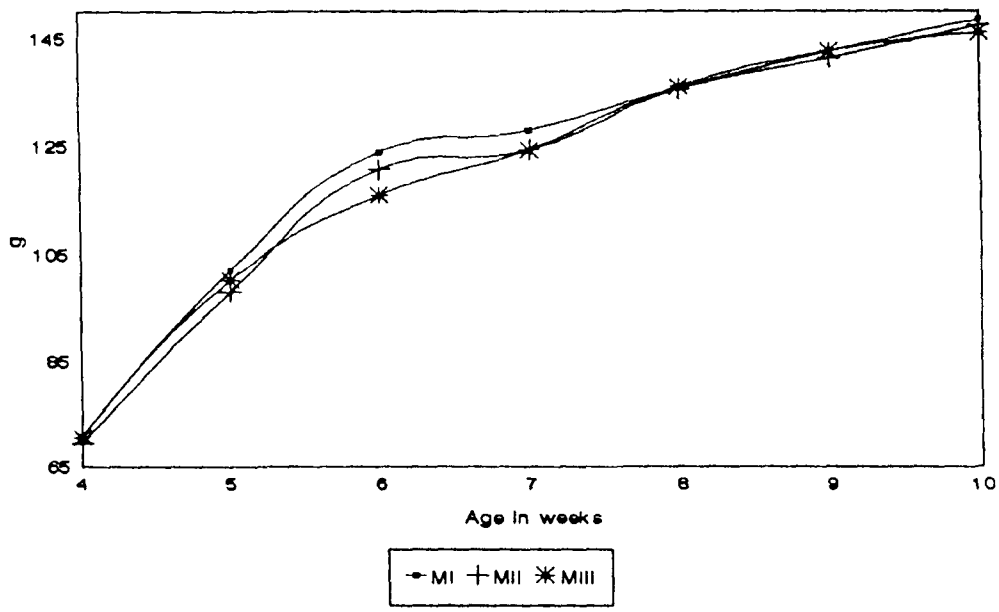
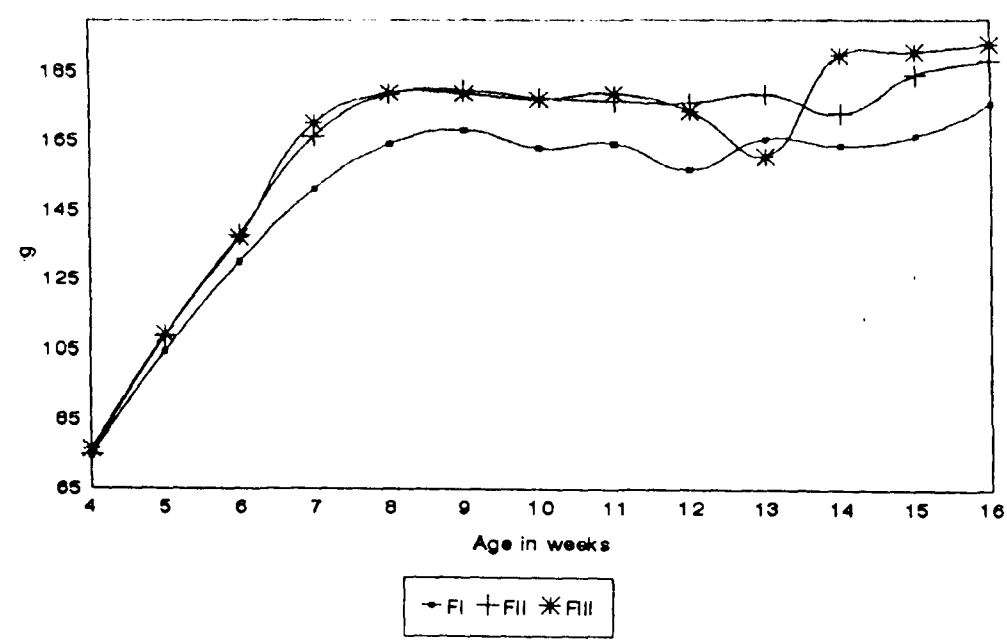


Fig.7.2 BODY WEIGHT UNDER THE INFLUENCE OF DIETARY OILS IN FEMALE JAPANESE QUAILS



4.8 Influence of dietary oils on feed efficiency of Japanese quails

The mean value for feed efficiency in male quails in groups M-I, M-II and M-III were 9.960 ± 0.420, 10.406 ± 0.379 and 9.668 ± 0.401 respectively (Table 11.1). On statistical analysis it was observed that there was no significant difference in feed efficiency of male Japanese quails under the three dietary oil treatments (Table 11.3). The feed efficiency observed in Japanese quail females under gingelley oil, coconut oil and sunflower oil treatments were 3.396 ± 0.163, 3.092 ± 0.120 and 3.076 ± 0.113 respectively (Table 11.2). The feed efficiency value calculated on egg mass basis in female quails of three dietary oil groups (F-I, F-II and F-III) were significantly different ($P \leq 0.05$) between the groups (Table 11.4, 11.5 and Fig.8.1). The value was highest in gingelley oil fed group and the value was lowest in sunflower oil fed group (Table 11.2).

Table 11.1 Feed efficiency on weight gain basis under the influence of dietary oils in male Japanese quails

No.	M-I	M-II	M-III
1	8.61	12.75	9.86
2	9.74	7.97	10.69
3	8.22	8.70	9.62
4	10.57	9.33	8.55
5	11.21	10.07	10.12
6	9.61	9.56	13.27
7	9.49	10.07	10.69
8	11.94	10.34	10.40
9	9.25	11.25	10.74
10	8.04	9.56	10.12
Mean±SE	9.960±0.420	10.406±0.379	9.668±0.401

Table 11.2 Weekly feed efficiency on egg mass basis under the influence of dietary oils in female Japanese quails

Age in weeks	F-I	F-II	F-III
7	4.67	3.94	3.53
8	3.07	2.94	2.67
9	3.20	2.68	3.35
10	3.09	2.84	3.49
11	3.30	3.05	3.02
12	3.27	2.95	3.21
13	3.20	3.29	2.68
14	3.27	3.11	3.03
15	3.49	3.03	2.70
Mean±SE	3.396±0.163	3.092±0.120	3.076±0.113

NB: Feed efficiency at sixth week is not taken into account since egg production was too low at sixth week

Table 11.3 Analysis of variance for the feed efficiency under the influence of dietary oils in male Japanese quails

Character	Source	Degrees of freedom	Sum of squares	Mean square	F-value	Probability
Feed efficiency (male)	Between treatments	2	2.763	1.381	0.861 NS	
	Within treatments	27	43.316	1.604		

NS - Non significant

Table 11.4 Overall weekly feed efficiency under the influence of dietary oils in female Japanese quails

Weeks	Feed efficiency Mean ± S.E
7	4.048 ± 0.332
8	2.893 ± 0.117
9	3.077 ± 0.203
10	3.140 ± 0.189
11	3.123 ± 0.088
12	3.143 ± 0.098
13	3.057 ± 0.189
14	3.137 ± 0.070
15	3.073 ± 0.229

Table 11.5 Analysis of variance for feed efficiency in female Japanese quails

Character	k value	Source	Degrees of freedom	Sum of squares	Mean square	F-value
Feed efficiency female	1	Replication	8	2.634	0.329	4.0680**
	2	Factor A	2	0.584	0.292	3.6079*
	-3	Error	16	1.295	0.081	

** - Significant at 1% level

* - Significant at 5% level

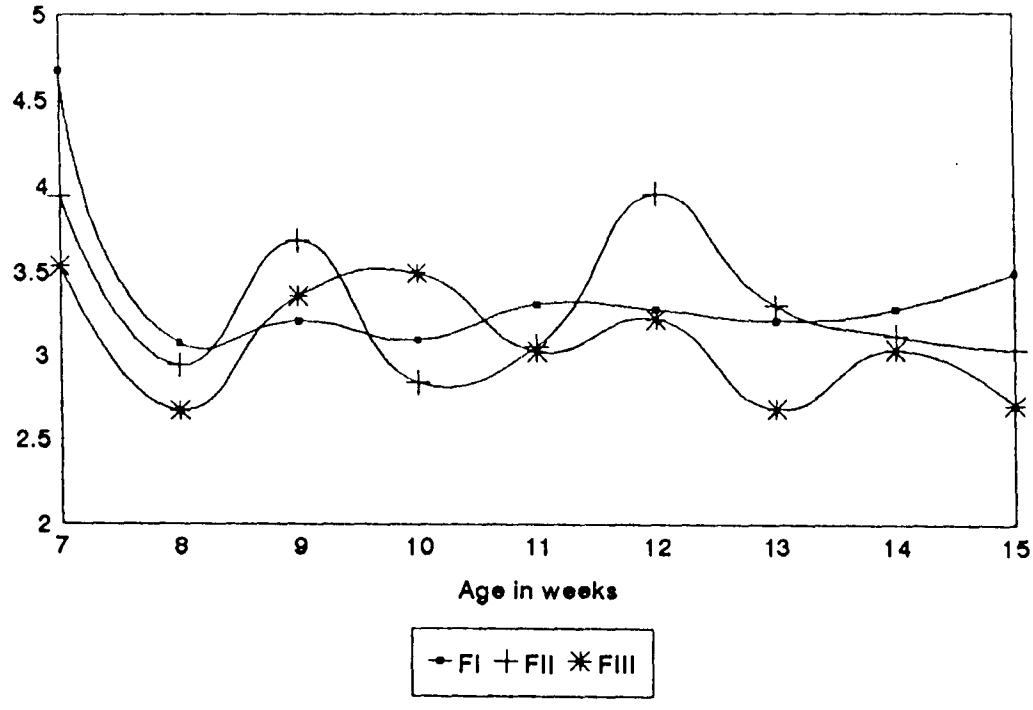
CD value showed no significant difference between groups in Female Japanese quails

Table 11.6 Comparison of overall feed efficiency in female Japanese quails between weeks under the influence of dietary oils

Weeks	CD value
7 Vs 8	0.903**

** - Significant at 1% level

Fig.8.1 FEED EFFICIENCY UNDER THE INFLUENCE OF DIETARY OILS IN FEMALE JAPANESE QUAILS



Discussion

DISCUSSION

5.1 Influence of dietary oils on lipid profile in plasma of Japanese quails

5.1.1 Total lipid

Statistical analysis revealed that there was no significant difference in the total lipid content in plasma among the groups, in male and female Japanese quails. The values are presented in Tables 4.4 and 4.9.

Reports indicate that dietary fat could not exert significant influence on lipid metabolism until it constitute 40 per cent of caloric intake (Ahrens *et al.*, 1957). In the present study dietary oils were added at 2 per cent level only in the quail ration which was presumably ineffective to cause perceptible alteration in the total lipid content of plasma. Reports in quails with reference to the influence of dietary oil treatments on plasma lipid content are scarce. Walker *etal.* (1951) were of the opinion that vegetable fats in the layer ration of White Leghorn birds as high as 18 per cent could only bring a negligible influence on the level of blood lipids. This was due to the bird's ability to tolerate high level of fat in diet without altering the lipid level in plasma.

However, reports on record stating an increase in total lipid content in plasma of chicken by feeding animal fat at 5 to 10 per cent level (Weiss and Fisher, 1957) and of rats by feeding cholesterol (Adamopoulos *et al.*, 1996). The higher amount of fat and cholesterol are deposited in liver, which are transported through blood to various parts of the body, resulting in an elevated total lipid content in plasma. The lower concentration of total lipid content in plasma of rats fed sunflower oil than cotton seed oil observed by El-Husseiny *et al.* (1980) was only due to increased excretion of sterols and free fatty acids in the former case. They used oils at 5 per cent level, while in the present study the levels of incorporation were only at 2 per cent, which was probably insufficient to exert a significant influence.

The level and interelationship between the lipid fractions are always maintained at a constant degree in fowl's body (Walker *et al.*, 1951). If synthesis of one of the lipid fractions is less, that change will reflect in all other fractions, since all the fractions are interrelated. A sudden change in one of the fractions cannot occur, since all the fractions have to be altered correspondingly. Hence, for a particular oil to exert its effect on the total lipid content in plasma it should be consumed in sufficient quantity to alter all the lipid fractions.

The influence of sex on the plasma total lipid content of Japanese quails under different dietary oil treatments was recorded in the study. The overall mean plasma total lipid content in male and female Japanese quails recorded were 704.567 ± 18.934 and 1454.033 ± 69.931 mg/dl respectively (Table 4.12; Fig.1.5). The values were in agreement with those reported by Shapira *et al.* (1979) in male quails and by Maurice and Jensen (1978) in female quails. The plasma total lipid content in female quails of all the groups were significantly ($P \leq 0.01$) higher than that in male quails indicating that sex was exerting a significant influence. Kirchher and Hartfiel (1974), Yu *et al.* (1976), Neill *et al.* (1977) and Joshi *et al.* (1992) observed that blood lipid content in White Leghnorn birds was closely correlated with sexual maturity and egg production. The higher plasma total lipid content observed in the present study in laying quails was in a line with the above reports. This higher level was a reflection of the increase in liver lipid turn out, during egg production. A similar report was also putforth by Noble and Cocchi (1990). Yolk on wet basis contains approximately 30 per cent of lipid. Main part of the yolk lipid is synthesised in liver and transported to the ovary via blood, which can be the reason for the higher total lipid content in blood of female quails.

5.1.2 Triglyceride

There was no significant difference in the plasma triglyceride content among the groups of both male and female Japanese quails. The mean values are presented in Tables 4.4 and 4.9.

A similar line of study in Japanese quails was not traceable from the available literature. Reports in other species in relation with the influence of dietary oils on the plasma triglyceride content were scanty. However, Rodriguez *et al.* (1993) and Castillo *et al.* (1994) got an elevated serum triacylglycerol level in chicks fed coconut oil (20%) in the diet. Coconut oil feeding leads to the enhanced secretion of insulin and utilization of glucose for triglyceride synthesis (Thampan, 1994). Insulin also stimulates the synthesis of triglyceride in liver. This effect was not observed in the present study which may be due to the fact that coconut oil used was only 1/10 of that used in the above trial. Kurup and Rajmohan (1994) also have observed that consumption of coconut oil in human beings did not elevate serum triglyceride level.

Conversely a decline in the plasma triglyceride content of pigs fed on saturated fat (tallow) over unsaturated fat (sunflower oil) was reported in rats by Klingenberg *et al.* (1995). This was due to lower absorption of tallow (animal

fat). But in the present study the oils used were vegetable oils all of which were not much different in their rate of absorption. A lower concentration of plasma triglyceride was observed by Phelteplace and Watkins (1990) in broiler chicken fed on diet having higher polyunsaturated: saturated fat ratio. The increased excretion of free fatty acids and sterols in polyunsaturated fat feeding lowered the plasma triglyceride concentration in the above study. Similarly feeding of sunflower oil in the diet of WLH layers resulted in lower triglyceride content in serum (Prakash *et al.*, 1996). Unsaturated fat in the diet will suppress the genes coding the lipogenic enzymes and also inhibit the VLDL and triglyceride synthesis in liver. Eventhough not significant a lowered plasma triglyceride content was observed in male birds of sunflower oil fed group in the present study. El-Husseiny *et al.* (1980) also got a lower triglyceride content in serum of rats fed sunflower oil than cotton seed oil. Higher levels (5%) of oils were used in the above study, of which sunflower oil enhanced the excretion of free and neutral fatty acids. The excretion of these unsaturated fat will be increased only when its level in the blood plasma become excess than normal. In the present study 2 per cent level of dietary oils as gingelley oil and sunflower oil (unsaturated fatty acids) could not cause an excess level of triglyceride than that produced by coconut oil. If at all any higher level of

triglyceride occur in plasma, it is stored in adipose tissue and the bird would try to maintain a constant level of triglyceride in plasma. In case of females the excess of triglyceride in plasma is eliminated through egg.

The overall mean value for plasma triglyceride content recorded in the male and female Japanese quails in the present study were 136.118 ± 6.030 and 765.160 ± 39.273 mg/dl respectively (Table 4.12). Significantly ($P \leq 0.01$) higher triglyceride concentration was observed in the present study in the female quails of the three groups (Table 4.11; Fig.1.5) which was indicative of the influence of sex on the plasma triglyceride content of Japanese quails. Brackenbury and El-Sayed (1984), Yu *et al.* (1976) and Joshi *et al.* (1992) also recorded a higher triglyceride content in female chicken. Itoh *et al.* (1995) also reported a higher plasma triglyceride content in female quails and chicken than their males.

In the laying hens, the cholesterol, triglyceride and phospholipid are synthesised in the liver transported to the ovary through blood as the lipoproteins and eliminated in the form of egg yolk. The higher plasma triglyceride value recorded in laying quails was actually due to the increased transportation of triglyceride from liver to ovary via blood for the formation of egg yolk which was under the influence of female sex hormone oestrogen.

5.1.3 Total cholesterol

There was no significant difference in the total cholesterol content in plasma among the groups in both male and female Japanese quails. Tables 4.4 and 4.9; Fig.1.1 and 1.3) indicate the observed mean values of plasma total cholesterol content in male and female Japanese quails.

Concurring reports are available in Japanese quails (Sun and Shim, 1994) and in rats (Klingenberg *et al.*, 1995). Yet a lower serum cholesterol level on feeding sunflower oil was observed by Daghir *et al.* (1960) in layers and by El-Husseiny *et al.* (1980) in rats. The explanation provided was that the increased excretion of fatty acids and sterols occurred on feeding unsaturated fat. Lack of decrease in cholesterol level in sunflower oil fed group (M-III and F-III) in the present study may be because of the lower level of sunflower oil (2%) used which may be insufficient to exert a significant influence on lipid metabolism.

However, Tanaka *et al.* (1981) noticed an increase in serum cholesterol content in chicks fed a fat free diet than coconut oil incorporated diet. This was due to lack of fat in the diet causing an activation of cholesterol synthesis in liver. A significant elevation in serum/plasma cholesterol concentration was observed with coconut oil feeding in chicks

(Castillo *et al.*, 1994) and in human beings (Kurup and Rajmohan, 1994). Coconut oil is having low content of essential fatty acids. In the absence of essential fatty acids, cholesterol esters fail to get metabolised giving rise to a higher serum cholesterol level. But in the present study the oil cakes used in the ration might have contained the essential fatty acids and hence plasma cholesterol was not elevated.

However, a higher concentration of total cholesterol in blood of Japanese quails fed exogenous cholesterol was recorded by Smith and Hilker (1973), Morrissey and Donaldson (1977a), Siegel *et al.* (1995) and Verma *et al.* (1995). The elevation of plasma total cholesterol was due to dietary cholesterol accelerating lipogenesis in the hepatic tissues.

Chicken can tolerate relatively large quantities of fat in their diet without having an appreciable increase in cholesterol content of blood plasma (Johnson *et al.*, 1959). The similar concentration of plasma total cholesterol in the three groups may be due to their inherent quality or may be due to the inability of the oils to exert an influence on the enzymes involved in the synthesis and degradation of cholesterol, particularly Hydroxy methyl glutaryl - coenzyme A (HMG-COA).

The overall mean plasma total cholesterol was significantly ($P \leq 0.01$) higher in male quails (211.757 ± 6.592) compared to female quails (128.294 ± 6.302 mg/dl) (Table 4.12; Fig.1.5). However, the plasma total cholesterol concentration in quails recorded by Morrissey and Donaldson (1977b), Shapira *et al.* (1979) and Joshi *et al.* (1982) were higher which may be due to the difference in the strain and age of the birds studied. In the present study plasma total cholesterol in female quails of the three groups were significantly lower than that of male quails. Joshi *et al.* (1982) and Girishkumar (1997) have recorded similar values in female quails. The logical conclusion is that it is due to the constant elimination of cholesterol through the yolk component of egg in case of females.

5.1.4 HDL-cholesterol

The plasma HDL-cholesterol concentration in adult male and female Japanese quails were not different among the groups. Tables 4.4 and 4.9; Fig.1.1 and 1.3) illustrate the mean values.

Reports on the influence of dietary oils on the plasma HDL-C content of Japanese quail are sparse in the availabile literature. However, few reports in other species like chicken, rodents, pigs and human beings are available on

dietary oil treatments. Unfortunately many observations in these studies are conflicting. Klingenberg *et al.* (1995) could not find any difference in HDL-C content of rats by feeding sunflower oil or beef tallow in the diet. According to them degree of saturation did not affect the sterol excretion. Since HDL transports cholesterol from peripheral tissues to liver for degradation, HDL-C also does not vary according to the differences in the degree of saturation of fat. Vijayammal *et al.* (1982) observed a lower HDL-C in rats fed sunflower oil. Sunflower oil in the diet tends to decrease the activity of triglyceride lipase in adipose tissue which caused reduced transport of lipids in HDL fraction from peripheral tissues to liver for degradation. In the present study sunflower oil may be insufficient at 2 per cent level to cause a significant effect.

Influence of dietary coconut oil to increase HDL-C was reported in rats (Baba *et al.*, 1993) in rabbits (Carlson and Kolteke, 1991) and in human beings (Kurup and Rajmohan, 1994). Coconut oil is deficient in essential fatty acids, in the absence of which cholesterol esters fails to be metabolised, leading to the accumulation of cholesterol in peripheral tissues. Cholesterol is then transported in HDL fraction to liver, resulting in a higher concentration of HDL-C of blood. Some reports stated that sunflower oil would depress the level of HDL-C, VLDL-C and LDL-C, while coconut oil would depress

VLDL-C and LDL-C and elevate HDL-C. Hence coconut oil exerts a beneficial effect. Allen and Wong (1993) did not find any significant difference in the HDL-C content of chicken fed even cholesterol as such in the diet. Concentration of HDL may be a function of time on the diet which tend to remain rather constant. According to Verma *et al.* (1995) combined addition of fat and cholesterol in the diet raised HDL-C level in quails. The addition of fat and cholesterol might have caused elevated transport of cholesterol from peripheral tissues to liver for degradation.

Degree of unsaturation of dietary fat might not have any significant influence on pattern of plasma lipoprotein cholesterol (Basilov and Vargas, 1989). This may be one of the reasons for the result observed in the study. HDL scavenges cholesterol from various parts of body to liver for degradation, thus performing a useful function. Smaller alterations in the cholesterol content in various parts of the body, due to the dietary oil treatments may be the reason for non-significant variation in HDL-cholesterol observed among the groups in both male and female quails.

The overall mean HDL-C value in male and female Japanese quails (the values in the three groups together) were 167.719 ± 6.471 and 25.678 ± 0.597 mg/dl respectively (Table 4.12; Fig.1.6). Male quails in each group had significantly higher

HDL-C content in plasma than female quails. Similar observations were made by Girishkumar (1997) in Japanese quail and of Yu *et al.* (1976) and Peebles *et al.* (1996) in chicken.

In male quails synthesis of lipid in the body is less compared to females. VLDL and LDL transports the synthesised lipids of tissue. Hence in male birds the concentration of (VLDL + LDL)-C was lower in the present study and the cholesterol content was seen mainly in conjugation with the HDL fraction. HDL transports lipids to liver for degradation.

5.1.5 (VLDL + LDL) - cholesterol

Irrespective of whether male or female there was no significant difference in the (VLDL + LDL)-cholesterol content among the groups. The mean values were presented in Tables 4.4 and 4.9; Fig.1.2 and 1.4.

Available literature did not reveal any influence of dietary oils on plasma (VLDL + LDL)-C content in Japanese quails. Klingenberg *et al.* (1995) did not find any difference in the concentration of VLDL-C and LDL-C in rats fed diets containing beef tallow (saturated fat) or sunflower oil (unsaturated fat). Animal fat (tallow) was not absorbed much. Sunflower oil (unsaturated fat) will cause increased excretion of free fatty acids and sterols. In the present study, the three dietary oils used could not exert a significant effect

on the synthesis of cholesterol in the liver. Hence the cholesterol content in the transport form also did not vary. A lowering effect on the levels (VLDL + LDL)-C in rats fed either coconut oil or sunflower oil (8%) in the diet than control was noticed by Vijayammal *et al.* (1982). According to them coconut oil and sunflower oil in the diet cause a depression in the triglyceride lipase activity in adipose tissue. Hence the triglyceride are broken down less and there will be less amount in the transport form also. While they used the oils at 8 per cent level in rats, in the present study the incorporation was only at 2 per cent level, which might not influence the enzyme activity at a significant level. Rodriguez *et al.* (1993) got an elevation in VLDL-C and LDL-C content by feeding coconut oil in the diet of *Gallus domesticus* chicks. Fat accumulation in liver of growing and laying chicken can be stimulated by feeding saturated fat. Hence the transport of cholesterol in the VLDL and LDL fraction was also more. In the present study 2 per cent coconut oil might not be able to cause accumulation of fat in liver. A higher LDL-C content in rats fed coconut oil compared to fish oil was observed by Ventura *et al.* (1989). Here polyunsaturated fatty acids in fish oil caused an increased excretion of sterols from the body. Unsaturated fat will inhibit the enzyme Hydroxy methyl glutaryl coenzyme A (HMG-CoA)-reductase and pyruvate carboxylase which are the

chief enzymes involved in the cholesterol synthesis and lipogenesis respectively. In the present study the unsaturated fatty acids used (gingelley oil and sunflower oil) may be insufficient to exert a significant influence on the synthesis and excretion. Verma *et al.* (1995) registered a higher lipoprotein cholesterol in Japanese quails fed exogenous cholesterol in the diet. Exogenous cholesterol feeding stimulates lipogenesis in liver.

Basilov and Vargas (1989) reported that degree of saturation of dietary fat had no influence on the pattern of plasma lipoprotein cholesterol. VLDL transports lipids that are synthesised in the body. Cholesterol is mainly synthesised in liver. Since there was no change in cholesterol content in liver due to dietary oil treatments it is unlikely to have any change in the transport form, VLDL-C. Since VLDL is the precursor of LDL there was no change in the LDL-C.

Female quails had significantly ($P \leq 0.01$) higher (VLDL+LDL)-C content in plasma (102.615 ± 5.873 mg/dl) than male quails (44.038 ± 1.280 mg/dl) vide table 4.12. Verma *et al.* (1995) and Girishkumar (1997) also observed a higher (VLDL+LDL)-C in adult female Japanese quails than male quails which were in agreement with the present study. The influence of sex on VLDL-C and LDL-C was also reported by Yu *et al.*

(1976) in White Leghorn chicken, who observed a higher value in female birds.

The very low density lipoproteins, which are rich in triglyceride and phospholipid, transport the lipid synthesised in the body, to various tissues. Low density lipoprotein (LDL) is the main carrier of cholesterol from liver to various tissues. The significantly higher level of (VLDL+LDL)-cholesterol in laying female quails recorded in the study was mainly due to an increase in very low density lipoprotein level which are the transport form of lipids from the liver to the ovary. The increase in the (VLDL+LDL)-C was due to an increase in the LDL-cholesterol also, which is formed from VLDL. The increased level of VLDL-cholesterol in females may be due to the decreased lipolysis as a result of low lipoprotein lipase activity in circulation under the influence of oestrogen (Griffin *et al.*, 1982; Yu *et al.*, 1976, Noble and Cocchi, 1990).

5.1.6 Phospholipid

The plasma phospholipid concentration did not exhibit any significant variation among the various groups in both sexes. The values are presented in Tables 4.4 and 4.9.

Sreekumar and Kurup (1978) recorded a lower serum phospholipid content in rats fed maize oil compared to

safflower oil. Safflower oil contains more unsturated fatty acids than maize oil, which causes increased excretion of free fatty acids. The more unsaturated fatty acids increase the intestinal growth of microorganisms which will consequently enhance the excretion of fatty acids and sterols. In the present study the sunflower oil used was only 1/10th of that used in the above study in rats. A higher serum phospholipid content in rats fed maize oil than sunflower oil in the diet was noticed by El-Husseiny *et al.* (1980) and it was stated that higher level (5%) of unsaturated fat in the diet would enhance the transportation of lipids to liver for degradation.

Plasma phospholipid has the function to stabilize the colloidal dispersion of cholesterol (Raghuram and Rugmini, 1995). Phospholipid level will alter only if there is significant change in the plasma cholesterol level. Here there was no significant change in plasma cholesterol content due to dietary oil treatments. Plasma phospholipid concentration can also alter if the oil in the diet is sufficient to alter the membrane fluidity and function, since they are one of the main constituents of membranes. The dietary oil used in the present study was only in normal level of 2 per cent.

There was significant influence of sex on the plasma phospholipid content of Japanese quails, the female quails in each group had significantly ($P \leq 0.01$) higher plasma phospholipid content than male birds (Table 4.12). The overall mean values recorded in the male and female quails were 349.061 ± 11.976 and 547.074 ± 25.465 mg/dl respectively (Table 4.12; Fig.1.5). In the present study higher levels of phospholipid content in plasma observed in all groups of female quails might have been due to increased transportation of phospholipids from the liver to the ovary for the formation of egg yolk (Yu *et al.*, 1976 and Neill *et al.*, 1977). Yu *et al.* (1976) recorded a higher plasma phospholipid content in White Leghorn laying hen. Neill *et al.* (1977) were of the opinion that a significant increase in the concentration of plasma phospholipid occur at the onset of sexual maturity in females and at the time of egg production. Higher plasma phospholipid level in laying quails could be due to the influence of female sex hormone oestrogen during the laying period (Noble and Cocchi, 1990).

5.2 Influence of dietary oils on lipid profile in liver of Japanese quails

5.2.1 Total lipid

The mean value for the total lipid content in liver of the male and female Japanese quails in the three groups are presented in Table 5.4 and 5.10; Fig.2.1 and 2.2. Analysis of variance revealed that there was no significant difference among the groups in male quails (Table 5.7). The female quails of gingelley oil fed group had significantly higher total lipid content in liver than the coconut oil and sunflower oil fed groups (Table 5.10 and 5.11).

A similar line of study for comparing the lipid content in Japanese quails under the influence of gingelley oil, coconut oil and sunflower oil was not available. Chung *et al.* (1965) observed a higher level of total lipid in liver of laying hen fed hydrogenated coconut oil. Saturated fatty acids at higher level (10%) would cause accumulation of fat in the liver. Sim and Bragg (1978) got a higher level of total lipid in liver of laying hen fed hydrogenated coconut oil in the diet than safflower oil. The saturated fatty acids at higher levels (10%) cause accumulation of fat in liver and the poly unsaturated fatty acids in the diet have a suppressing effect on fatty acid biosynthesis in liver of laying hens.

Triglyceride lipase is involved in the intracellular hydrolysis of triglycerides. In adipose tissue triglyceride lipase serves to mobilize fatty acids which are transported to the liver and other tissues. Triglyceride lipase activity was found to be lower in coconut oil fed group and sunflower oil fed group, compared to groundnut oil fed group in rats (Vijayammal *et al.*, 1982). Groundnut oil is almost similar to gingelley oil in its fatty acid composition (Ghafoorunissa, 1995). The lower triglyceride lipase activity in coconut oil and sunflower oil fed groups may result in lowering of the triglyceride content in liver. Eventhough the decrease in triglyceride content in liver in these two groups were non significant, this may contribute partially to the lowering of the total lipid content in liver. In male quails eventhough nonsignificant, lowering of total lipid content in liver of coconut oil fed group and sunflower oil fed group were noticed.

A higher deposition of lipid in tissues of rats fed sunflower oil than those fed maize oil in the diet was noticed by El-Husseiny *et al.* (1990). Sunflower oil contains more long chain fatty acids than maize oil. The long chain fatty acids are difficult to get oxidised to carbon dioxide. So the fat accumulation was more in sunflower oil fed group than maize oil fed group. In the present study the amount of sunflower oil used did not cause an elevation in the fat

level. A lowering of lipid content in liver by feeding sunflower oil in the diet of rats was reported by Sreekumar and Kurup (1978) also. The unsaturated fat will enhance the transportation of lipids to liver for degradation. Polyunsaturated fatty acids have the ability to suppress the expression of genes coding for lipogenic enzymes (Clarke *et al.*, 1990) that is by inhibition of lipogenesis at the point of pyruvate carboxylation and hyroxy methyl glutaryl coenzyme A (HMG-CoA) reductase the rate limiting enzyme in the cholesterol biosynthesis.

Kruski and Narayan (1972), Sim and Bragg (1978) and Kim and Han (1985) observed an increase in the total lipid content in liver by feeding exogenous cholesterol in the diet of chicken. Exogenous cholesterol feeding causes deposition of lipid in liver. Increased concentration of lipid in liver might occur due to various factors as increase in feed intake, increased digestion, bile production and absorption causing increased utilization of dietary fat or increased transfer of dietary lipids to the liver and/or due to the increased lipogenesis as such. Variation in hepatic total lipid content can also occur due to the differences in the amount, availability or both of some dietary factor (Maurice and Jensen, 1977).

The mean value observed for the total lipid content in female quails (10.567 ± 0.127 g%) was significantly ($P \leq 0.01$) higher than that of male quails (5.367 ± 0.107 g%) vide Table 5.14. Theyer *et al.* (1973) and Neill *et al.* (1977) have noticed higher total lipid content in liver of laying chicken. In case of birds lipogenesis is largely confined to the liver and assumes major significance during the sexual development (Pearce, 1974). The increased liver lipid content in laying quails may be due to the influence of oestrogen, stimulating hepatic lipid synthesis (Nirmalan and George, 1972) and an increase in the activities of liver lipogenic enzymes such as ATP citrate lyase and malic enzyme after the commencement of laying compared to nonlaying pullet and White Leghorn cockerel (Pearce, 1971). As in the present study, Leclercq (1984) and Furuse *et al.* (1991) also reported that there was an increase in liver lipid content in female birds which may be due to the influence of oestrogen causing increased lipogenesis or increased lipogenic enzyme activity. A significant increase in the liver lipid content in broiler chicks was confirmed by Bolden *et al.* (1984) by implanting oestradiol dipropionate and implanted chicks showed significantly higher total lipid content in liver.

5.2.2 Triglyceride

There was no significant difference in the triglyceride content in liver among the groups in both male and female Japanese quails. The values are presented in Tables 5.4 and 5.10; Fig.2.1 and 2.2.

Research works regarding the influence of dietary oils on the liver triglyceride content of Japanese quails are scanty. Triglyceride content in liver did not differ significantly by feeding different dietary fats in chicken (Phelteplace and Watkins, 1990) and in rats (Chiang-Meng Tsan *et al.*, 1995). They used combinations of animal fat and fish oil in the diet, which were not able to exert any difference in the rate of absorption or excretion of fatty acids and sterols. However, the general trend noticed was that inclusion of fat with saturated fatty acid would tend to cause an increase in triglyceride content of liver. Tanaka *et al.* (1981) observed an increased liver triglyceride content in chicks fed on a fat free diet compared to those fed coconut oil or safflower oil in the diet. Feeding fat decreases the hepatic synthesis of lipids. Similarly El-Husseiny *et al.* (1980) got a lowered concentration in triglyceride content in liver of rats fed sunflower oil in the diet compared to cotton seed oil. The more unsaturated fatty acid (sunflower oil) caused an inhibition in the synthesis of triglyceride and VLDL in the

liver. But in the present study the sunflower oil used was only at 2 per cent level which was not able to cause any influence on the synthesis or degradation of triglyceride. According to Naber and Biggert (1989) and An *et al.* (1995) feeding of poly unsaturated fatty acids tend to decrease the triglyceride content in liver of chicken and increase intestinal growth of microorganisms resulting in the increased excretion of faecal sterols and free fatty acids.

The non significant variations in the triglyceride content in liver observed in the study may be due to the inability of the dietary oils used at 2 per cent level to exert a significant influence on the triglyceride lipase activity in adipose tissue. Coconut oil and sunflower oil at higher levels may reduce the triglyceride lipase activity in adipose tissue that may result in less transportation of fatty acids to liver, leading to decreased triglyceride synthesis in liver.

The overall mean values for liver triglyceride content in female Japanese quails (6.761 ± 0.087 g%) was significantly ($P \leq 0.01$) higher than male quails (2.139 ± 0.041 g%) which may be due to the influence of female sex hormone oestrogen (Park and Cho, 1990; Leenstra, 1986; Furuse *et al.*, 1991). Girishkumar (1997) also recorded a higher liver triglyceride

content in female quails (6.630 ± 0.18 g%) than males (1.99 ± 8.15 g%) at ninth week of age. A higher value in laying chicken was also reported by Noble and Cocchi (1990). The highest proportion of lipids present in liver is in the triglyceride form. Therefore in the laying bird increased lipid synthesis in the liver is reflected as the triglyceride content. Laying birds are under the influence of oestrogen which can favour lipid synthesis in liver for the subsequent deposition in egg yolk.

5.2.3 Total cholesterol

No significant variation could be noticed in the total cholesterol content of liver in both male and female quails (Table 5.5). The mean values of males and females are presented in Tables 5.4 and 5.10; Fig.2.1 and 2.2.

Morrissey and Donaldson, 1977a; Treat *et al.*, 1960; Chung *et al.*, 1965 and Theyer *et al.*, 1973 have reported that birds can tolerate high amount of fat in the diet without altering the lipid synthesis or deposition in the liver. Castillo *et al.* (1994) also did not observe any significant variation in the liver cholesterol concentration by feeding coconut oil in the diet of chicks. Coconut oil contains medium chain fatty acids which are oxidised to carbon dioxide easily. Chung *et al.* (1965) recorded a lower value for liver cholesterol

content in laying hens fed hydrogenated coconut oil compared to corn oil or lard when they were fed along with cholesterol. Coconut oil in the feed was metabolised easily than the other fats. Weiss *et al.* (1967) reported an elevation in hepatic synthesis of cholesterol on feeding unsaturated fat (safflower oil) in the diet of laying hens. Safflower oil contains trans-fatty acids which are hypercholesterolemic. The amount of trans-fatty acids consumed in the sunflower oil (unsaturated fat) in the present study was lower, since the level of oil used in the study was only 2 per cent. Similarly, El-Husseiny *et al.* (1980) got a lower value for liver cholesterol in rats fed maize oil than sunflower oil. The more unsaturated fat (sunflower oil) in the above experiment enhanced the transportation of cholesterol to liver for degradation. Unsaturated fatty acids will also promote the growth of intestinal microorganisms, which promote the faecal excretion of sterols.

Chung *et al.* (1965) had the opinion that addition of cholesterol to the high fat diet, but not to the basal diet elevated the liver cholesterol level in the laying hens. Addition of cholesterol resulted in elevation of the liver cholesterol content in male birds (Sutton *et al.*, 1984; Ueda *et al.*, 1995) and in rats with cholesterol and egg (Liu Liyun *et al.*, 1995) with cholesterol and lard (Nakasa *et al.*, 1995).

High fat in the diet enhanced the absorption of cholesterol and the cholesterol synthesis in liver.

The non significant variation in the liver cholesterol content among groups in the present study may be due to the insufficient level of the oils used to exert a significant influence on the enzymes involved in either the synthesis or degradation of cholesterol.

The overall mean liver cholesterol content in males and female Japanese quails in the present study were 1.464 ± 0.087 and 2.137 ± 0.089 g% respectively (Table 5.14; Fig.2.3). Female quails in each group had significantly higher total cholesterol content in liver than the male quails. A higher value for total cholesterol in females was also recorded by Noble *et al.* (1988) in chicken. Liver is the site of synthesis of lipid in birds. The increased liver cholesterol content in female birds might be due to the increased synthesis of cholesterol in the liver under the influence of oestrogen, for transportation into the ovary for the formation of the egg yolk.

5.2.4 Phospholipid

The phospholipid content in liver among the male birds was significantly higher in gingelley oil fed (MI) group

compared to sunflower oil fed (MIII) group. There was no significant difference between the coconut oil fed group M-II and sunflower oil fed group M-III and also between gingelley oil fed group M-I and coconut oil fed group M-II in male birds (Table 5.6). Scrutiny of results revealed no significant difference among the groups in female birds (Table 5.11).

In a similar study Sreekumar and Kurup (1978) recorded a higher liver phospholipid content in rats fed sesame oil than coconut oil and safflower oil in the diet. Safflower oil is similar in its degree of unsaturation to sunflower oil. Coconut oil contains saturated fat and the degree of unsaturation of gingelley oil lies in between coconut oil and sunflower oil. Unlike many other reports, unsaturated fat (sunflower oil) did not give a significantly lower value in the above study. They were of the opinion that it is not the degree of unsaturation, but the triglyceride structure is responsible for its effect in lipid metabolism. Previous reports narrate that the unsaturated fats enhance the transport of cholesterol from serum to liver thereby increasing the hepatic degradation of cholesterol. It is possible that the unsaponifiable portion of fat may also be involved in lowering the lipid content in liver. Sunflower oil is rich in unsaponifiable fraction like alpha tocopherol. This may be the reason for the lower phospholipid content in

liver of sunflower oil fed group (MIII) of male birds in the present study. In female birds the lowering of the liver phospholipid content in sunflower oil fed group was not at a significant level. This may be due to the interaction of factors like sex hormones on the lipid profile.

According to El-Husseiny *et al.* (1980) feeding of sunflower oil containing diet in rats produced lower liver phospholipid content than those fed olive oil or maize oil. The higher excretion of free fatty acids in the faeces was the reason for this. In the present study the sunflower oil used might not be sufficient to bring about such an effect. Chiang-Meng Tsan (1995) noticed a lower liver phospholipid content in rats fed unsaturated fat (fish oil) than saturated fed (lard).The explanation is that the saturated fats are metabolised less easily than unsaturated fats. But in the present study the coconut oil used was only 2 per cent which might not have created a difficulty in lipid metabolism (oxidation). However, chicks fed on a diet with coconut oil produced lower liver phospholipid content than those fed on a fat free diet (Tanaka *et al.*, 1981), fat free diet enhanced the synthesis of lipids in the body.

Gingelley oil contains more oleic acid than coconut oil and sunflower oil. Oleic acid enhances the utilization of

fat. This may also contribute to the higher phospholipid content in liver of gingelley oil fed group.

The overall mean values of phospholipid content in the liver of male and female Japanese quails were 1.604 ± 0.073 and 1.509 ± 0.056 g% which were not significantly different (Tables 5.13 and 5.14). Higher phospholipid synthesis occur in female birds at sexual maturity, under the influence of oestrogen, which declines later resulting in lowering of the level. In female quails liver phospholipid content was not significantly higher because the values were estimated at 16th week of age at which time the oestrogen level might have been lowered from the peak level present at the time of sexual maturity. Another reason for the non significant variation in the liver phospholipid content between male and female quails may be due to the constant elimination of phospholipid in the egg. Phospholipid content in liver of male birds was as high as that of females since phospholipids, unlike other classes of lipids have more functions in the body. They form part of the membranes and are part of precursors of prostaglandins. The phospholipid in male birds is not transferred into the yolk unlike in females, but continuously recirculated in the body.

5.3 Influence of dietary oils on weight of the liver in Japanese quails

The weight of the liver recorded in male and female Japanese quails of the three groups are presented in Tables 6.1 and 6.2). Irrespective of whether male or female there was no significant difference in the weight of the liver among the groups.

No significant variation in the weight of the liver in chicken was also recorded by feeding different vegetable oils in the diet (Oruwari *et al.*, 1993; An *et al.*, 1995). The oils used in the above studies were not able to exert a significant influence on liver lipid synthesis. Different types of dietary fatty acids also could not influence the liver weight in Japanese quails (Vilchez *et al.*, 1991). According to them dietary fatty acids could alter only the fatty acid composition of the liver lipids. Increase in liver weight occur only due to hyperplasia or hypertrophy of liver cells. Since the energy content of the three feeds in the present study were the same, there were no difference in the protein synthesis or liver cell enlargement among the groups.

Morrissey and Donaldson (1977a) recorded a higher liver weight in Japanese quails fed 10 per cent fat and 1 per cent cholesterol. This was due to higher lipid deposition in the

liver of the birds. In the present study no variation in the weight of the liver among the groups was noticed which may probably be due to the insufficient quantity of oils given to cause an elevation/degradation of lipid content in liver.

Incidentally male quails had a significantly lower liver weight (2.430 ± 0.933 g) than female quails (6.930 ± 0.383 g) as per Table 6.4. Raji (1997) also recorded a lower value for the weight of the liver in male quails (2.134 ± 0.07 g) than female quails (5.068 ± 0.283 g). The higher liver weight in female quails may be due to their higher body weight attained at sexual maturity.

5.4 Influnence of dietary oils on lipid profile in egg yolk of Japanese quails

5.4.1 Total lipid

Irrespective of the age, the total lipid content in egg yolk was not different among the groups. The values are presented in Tables 7.4, 7.5 and Fig.4.1. Reiser *et al.* (1951) and Marion and Edwards (1962) have observed that total lipid content in egg yolk was not altered by dietary fats. Egg yolk is least susceptible to changes since the hen attempts to provide a desirable environment for embryonic development. Chung *et al.* (1965) also observed that the

percentage lipid content of egg yolk of WLH birds was not significantly influenced by supplementing hydrogenated coconut oil at 10 per cent level in the diet. Egg yolk was most resistant to dietary change and the excess fat in the feed is deposited in the abdominal adipose tissue with a minimum of change. Jiang *et al.* (1991) failed to observe any change in the total lipid content in the egg yolk of laying hen by feeding different types of sunflower seed with varying proportion of fatty acids. They used the same level of the sunflower seed, and only the fatty acid composition was different. The differences in the fatty acid composition of the diet could alter only the fatty acid composition of the yolk, but not the percentage content of lipids.

Lack of variation in the total lipid content in egg yolk among the groups in the present study may be due to the fact that egg yolk is the main source of energy and nutrients to the developing embryo. Yolk is mainly composed of lipids and alteration in the yolk may affect the survival of the embryo. With regard to the effect of age on total lipid in egg yolk, there was significant increase in the total lipid content in egg yolk as the age advanced. The mean value for total lipid content in egg yolk at 14th, 15th and 16th week of age were 23.540 ± 0.485, 26.957 ± 0.441 and 31.601 ± 0.894 g% respectively (Table 7.14). Katsuya *et al.* (1973) and Miric *et al.* (1973) have recorded the yolk total lipid content as 23.2

to 30.8 per cent and 32.92 to 35.37 per cent respectively. Shafey (1996) observed an increase in the yolk total lipid content per egg in older hens compared to the younger hens, due to the increase in weight of eggs. In the present study the reason for the increase in total lipid content in egg yolk observed as age advanced, may possibly be due to condensed consistency of the yolk (?)

5.4.2 Total cholesterol

The total cholesterol content in the egg yolk of the three groups of Japanese quails (F-I, F-II and F-III groups) on the last day of 14th, 15th and 16th week of age are presented in Table 7.10; Fig.4.2. It was observed from the statistical analysis that yolk cholesterol content was not significantly different among the groups in each week (Table 7.11).

According to Sun and Shim (1994) the cholesterol concentration in the egg yolk of Japanese quails fed fish oil or sunflower oil in the diet for a period of seven weeks, was not significantly different. Eventhough polyunsaturated fatty acids enhance the faecal excretion of sterols, they were not able to change the excretion of cholesterol in the egg yolk. Experiments of Reiser *et al.* (1951) and Edwards *et al.* (1962) indicated that yolk cholesterol is resistant for changes due

to the alteration in dietary fat. This was due to the ability of the hen to maintain an optimum condition for the development of the embryo. No influence on the total cholesterol content in egg yolk was also recorded in WLH birds, by feeding sunflower oil in the diet (Hirata *et al.*, 1986) and by coconut oil in the diet (Meluzzi *et al.*, 1996). The degree of saturation of dietary fat was not able to influence the cholesterol content in egg yolk of the birds. Chung *et al.* (1965) recorded an increase in the total cholesterol content in egg yolk by feeding hydrogenated coconut oil in the diet of laying hens. The explanation was that saturated fatty acids try to reduce triglyceride synthesis and enhance cholesterol synthesis, which is transported to the ovary for subsequent deposition in the egg yolk. Sim and Bragg (1978) got a reduced total cholesterol content in egg yolk of hens fed safflower oil in the diet than hydrogenated coconut oil. According to them unsaturated fatty acids absorbed more from the intestine, since the fatty acid binding protein had higher affinity towards unsaturated fat. Grashorn (1994) observed that when laying hens were fed different types of dietary fats, the lowest egg cholesterol concentration was in hens fed diets containing soyabean oil with the widest ratios of polyunsaturated : saturated fatty acids and the highest cholesterol concentration was recorded by them with coconut oil. Polyunsaturated fatty acids are

metabolised easily and saturated fatty acids are accumulated in liver. But in the present study such an effect was not observed. Weiss *et al.* (1967) and Naber (1983) recorded an elevation in the egg yolk cholesterol content in laying hens on feeding the birds with unsaturated fatty acid rich oils. Poly unsaturated fatty acids are absorbed and eliminated through the egg easily.

Yolk is a route of elimination of fat in laying hen. Many reports state that unsaturated fatty acids cause an elevation in the elimination of cholesterol. But in the present study no significant variation was observed due to the dietary oil treatments. A minimum level of total cholesterol content should always be maintained in the egg yolk for the development of the embryo. It is likely that pharmacological or dietary manipulations alone would not produce a substantial change in the cholesterol content of egg yolk. When the cholesterol content in the body is lowered and a critical level is reached cessation of egg production occur (Hargis, 1988). Marks and Washburn (1977) also observed that the inability to reduce markedly egg cholesterol level was due to a physiological control mechanism that ultimately caused a cessation of egg production when yolk cholesterol deposition was inadequate for survival of the embryo. Yolk cholesterol level will not be increased too much, since a certain balance

between the lipid fractions in the body and egg yolk has to be maintained.

Regarding the influence of age on the yolk cholesterol concentration there was significant elevation in the level at 15th and 16th week compared to the 14th week of age. The yolk cholesterol concentration at 14th, 15th and 16th week of age were 2.268 ± 0.056, 2.620 ± 0.059 and 2.632 ± 0.086 g% respectively (Table 7.14). The higher value observed at 15th and 16th week of age might be due to interaction of other factors like sex hormones on the lipid profile of the bird. Marks and Washburn (1977) and Chand (1980) who recorded similar values in quails as 24.1 mg/g yolk and 2.18 g% respectively. The increase in cholesterol content per egg in Japanese quails and chicken as age advanced was only due to the increase in size of the yolk observed by Hammad *et al.* (1996) and Hall and McKay (1993). In the present study too there was an increase in g% of yolk cholesterol content possibly due to increased consistency of yolk as age advances.

5.5 Influence of dietary oils on production performance of Japanese quails

5.5.1 Egg production

The age at first egg, 38th day was earlier in the coconut oil (F-II) and sunflower oil (F-III) fed groups than in

gingelley oil fed (F-I) group (control) which was on a later date (41st day) vide Table 8.7. Above 50 per cent production was recorded at the seventh week in all the groups. Eventhough, the value for peak production (88.1%) was higher in coconut oil fed group (F-II) it was attained only in a later age (as tenth week) in comparison to gingelley oil fed group (F-I) and sunflower oil fed group (F-III) where peak production was achieved in the eighth week of age (Table 8.1). The age at first egg in Japanese quails varied from 35 to 51 days (Wilson *et al.*, 1961; Garret *et al.*, 1972; Narahari *et al.*, 1986; Sreenivasaiah and Joshi, 1988 and Philomina, 1994). Tiwari (1976) reported the age at 50 per cent production and peak production (95%) as 67 and 195 days of age respectively and the corresponding values reported by Sreenivasaiah and Joshi (1988) were 54 to 59 days and 80 to 106 days of age respectively. In the present study age at first egg in the treatment groups (F-II and F-III) were slightly earlier than the control (F-I). The age at 50 per cent production and peak production were also earlier than the reported values (Table 8.1). This may be due to the variation in the strain, feed or the experimental conditions.

Egg production in the present study was significantly higher in coconut oil fed (F-II) group (76.905 ± 6.964%) compared to gingelley oil fed (F-I) group (71.784 ± 7.028%) vide Table 8.1. There was no significant difference in the

production between F-I and F-III group and also between F-II and F-III groups. Significantly lower egg production observed in gingelley oil fed group may be due to deficiency of calcium in that group. The gingelley oil contains more palmitic acid, which can cause soap formation with major minerals resulting in poor absorption of these minerals.

Egg production was not influenced by dietary sunflower oil in chicken (Karunajeewa *et al.*, 1989; Prakash *et al*, 1996) and by diets containing coconut oil (Grashorn, 1994). The feed consumption, feed efficiency and the egg production in the treatment groups in the above studies were not different from the control group. Parsons *et al.* (1993) also did not observe any change in egg production by adding fat in the diet. The dietary fats were not favouring egg production in these studies.

As the age advanced egg production also improved to a certain extend, significantly higher egg production was recorded at the seventh week compared to the sixth week and at the eighth week compared to the seventh week of age (Tables 8.4 and 8.5). Egg production improved after the onset of sexual maturity upto peak production.

Tiwari (1976) recorded that egg production in Japanese quails increased as age advanced upto 78 days of age (74.87%).

Shrivastava *et al.* (1994) and Philomina (1994) recorded peak egg production attained by the 16th to 17th weeks of age in Japanese quails

5.5.2 Egg weight and egg mass

Egg mass is the product of egg weight and egg number. Eventhough the egg mass was not different among the groups, the egg weight was significantly higher in sunflower oil fed (F-III) group compared to coconut oil fed group (F-II). There was no significant difference in the egg weight between the groups F-I and F-II and also between F-I and F-III (Table 8.6). A significantly higher egg weight was recorded in chicken,fed soyabean oil compared to tallow (Scholfyssek, 1991), palm oil compared to coconut oil (Piliang, 1994) and soyabean oil compared to coconut oil (Halle, 1996; Meluzzi *et al.*, 1996). All these reports indicated a higher egg weight on feeding unsaturated fat compared to saturated fat. In the present study also a similar observation highest egg weight in F-III (sunflower oil fed group) was recorded. This may be due to the higher level of protein retention in the body by the unsaturated fats.

The egg production observed in the study was lower in gingelley oil fed (F-I) group compared to the other two groups (F-II and F-III), but egg weight was better in this F-I groups

than that of the coconut oil fed (F-II) group. Gingelley oil which is rich in monounsaturated fatty acids can retain proteins in the body more than the coconut oil. In coconut oil fed group (F-II) eventhough the egg weight was lower, egg production was better than sunflower oil fed groups, the sunflower oil fed group had the highest egg weight.

Regarding the influence of age, on the egg weight and egg mass both values were significantly higher at seventh week compared to sixth week of age and the egg weight was higher at 13th week compared to 12th week (Tables 8.3 and 8.5). The egg weight and egg mass increased upto the stage of peak egg production. Sreenivasaiah and Joshi (1988) also recorded ascending values for weight of quail eggs upto 10 weeks of age. As the age advanced the weight of egg increased markedly (Tiwari and Panda, 1978), the formation of egg production becomes more efficient with the advancement of age.

5.6 Influence of dietary oils on feed consumption of Japanese quails

Feed consumption in each group of Japanese quails (males and females) under dietary oil treatments was recorded daily and the feed consumption/bird in each week is presented in Tables 9.1 and 9.2. Analysis of the results revealed that there was no significant difference in the feed consumption

among the groups in both male and female Japanese quails. Available literature did not reveal the existence of the influence of dietary oils on the feed consumption in Japanese quails. Feed consumption of Japanese quail hens was higher on a diet with palmitic acid (3%) than on diets with oleic or linoleic acid at the same level (Vilchez *et al.*, 1990) which may be due to the inability of the birds to utilize palmitic acid so efficiently as the other oils when they form the major component of fat in the diet.

In the present study the small variation in values observed in male and female Japanese quails in the three groups were not consistent throughout the experiment. Hence a conclusion could not be drawn on the influence of these dietary oils on the extent of feed consumption to denote one particular oil as superior. It is well known that bird eat for calorie and it has taste preferences. The feed consumption was not different between groups since the caloric density of the three oil diets were the same. More over 2 per cent of the oil may be insufficient to exert any difference in taste of the three diets.

The feed intake in Japanese quails recorded in the present study was similar to that reported by Panda (1990) and Christaki *et al.* (1994). Feed intake/bird/day increased during the growth of the bird. Panda (1990) recorded the feed consumption for four, five and six-week old Japanese quails

and in adult (10-12 week-old quails) as 15, 17, 21 and 23.8 g/bird/day.

The feed consumption in female quails was significantly higher than that of male quails in each group. Panda (1990) also recorded female quails to consume more feed. Raji (1997) recorded the feed consumption of male and female Japanese quails at fortnightly intervals from second to 16th week of age and noticed that feed consumption in female quails was significantly higher than that of males. Increased growth rate in female birds could be the reason for their higher feed requirement and consumption.

5.7 Influence of dietary oils on body weight of Japanese quails

There were no significant difference in body weight among the groups in male Japanese quails during major part of the experiment (Table 10.9). Among the females the body weight of quails in gingelley oil fed group (F-I) was significantly lower during most part of the experimental period (Table 10.10) which may be due to the lower mineralisation of the bones in them. Gingelley oil contains more palmitic acid which cause soap formation with major minerals resulting in poor absorption of the minerals including calcium. In male quails there was no significant difference in the body weight among the groups. This may be due to the insufficient feeding time

(10 weeks) provided for the male quails to get a marked response.

However, Rupic *et al.* (1995) recorded a higher body weight in chickens fed on diets supplemented with fat at 10.5% levels from different sources including sunflower oil, than at 4.5 per cent level. This might be due to higher energy retention at higher levels of dietary fats. Shrivastava and Panda (1993) recorded a higher body weight in Japanese quails fed groundnut oil than beef tallow and the lower body weight observed in beef tallow group was due to higher excretion of fat without proper digestion. Animal fats are wasted more with a lower rate of absorption due to their increased potency for soap formation.

In the present study the feed intake and feed efficiency were not different among the groups. Hence the body weight was also not different among the groups in males. Olomu and Baracos (1991) also did not observe any difference in body weight of WLH chicks fed in various proportions of animal tallow or flax seed oil. The absorption and utilization of fat were same in all the groups.

Male quails of all the groups showed significant increase in body weight upto sixth week, whereas female birds of all the groups showed significant increase in body weight upto eight weeks of age (Tables 10.11 and 10.12). This was due to

faster growth rate and higher adult body weight of female quails.

Female birds of all the groups showed significantly higher body weight than the male quails (Tables 10.13 and 10.14). Christaki *et al.* (1994); Philomina (1994) and Raji (1997) also recorded higher body weight in females than the male quails. The higher body weight in female birds was due to heavier gonads, liver and intestine.

In the present study the mean values for body weight at first egg (Sixth week) in groups F-I, F-II and F-III were 129.800 ± 3.225, 137.800 ± 3.446 and 137.000 ± 3.162 g respectively (Table 10.8). A similar observation was recorded in Japanese quails by Ahuja *et al.* (1978), Sato *et al.* (1981) and Philomina (1994) who recorded the age of sexual maturity as six weeks. The body weight of Japanese quails (both male and female) observed in the present study were in agreement with the reported values.

5.8 Influence of dietary oils on feed efficiency of Japanese quails

The feed efficiency in male quails was calculated on body weight gain basis and that in female quails on egg mass basis. The efficiency for feed conversion did not vary much among the male quails (Table 11.3).

Among the female quails coconut oil (F-II) and sunflower oil (F-III) fed groups had better feed efficiency than gingelley oil fed group (F-I) vide Table 11.5. This may be due to lower utilization of feed for egg production in the gingelley oil fed group. The lower egg production observed in gingelley oil fed group (F-I) may be due to the lower utilization of minerals in them.

Identical reports in order to compare the influence of dietary oils on feed efficiency of Japanese quails are not available. However, Reddy *et al.* (1991) and Girishkumar (1997) reported that there was no variation in feed efficiency of Japanese quails by feeding onion or garlic in the ration. Feed efficiency between the groups will vary only if the diet contain certain factors that will interfere/promote the digestion of food and its absorption and assimilation into the body. The three diets used in the present study were similar in composition except for the different oils. The difference in the fatty acid composition of the oils may not be sufficient enough to exert a significant influence on the utilization of feed for body building or egg production.

Summary

SUMMARY

Influence of different dietary oils as gingelley oil, coconut oil and sunflower oil on the lipid profile of plasma, liver and egg yolk, weight of liver and production performance of Japanese quails were evaluated in the study.

A total number of 72 (36 males and 36 females) four-week old, clinically healthy Japanese quail chicks of the same strain (egg type) and hatch were selected at random from the Kerala Agricultural University Poultry Farm, Mannuthy and reared under standard farm conditions. The birds were divided into three main groups (24 birds with 12 males and 12 females in each group) G-I, G-II and G-III and each main group was again divided into two subgroups comprising of twelve males (subgroup M) and twelve females (subgroup F) viz. M-I, F-I, M-II, F-II, M-III, F-III. The birds were reared on standard quail grower ration upto six weeks of age and on adult quail ration (Panda, 1990) from six weeks to the final period of the experiment. Vegetable oils namely gingelley oil, coconut oil and sunflower oil were incorporated in the ration at the level of 2 per cent viz. G-I group (M-I and F-I) acted as the control provided with gingelley oil, G-II group (M-II and F-II) with coconut oil and G-III group (M-III and F-III) with sunflower oil acted as the treatments.

Daily feed intake and egg production of birds in each group and weekly body weight of the individual birds were recorded regularly. Weight of the individual eggs were noted daily. Egg mass and feed efficiency were calculated from the data. The eggs of three groups (F-I, F-II and F-III) on the last day of 14th, 15th and 16th week of age were stored separately at 4°C for biochemical analyses.

Male birds (M-I, M-II and M-III) were sacrificed by decapitation at the 10th week of age and the female birds (F-I, F-II and F-III) at 16th week of age, after fasting for 14 hours. The blood from the individual birds collected separately and plasma was separated by centrifugation and stored at -20°C. The liver was separated from the carcass, weighed and stored at -20°C for further analyses. Estimation of total lipid, triglyceride, total cholesterol and phospholipid were conducted in both plasma and liver. HDL-cholesterol and (VLDL+LDL)-cholesterol were also estimated in the plasma. Egg yolk was analysed for the concentration of total lipid and total cholesterol.

The concentration of total lipid, triglyceride, total cholesterol, HDL-cholesterol, (VLDL+LDL)-cholesterol and phospholipid in plasma were not significantly different among the groups in both male and female Japanese quails.

The total lipid content in liver in male quails was not significantly different among the groups. Among the female quails, the total lipid content in liver of gingelley oil fed group was significantly higher than that of coconut oil and sunflower oil fed groups. Irrespective of whether male or female Triglyceride and total cholesterol content in liver were not significantly different among the groups. In male quails the phospholipid content in liver of gingelley oil fed group (M-I) was significantly higher compared to sunflower oil fed group (M-III). There was no significant difference in the liver phospholipid content of gingelley oil fed group (M-I) and coconut oil fed group (M-II) and also between coconut oil fed group and (M-II) sunflower oil fed group (M-III) among the male birds. The liver phospholipid content in female Japanese quails was not significantly different among the groups. The weight of the liver was not different among the groups in both male and female Japanese quails.

All the lipid parameters in plasma were influenced by sex. The mean values for total cholesterol and HDL-cholesterol in plasma were significantly higher in male quails compared to females. Total lipid, Triglyceride (VLDL+LDL)-cholesterol and phospholipid in plasma were significantly higher in female quails compared to male quails.

Total lipid, Triglyceride and total cholesterol content in the liver of female quails in each group were significantly higher than that of male quails. Phospholipid content in liver of male quails were not significantly different from that of female quails in each group. The liver weight in female quails was significantly higher than that of male quails. The total lipid and total cholesterol content in egg yolk were not significantly different among the groups in each week (14th, 15th and 16th week of age). Total lipid in egg yolk was increased as age advanced. Total cholesterol content in egg yolk at 15th and 16th week of age were significantly higher than that of 14th week of age.

The egg production was significantly higher in coconut oil fed group (F-II) compared to gingelley oil fed group (F-I). There was no significant difference in egg production between the groups F-I and F-III and also between F-II and F-III. The weight of the egg was significantly higher in sunflower oil fed group (F-III) compared to coconut oil fed group (F-II). There was no significant difference in the egg weight between F-I group and F-III group and also between F-I group and F-II group. There was no significant difference in egg mass among the groups. The age at first egg was earlier in the treatment groups (F-II and F-III) compared to the control group (F-I). Peak production eventhough attained

later (ninth week) was better in coconut oil fed group (F-II) compared to the other groups (F-I and F-III).

Feed consumption was not different among the groups in both male and female Japanese quails, female quails had significantly higher feed intake than the males.

Body weight was not different among the groups in male Japanese quails. Among the female Japanese quails, gingelley oil fed group had significantly lower body weight than coconut oil and sunflower oil fed groups during most part of the experiment. Body weight of female quails was significantly higher than that of male quails. Feed efficiency in male quails was not significantly different among the groups. Females birds of coconut oil (F-II) and sunflower oil (F-III) fed groups had better feed efficiency than that of gingelley oil fed group (F-I).

The results of the present study indicated that the coconut oil (saturated fat) and sunflower oil (unsaturated fat) at 2 per cent level cannot exert significant influence on blood and yolk lipid profile in Japanese quails. The egg production in coconut oil fed group and egg weight in sunflower oil fed group were better.

From the results it could be concluded that coconut oil was not harmful to the body when fed at 2 per cent level as there was no significant difference in the lipid profile among the different dietary oil fed groups.

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INFLUENCE OF COCONUT OIL AND SUNFLOWER OIL ON PLASMA AND LIVER LIPID PROFILE AND PRODUCTION PERFORMANCE IN JAPANESE QUAIL *(Coturnix coturnix japonica)*

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ABSTRACT

The role of dietary factors in the genesis and development of atherosclerosis has been associated with elevated serum cholesterol levels, both in man and animals. Coconut oil has been a dietary component for Keralites from time immemmorial. There are several reports implicating coconut oil (a saturated fat) as one of the major factors involved in the production of increased blood cholesterol level leading to the increased incidence of cardio vascular disease (CVD) in human beings and animals. No systematic investigation has been carried out so far to study how increasing unsaturation of the oil affects lipid metabolism in warding off atherosclerosis. In addition to the chain length of fatty acids their relative position in the triglyceride molecule appears to affect their potency for atherogenicity. Gingelley oil is commonly used as one of the energy source in poultry feed and sunflower oil is also gaining popularity now a days, since many reports indicated that feeding of unsaturated fat decreased the cholesterol content in the body. Hence it was thought worthwhile to study the influence of these three oils on the levels of total lipid, triglyceride, total cholesterol and phospholipid in plasma and liver, the concentration of HDL-cholesterol and (VLDL+LDL)-cholesterol in plasma, weight of the liver and the level of total lipid and total cholesterol in egg yolk. The production performance

under these dietary oils was also assessed in Japanese quails by recording the egg production, egg weight and egg mass, feed consumption, body weight and feed efficiency.

A total number of 72 (36 males and 36 females), four-week old Japanese quails of the same strain (egg type) and hatch were procured from the Kerala Agricultural University Poultry Farm, Mannuthy and divided into three main groups (12 males and 12 females in each main group viz. GI, GII, GIII) and then subdivided to 12 males and 12 females as M-I, M-II and M-III (males) and F-I, F-II and F-III (females). The birds were provided grower ration upto sixth week of age and then adult ration, from the sixth to the 10th week of age in males and 16th week of age in females. The standard ration was incorporated with the different dietary oils at 2 per cent level viz. GI (MI and F-I) with gingelley oil, GII (MII and F-II) with coconut oil and GIII (MIII and F-III) with sunflower oil. Feed consumption, egg production and egg weight were recorded daily and body weight recorded weekly. The eggs from the three groups (F-I, F-II and F-III) were collected on the last day of 14th, 15th and 16th week of age, weighed and stored at 4°C for biochemical analyses. The male birds were sacrificed at the 10th week of age and females at the 16th week of age. The weight of the liver noted and plasma and liver stored at -20°C for analyses.

Total lipid, triglyceride, total cholesterol, HDL-cholesterol (VLDL+LDL)-cholesterol and phospholipid in plasma of male and female Japanese quails were not significantly different among the groups, since the normal level (2%) of oils used in the present study was not able to exert any significant influence on the lipid metabolism in quails.

The total lipid content in the liver in male quails was not significantly different among the groups. In the female quails the total lipid content in liver of gingelley oil fed group (F-I) was significantly higher than that of coconut oil fed (F-II) and sunflower oil fed (F-III) groups. Lower triglyceride lipase activity in coconut oil and sunflower oil fed groups, which causes decreased break down of triglyceride in adipose tissue and lower transportation of fatty acids to liver may be the reason for the lower total lipid content in liver in these two groups. Irrespective of sex the triglyceride and total cholesterol content in liver were not significantly different among the groups.

The liver phospholipid content in male quails of gingelley oil fed group (MI) was significantly higher than that of sunflower oil fed group (MIII). Sunflower oil (unsaturated fatty acids) causes enhanced faecal excretion of free fatty acids.

The total lipid, triglyceride, (VLDL+LDL)-cholesterol and phospholipid in plasma were significantly higher in adult female quails compared to males in all the groups. In the laying bird lipids are synthesised in the liver and transported to the ovary in the form of lipoproteins. This is the reason for higher total lipid, triglyceride and phospholipid in plasma of laying hen (VLDL+LDL)-cholesterol content was also higher in the female quails since they are the transport form of cholesterol from liver to the ovary.

The total cholesterol and HDL-cholesterol were higher in male quails compared to females, since the cholesterol is not eliminated through the egg yolk and are mainly found along with the HDL fraction in males unlike females. The total lipid, triglyceride and total cholesterol content in liver of female quails were significantly higher than that of male quails. There was higher lipid synthesis in the liver of female quails under the influence of oestrogen. There was no significant difference in the liver phospholipid content between male and female quails.

No significant difference in the weight of the liver among the groups in both male and female Japanese quails could be noticed. However, weight of the liver in females was significantly higher than the males in each group.

There was no significant difference in the total lipid and total cholesterol content in egg yolk among the groups, at

the 14th, 15th and 16th week of age. This was because the total lipid and total cholesterol content in the egg yolk has to be maintained at a constant level in order to create a favourable environment for the development of the embryo.

Female quails attained sexual maturity earlier at the end of fifth week (38 to 41 days of age). Egg production started on the 38th day in groups F-II and F-III while it was on the 41st day in group F-I. The egg production was lower in gingelley oil fed group (F-I) than coconut oil fed group (F-II) may be due to lower mineral absorption in gingelley oil fed group. The egg weight was higher in sunflower oil fed group (F-III) than coconut oil fed group (F-II) since sunflower oil in the diet causes higher protein retention. The egg mass was not significantly different among the groups. However, the egg weight and egg mass significantly increased with age.

There was no significant difference in feed intake among the groups in both male and female Japanese quails as the caloric value of the feeds were the same. Female quails had higher feed intake than males due to their higher growth rate.

The body weight of the male quails was not significantly different among the groups. The body weight in gingelley oil fed group was the lowest among the female quails during most part of the experimental period, since there is lower mineralisation of bones in that group. The body weight of

female quails in the three groups was significantly higher than that of males.

Feed efficiency was not different among the groups in male Japanese quails. Among the female Japanese quails coconut oil (F-II) and sunflower oil (F-III) fed groups had better feed efficiency than gingelley oil fed group (F-I), lower rate of absorption of minerals in gingelley oil fed group (F-I) may the reason for the lowest feed efficiency and body weight.

In order to arrive at a conclusion as to which of the particular oil is ideal for health and for better production performance in Japanese quails, higher levels of oils are to be incorporated and a more detailed study is required.