Nutrient Benefits of Quail (*Coturnix Coturnix Japonica*) Eggs

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***Abstract*-** Cross-sectional study of quail eggs was conducted to evaluate the nutritional compositions of carbohydrate, fat, protein, calories, vitamin, minerals and sex hormones. The results showed that average of each whole quail egg weight was 10.67 g. Their contents of ash, carbohydrate, fat, protein and moisture were 1.06, 4.01, 9.89, 12.7 and 72.25 g $100g^{-1}$, respectively. Total energy in calories obtained was 156.50 kcal $100g^{-1}$ whole egg. The most essential amino acid found in egg whites, was leucine and the most non-essential amino acid was aspartic acid. Egg yolks contained the highest essential fatty acid content of linoleic acid and the highest non-essential fatty acid content of oleic acid. In addition, there was high content of vitamin E in egg yolks and sex hormone progesterone in both of egg yolks and whites. The most essential and trace minerals of whole eggs were nitrogen and iron. Iron was high content in egg whites meanwhile nitrogen and zinc were found high in egg yolks. This study indicated that quail eggs contained high nutritional contents of amino acids, fatty acids, vitamin E, sex hormone P and minerals of nitrogen, iron and zinc. Quail eggs are the good source of nutrients for human health.

***Index Terms*-** Quail egg, nutritional compositions, benefit

I. Introduction

Good nutrition affects growth and development of human body. Nutritional composition research has shown that eating a well-balanced food can improve human health. A variety of foods, including vegetables, fruits, grain, and protein, is essential to get the full range of nutrients for good health. The right balance of calories, protein, fat, carbohydrates, vitamins, and minerals provides energy, and the variety of nutrients growing children and working adult need. Foods that are high in fat, sugar, or salt, should be limited, they do not provide important nutrients. Both Child and Adult Care Program (CACFP) meal pattern and the Pyramid Web site by US. Department of Agriculture, Food and Nutrition Service, encourages eating a variety of foods (US Department of Agriculture, Food and Nutrition Service, 2005). Egg consumption is a popular choice for good nutrients which they are variety of chicken, duck, roe, and caviar, but by a wide margin the egg most often humanly consumed is the chicken egg, typically unfertilized (Applegate, 2000). Besides, a lot of people especially in Asian countries consume quail eggs (or *Kai Nok Kra Tha*, Thai name) which previous study reported that quail eggs are packed with vitamins and minerals even with their small size, their nutritional value is three to four times greater than chicken eggs. Regular consumption of quail eggs helps fight against many diseases which is a natural combatant against digestive tract disorders such as stomach ulcers. Quail eggs strengthen the immune system, promote memory health, increase brain activity and stabilize the nervous system. They help with anemia by increasing the level of hemoglobin in the body while removing toxins and heavy metals (Troutman, 1999-2012). Chinese use quail eggs to help treat tuberculosis, asthma, and even diabetes. Quail eggs can help prevent sufferer of kidney, liver, or gallbladder stones and remove these types of stones. The nutritional value of quail eggs is much higher than those offered by other eggs with they are rich sources of antioxidants, minerals, and vitamins, and give us a lot of nutrition than do other foods (Lalwani, 2011). It may consume about 2 quail eggs in a day. But there were argued in nutrient information of quail eggs cause of lack of scientific data. Thus, this study aimed to evaluate nutritional compositions of carbohydrate, fat, protein, calories, vitamin, mineral and sex hormone contents of Thai quail eggs. The idea that may resolve the world food problem for developing countries. The limited knowledge of Western science about food is over shadowed by the centuries.

II. Materials and Methods

2.1. Samples collection

Quail egg (Coturnix coturnix japonica) samples were collected from local markets in Ayutthaya province. Tripicate samplings of eggs were conducted, and Eggs samples were carefully handled in an ice-box, and transported to the laboratory. They were kept in the refrigerator (@ 7°C) before analyses.

2.2. Samples preparation and analyses for chemical compositions, amino acids, fatty acids and vitamins

Egg sample was weighed for whole, and separated for egg whites, and egg yolks, respectively. Egg samples were separately homogenized by a laboratory blender (Moulinex A327, France), and subjected to proximate analyses (Shapiro, 1995a, 1995b; AOAC, 2007), profiles of amino acids were determined by acid hydrolysis and derivertization prior analysis by GC-FID detection (Robert and Sarwar, 2005), fatty acids profiles by methylation prior analysis by Capillary GC detection (Ratnayake *et al.*, 2006). Vitamin analysis was conducted by saponification and liquid extraction of organic solvents with HPLC-Fluorescence detection (DeVries, 2005). All analyses were performed by a certified laboratory (ALS Laboratory Group Co.,Ltd., Bangkok).

2.3 Minerals analyses

All samples were oven dried before ashing at 550 ºC. for 5 hours. Addition of 20 mL of 1 N hydrochloric acid (HCl) followed by qualitative and quantitative analysis by Inductively Couple Plasma (ICP) (Allen, 1971) for phosphorous (P), potassium (K), calciumiron (Ca), magnesium (Mg), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn) and nitrogen (N) analysis (Allen, 1945).

2.4 Sex hormones analyses

Whole egg samples were separated for egg whites and egg yolks, and they were homogenized. Each sample was weighed for 5.0 g of each and 50.0 ml of hexane was added for a 3-minute extraction in a mixer (Vortex Genie 2 TM, Scientific Industries, INC, BOHEMIA, N.Y.11716, USA). Solvent of the extract was evaporated in nitrogen gas. Sample extracts were soluble in phosphate buffer (pH 7.0): dimethylsulfoxide (DMSO) (1:1, vol/vol) before determinations of sex hormones of LH (Luteinizing Hormone), FSH (Follicle Stimulating Hormone), P (Progesterone), E2 (Estradiol), T (Testosterone) by ECLIA (Electrochemiluminescence immmunoassay, method (Xin et al., 2012) using Roche Diagnostics kits and PRL (Prolactin) by IFMA (Time-resolved fluoroimmunoassay) method (Diamandis, 1988) using PerkinElmer Life and Analytical Sciences kit. The hormonal analyses were performed by reference laboratory of King Chulalongkorn Memorial Hospital, Bangkok.

2.5. Data analyses

Statistical analyses of the results were carried out using descriptive statistical analysis and compared with One-Way ANOVA: Post Hoc Multiple Comparison (LSD) between egg groups (whole eggs, egg whites and egg yolks). Mean differences were considered statistical significant. All statistical analyses performed by SPSS for window version 17.0.

III. RESULTS AND DISCUSSION

3.1 Nutritional compositions of whole quail eggs, egg whites, and egg yolks

Whole quail eggs were 10.67 g egg^{-1} in weight. Their contents of ash, carbohydrate, fat, protein and moisture were 1.06, 4.01, 9.89, 12.7, and 72.25 g 100g^{-1}, respectively. Energy obtained from whole eggs was 156.50 kcal 100g^{-1} (Fig. 1). Most of nutrients determined in egg yolks were significantly higher in contents than those of egg whites ($p<0.001$). There was highest protein (N * 6.25) content in egg whites. The nutrient compositions of quail eggs showed higher ash, carbohydrate (include dietary fiber), fat, protein and calories in egg yolks. This study resulted that good nutrients should be more in egg yolks.

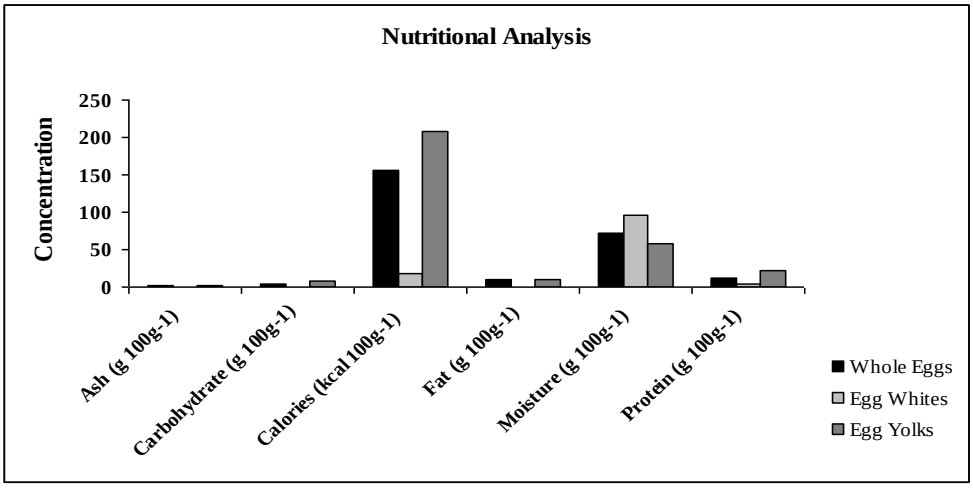

Fig. 1. Nutritional compositions of whole quail eggs, egg whites, and egg yolks.

3.2 Profile amino acids of quail egg whites

The most essential amino acid (EAA) of egg whites were leucine (1139.0 mg 100g^{-1}), valine (869.5 mg 100g^{-1}) and lysine (790.0 mg 100g^{-1}) (Fig. 2). Leucine is a branched chain amino acid along with valine and isoleucine. It is beneficial and functional to protein structure for 60-70% in human body, and blood sugar level regulation which maintains a balance of insulin and glucose (Khan, 1999-2012). It proposed as a promising pharmaconutrient in the prevention and treatment of sarcopenia and/or type 2 diabetes (van Loon, 2012). Valine is required for muscle metabolism, repair and growth of tissue and maintaining the nitrogen balance in the body. Valine also assists to regulate blood sugar and energy levels (Vitalhealthzone, 2007a). While lysine is required for growth and bone development in children, assists in calcium absorption and assists in maintaining the correct nitrogen balance in the body, as well as maintaining lean body mass. Lysine is also needed to produce antibodies, hormones, enzymes, collagen formation as well as repair of tissue (Vitalhealthzone, 2007b). The body consists of the branched chain amino acids, their effects are synergistic when they were taken together. The total EFA (5486.5 mg 100g^{-1}) and total NEFA (5297.0 mg 100g^{-1}) were not significant different concentration.

While most of non-essential amino acid were aspartic (1488.0 mg 100g^{-1}), alanine (739.0 mg 100g^{-1}) and serine (665.5 mg 100g^{-1}). Aspartic acid is plays a vital role in energy production while alanine plays a key role in maintaining glucose

levels in the body by helping the body to convert glucose into energy. Alanine also eliminates excess toxins from the liver (Vitalhealthzone, 2007c, 2007d). They are good health which both NEAA and EAA should be considered in the classic "ideal protein" concept or formulation of balanced diets to maximize protein accretion and optimize health in animals and humans (Wu, 2010). The total of EAA and NEAA in this study were not significantly different.

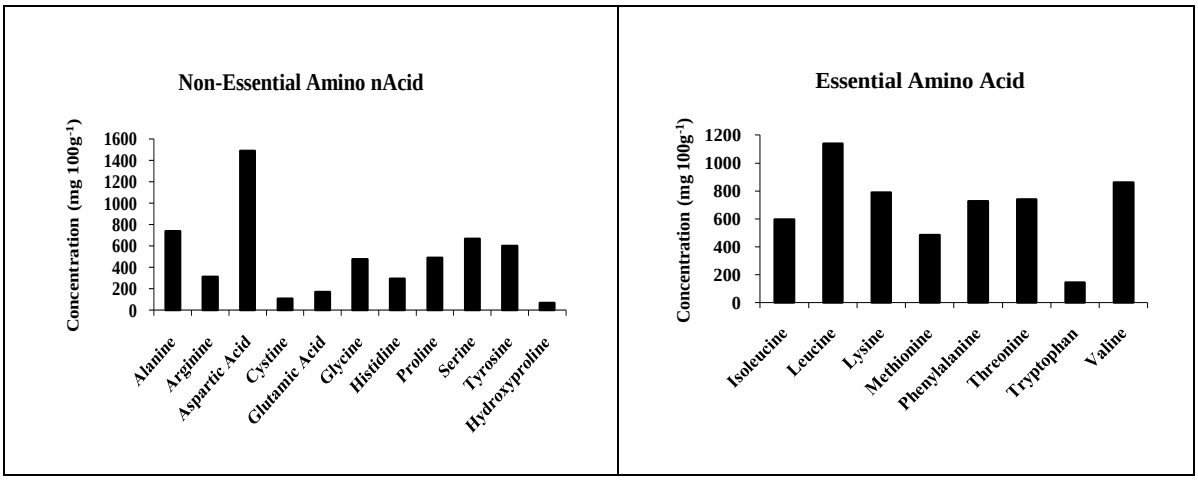

Fig. 2. Profiles of NEAA (left) and EAA (right) amino acids of quail egg whites

3.3 Profile fatty acids of quail egg yolks

The most essential fatty acid (EFA) in egg yolks were linoleic acid (2.58 g $100g^{-1}$), docosahexaenoic acid (0.50 g $100g^{-1}$ and arachidonic acid (0.44 g $100g^{-1}$) (Fig. 3) which they were UFA. While most non-essential fatty acid (NEFA) in egg yolks were oleic acid (8.84 g $100g^{-1}$), palmitic acid (5.13 g $100g^{-1}$) and stearic acid (2.03 g $100g^{-1}$). Total NEFA (17.09 g $100g^{-1}$) was higher than EFA (3.70 g $100g^{-1}$). Linoleic acid must be consumed for proper health which effects on body composition. A diet only deficient in linoleate causes mild skin scaling, hair loss (Cunnane and Anderson, 1997) and poor wound healing in rats (Ruthig and Meckling-Gill, 1999). Docosahexaenoic acid (DHA) is essential for the growth, visual and functional development of the brain in infants and has a positive effect on diseases such as hypertension, arthritis, atherosclerosis, depression, adult-onset diabetes mellitus, myocardial infarction, thrombosis, and some cancers (Hrrocks and Yeo, 1999; Craig, 2005). Arachidonic acid is a polyunsaturated omega-6 fatty acid 20:4(ω-6). Along with omega-3 fatty acids, omega-6 fatty acids play a crucial role in brain function (Wang *et al.*, 2006; Fukaya *et al.*, 2007; Rapoport, 2008) as well as normal growth and development (Auestad *et al*., 2001; Clandinin *et al*., 2005; Leu and Schmidt, 2008). Also known as polyunsaturated fatty acids (PUFAs), they help stimulate skin and hair growth, maintain bone health, regulate metabolism, and maintain the reproductive system (Watkins *et al*., 2001; Remans *et al.*, 2004; Kirby, 2004). Total NEFA of quail egg yolks was higher than total EFA for 4.6 folds. In addition, quail egg yolks were higher UFA level than SFA for 1.79 folds. This result showed even quail eggs have high fat but most of them were UFA which was better for health. The quail eggs had low trans fatty acid which was bad for human health. Consuming trans fat increases low-density lipoprotein (LDL, or "bad") cholesterol. Food manufacturers in the United States and many other countries list the trans fat content on nutrition labels. They recommended a limit of less than 0.5 grams of trans fat per serving (CDC, 2012). The Dietary Guidelines for Americans (DGA) recommend that individuals keep trans fatty acid consumption as low as possible (US. Department of Agriculture and US. Department of Health and Human Services, 2010).

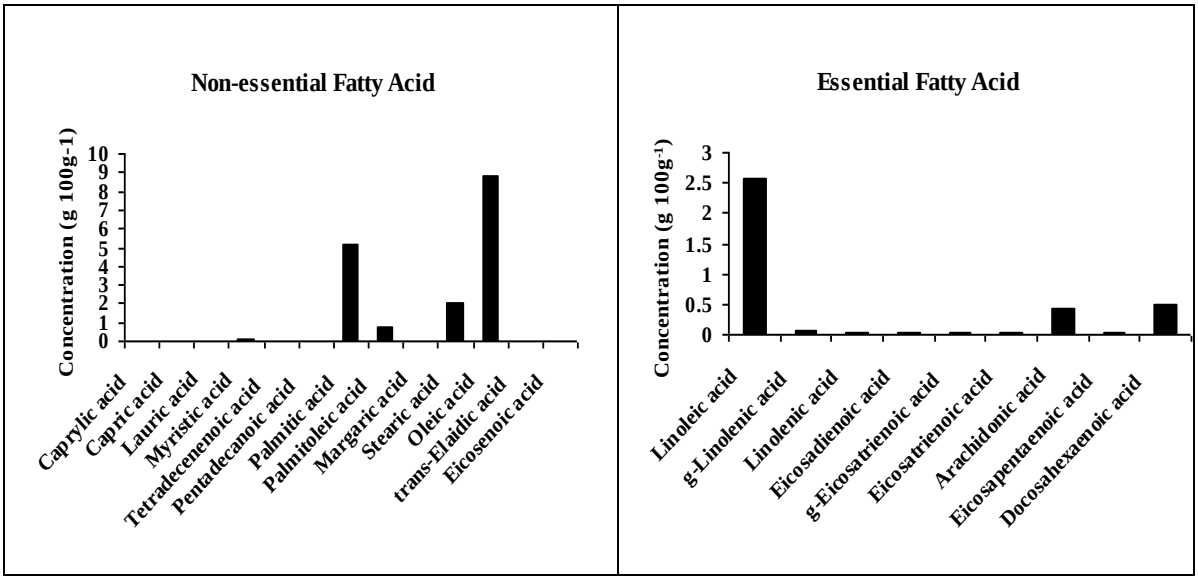

Fig. 3. Profiles of NEFA (left) and EFA (right) amino acids of quail egg yolks

Total unsaturated fatty acid (UFA, 13.3 g $100g^{-1}$) was composed of monounsaturated fatty acid (MUFA, 9.64 g $100g^{-1}$) and polyunsaturated fatty acid (PUFA, 3.68 g $100g^{-1}$) which was higher than total saturated fatty acid (SFA, 7.41 g $100g^{-1}$) (Fig. 4). The UFA to SFA ratio was 1.79.

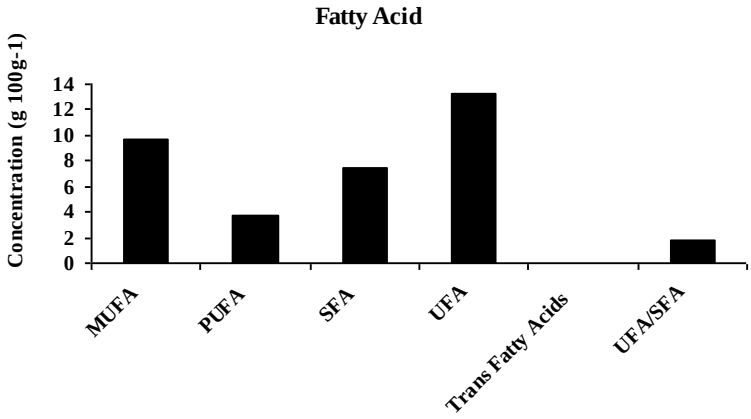

Fig. 4. Fatty acids of quail egg yolks

3.4 Vitamins of quail egg yolks

The most fat soluble vitamins of egg yolks were vitamin E (tocopherol, 5920.0 µg $100g^{-1}$) which was significantly higher than vitamin A (717.0 µg $100g^{-1}$, *p<0.001*) and vitamin D (1.14 µg $100g^{-1}$, *p<0.001*) (Fig. 5). The most vitamin of egg yolks was vitamin E but was low vitamin A and D which was different from previous study which reported that egg yolk is one of the few foods naturally containing vitamin D (NRC, 1976). Vitamin E is a fat-soluble vitamin with antioxidant properties. Vitamin E exists in eight different forms (isomers): alpha-, beta-, gamma-, and delta-tocopherol; and alpha-, beta-, gamma-, and delta-tocotrienol but alpha- is the most active form in humans. It has been proposed for the prevention or treatment of numerous health conditions, often based on its antioxidant properties. Its supplementation was linked to a 24% lower risk of cardiovascular death (Lee *et al*., 2010) and 26% reduced the risk of major cardiac events among women ages 65 and older (Harvard School of Public Health, 2012). Vitamin E might be involved: heart disease (Knekt et al., 1994; Glynn et al. 2007; Traber, 2007), cancer (Weitberg and Corvese, 1997; Lee *et al.,* 2005), eye disorders (Leske *et al.,* 1998; Jacques *et al.,* 2005) and cognitive decline (Sano *et al.,* 1997; Morris *et al*., 2002; Kang *et al*., 2006). Evidence suggests that regular use of high-dose vitamin E supplements may increase the risk of death from all causes by a small amount, although human research is conflicting. Caution is warranted (Miller *et al.,* 2005; Bjelakovic *et al.,* 2007; Mayo Clinic, 2011).

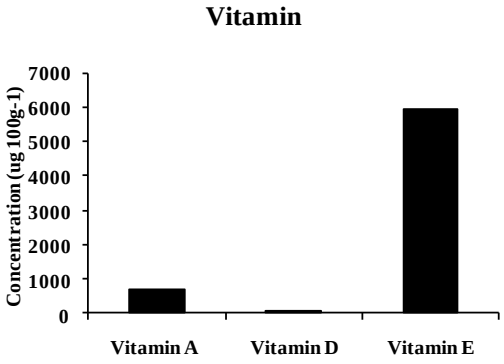

Fig. 5. Vitamin A, D and E of quail egg yolks

3.5 Minerals of contents of quail eggs

The most essential mineral of whole eggs was nitrogen (6.36 %) which it was mostly in egg whites (12.2 %) (Fig. 6). While most of trace mineral of whole egg were iron (80.8 mg L^{-1}) and zinc (46.9 mg L^{-1}). Both of iron (116.0 mg L^{-1}) and zinc (70.6 mg L^{-1}) were higher in egg yolks. Nitrogen functions as the component of nucleic acids, proteins, hormones, coenzymes (Soetan *et al.*, 2010). It is especially important is during pregnancy. The global nitrogen cycle changes affect human health well beyond the associated benefits of increased food production (Townsend *et al.*, 2003). In addition, most trace minerals in whole eggs were iron and zinc which were higher in egg yolks. Iron has many functions in the body and is also important for maintaining a healthy immune system which is essential for blood to work efficiently. Iron functions as haemoglobin in the transport of oxygen. Iron deficiency is not uncommon among athletes, especially long distance runners which can cause of fatigue among these athletes. If the lack of iron in our bodies is severe, we can get iron deficiency anemia. Iron deficiency anemia is probably the most common nutritional disease in the world, affecting at least five hundred million people (Mineral Information Institute (Soetan *et al.*, 2010, Mineral Information Institute, 2012). Zinc is involved in well over one hundred different reactions in the body. Some of these reactions help the bodies construct and maintain DNA, the molecule that controls how every single part of our bodies is made and works. It is also needed for the growth and repair of tissues throughout our bodies (Debjit Bhowmik and Sampath Kumar, 2010; Mineral Information Institute, 2012). This extremely important element is used to form connective tissue like ligaments and tendons. Teeth, bones, nails, skin and hair could not grow without zinc. The enrichment of zinc would be benefit for reduction of diarrhea and pneumonia mortality in children (Haider and Bhutta, 2009; Yakoob *et al.*, 2011). The previous study presented its biological role in homeostasis, proliferation and apoptosis and its role in immunity and in chronic diseases (Chasapis *et al.*, 2012). Toxicity disease or symptoms of zinc in humans include gastrointestinal irritation, vomiting, decreased immune function and a reduction in high density lipoprotein (HDL) cholesterol. Higher dietary levels of Zn are required in the presence of phytic acid to prevent parakeratosis and allow for normal growth (Sidhu *et al*., 2004). The optimum dietary level for the individual elements required for humans is very difficult to clearify cause of each variation of physiological response.

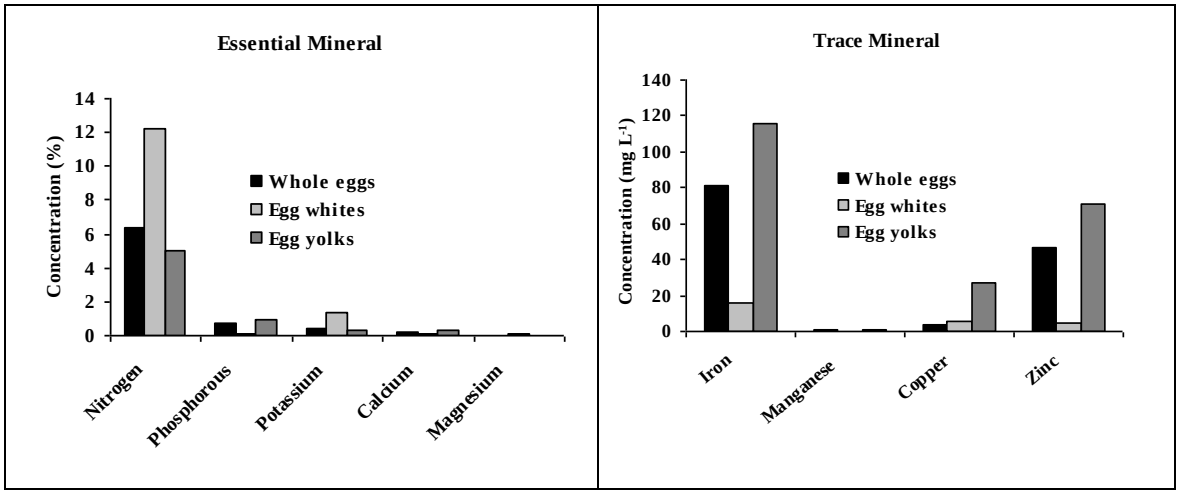

Fig. 6. Essential minerals (left) and trace minerals (right) contents of quail eggs

3.6 Sex hormones of quail eggs

The most sex hormone of whole eggs was P (318.8 ng g^{-1}) which was both high in egg whites (321.9 ng g^{-1}) and egg yolks (307.8 ng g^{-1}) (Fig. 7). And a little T of whole eggs was 3.1 ng g^{-1} which was higher in egg yolks (4.3 ng g^{-1}) than in egg whites (1.9 ng g^{-1}). Sex steroids are pleiotropic hormones that act on multiple targets including the central nervous system, bone, reproductive organs, and the immune system among others. Sex hormones influence the development, maturation, activation and death of immune cells (Verthelyi, 2001). The result showed that the most sex hormone of whole eggs was P which was both higher in egg whites and yolks. Hormone P are benefit for antidepressant, balancing blood sugar level, decreasing PMS and menopause symptoms and weight loss (Daniel, 2010). But quail eggs had low T which low testosterone levels lead to many problems for both genders such as reduced sexual drive, sexual

dysfunction, infertility, irritability, mood swings, depression, reduced concentration, and sense of well being and prostrate and testicular diseases in men (NSI, 2011). Men and women both possess testosterone hormones; however, the levels are different in both. Some studies also show that low levels of testosterone lead to the onset of Type 2 diabetes. The result of sex hormone from this study should be better for women and this result approved that quail eggs were not high male sex hormone of T.

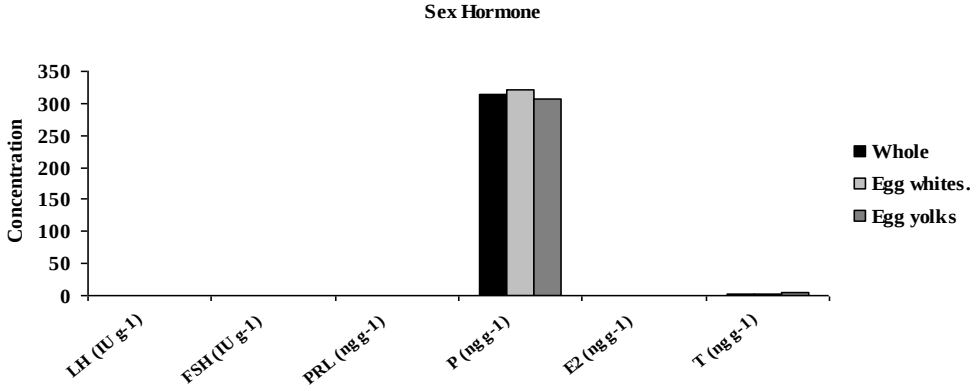

Fig. 7. Sex hormones contents of whole quail eggs, egg whites, and egg yolks.

Overall, quail eggs have both essential and non-essential nutrients which most of them were benefit for human health. The total calories were 156.50 kcal $100g^{-1}$ for human body using for function and maintenance of organ. Health benefits may be good for anti cancer effects and inhibits cancerous growth, straightens immune system by stunning aging in organs, helps to prevent anemia by promoting hemoglobin, is a remedy to gastritis and stomach ulcers as many reports (Ye *et al.*, 1999; Lalwani, 2011; Squidoo, 2012).

IV. CONCLUSION

There were many nutrient benefits of quail eggs which most of them as good sources of protein, fat, vitamin E, minerals (nitrogen, iron and zinc) and sex hormone P. Thus, we should educate or transfer knowledge to people for good nutrient benefits of quail eggs as good nutritional foods and may be the alternative resolving problem of people in some or all nutritional nutrients necessary for human health in developing countries and may be a good potential to resolve "World Food Problem".

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NOTES AND REFERENCES

The authors declare no competing financial interest.

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