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Designer eggs: An overview

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Abstract
Egg is a popular food item for all societies of the world, because of its excellent nutrients profile, less cost and versatility in food preparation. Chicken eggs supply all essential amino acids for humans and provide several vitamins and minerals, including retinol (vitamin A), riboflavin (vitamin B2), folic acid (vitamin B9), vitamin B6, vitamin B12, choline, iron, calcium, phosphorus and potassium. Although, the health conscious people are most of neglected essential fatty acids (EFA) and rich source of polyunsaturated fatty acids (PUFA), omega-3 fatty acids, vitamins and minerals. Various studies suggest that high amount of Polyunsaturated Fatty Acids (PUFA) in the diet of human beings promote the infant health and reduces the chances of atherosclerosis, heart attack and stroke. The beneficial effects of omega-3 fatty acids are faster development and enhanced functioning of brain, less chance of heart attack, better oxygen deliver to tissues and some support in rheumatoid arthritis, inflammatory disorders and other diseases. So in order to curb the prevalence of chronic diseases and several attempts were made to modify the eggs by adding ingredients which are beneficial for the health or by eliminating or reducing components that are harmful. This modification resulted in development of functional egg. Eggs can be designed through dietary approaches either through supplementation of specific nutrients, or certain herbs or specific drugs that have functional and therapeutic properties. Designer egg greatly increases the context of functional foods for human health.

Keywords: Eggs, egg composition, designer egg, functional food, herbal enriched designer eggs

Introduction
As the human population is escalating day after day progressively in the world one can't fulfill all the nutrient requirements of a normal human being and animals, if the nutrient requirement is satisfied than it result in deficiency diseases. Though we require to manipulate and modify the nutritional profile of most popular food which are consumed each one us such as grains, egg and meat. The per capita egg consumption is not increased quantitatively and qualitatively both through the years because of the high cholesterol level in egg yolk.

The modern concepts of glycemic index, macronutrient and micronutrient ratios and food groups, essential fatty acids (EFA) are one of the most neglected aspects of nutrition in modern society. Even though a diet that is nutritious by most standards can be deficient in polyunsaturated fatty acids (PUFA), omega-3 fatty acids are of particular importance to the present day enlightened consumers.

Consumers are always in search of newer and better products with potential health benefits well beyond those traditionally recognized. In the context of functional foods eggs are considered by most consumers to be a healthy food (American Dietetic Association, 2000) [1]. Due to its excellent nutrients profile, less cost and versatility in food preparation, egg is a popular food item for all societies of the world.

During the assessment of its potential as a food product, the avian egg's complexity is a major challenge for food scientists and nutritionists eager to elucidate its biochemical processes. Chicken eggs are the most commonly eaten eggs. They supply all essential amino acids for humans and provide several vitamins and minerals, including retinol(vitamin A), riboflavin(vitamin B_2), folic acid (vitamin B_9), vitamin B_6, vitamin B_{12}, choline, iron, calcium, phosphorus and potassium. They are also a single-food source of protein. Protein is necessary for the body to build and repair body tissues.

The health conscious consumers demand for the wholesome, healthy and nutritious food products free from harmful residues. They are more interested and ready to pay for the products which are more beneficial, wholesome and health promoting in order to improve their well-being.

The poultry products like egg has already gained a healthy image, so in order to curb the prevalence of chronic diseases and several attempts were made to modify the eggs by adding ingredients which are beneficial for the health or by eliminating or reducing components that are harmful. This modification resulted in development of functional egg. Improving consumers' health and nutritional status by designing nutritional profile of poultry egg through dietary approaches is relatively simple and economic. Eggs can be designed through dietary approaches either through supplementation of specific nutrients, or certain herbs or specific drugs that have functional and therapeutic properties.

Normal egg composition

The normal egg consists of water (74%), protein (13%), fat (11%), carbohydrates (1%) and other nutrients with minor percentage including minerals, vitamins and carotenoids. Egg's macrostructure is approximately 9-12% of shell, 60% of albumen and 30-33% of yolk. Yolk lipid content is around 33% including 63.3% of triacylglycerols, 29.7% of phospholipids (phosphatidylcholine: 73%; phosphatidylethanolamine: 15%) and 5.2% of total cholesterol.

History of Designer Eggs

Cruickshank (1934) was one of the first researchers document the ability to change the nutrient profile of the egg. In the late 80s, Sim, Jiang and their associates worked together to produce nutrient enriched eggs and developed designer egg, rich in n-3 fatty acids with antioxidants and patented this egg as 'Professor Sim's Designer Egg'. Later in 1997, Van Elswyk developed eggs enriched with conjugated linoleic acid (CLA).In Australia enriched the eggs with folic acid and iron. Other available designer eggs in the market include eggs enriched with vitamins. In Canada, produced lutein and selenium enriched eggs which help in preventing eye disorders.

In India, Narahari (2005) [7] has also developed Herbal Enriched Designer Eggs (HEDE), which is not only rich in carotenoids, n-3 PUFA, selenium, trace minerals and vitamin E, but also rich in herbal active principles like Allicin, Betaine, Euginol, Lumichrome, Lumiflavin, Lutein, Sulforaphane, Taurine and many other active principles of herbs, supplemented in the diets of hens. 30 These eggs also contain natural sterols (phytosterols) like β-sitosterol, Brassicasterol, Campesterol, Stigmasterol etc. which are cardiac friendly in nature.

Designer egg

"Designer eggs" are those in which the content has been modified from the standard egg. Designer eggs are produced by feeding egg-laying hens with a special diet rich in certain vitamins and other nutrients. The special diet usually includes kelp, flax seeds; canola oil and marigold extract (Manohar *et al*, 2015) [5].

Demand of designer egg

Foods are not only satisfying hunger but also provide necessary nutrients for humans. Consumer demands have changed considerably in the last few decades. Consumers believe that foods contribute directly to their health. Improve physical and mental well-being of the consumers. It increases demand of functional foods in developed countries. It also provides vast export opportunities for developing countries.

Salient features of designer egg

High vitamin content

Designer eggs can be produced with higher concentrations of several vitamins particularly vitamin A and E. Although, the vitamin content of eggs varies with the Chet, of hen but the hen may also differ in transferring the different vitamins with different efficacy. It is highest for vitamin A (60-80%), vitamin B12, riboflavin, biotin and pantothenic acid (40-50%), vitamin D3 and vitamin E (15-25%). So the attention should be there for the economic production of high vitamin eggs.

High mineral content

As we know that most of minerals particularly calcium and phosphorus are present in egg shell, so altering the calcium and phosphorus level of edible portion of egg (albumin and yolk) is very difficult. However, scientists have achieved the success In Increasing the micro mineral contents of these portion especially selenium, iodine, zinc, copper and chromium by dietary supplementation. Iodine deficiency exists in many developing countries including India, so eggs could be a good source for its supplementation. Selenium level in eggs can be increased by incorporating the selenium yeast in diet of hens.

Alteration in pigment content

The yolk colour is the indicator of pigment content of egg and varied with dietary supplementation such as plants *viz*., marigold chilli or corn; blue green algae *viz*., spirulina. Recently in a study, it was found that high intake of carotenoids reduced the macular degeneration, a major cause of blindness in the elderly.

Low cholesterol

An average sized egg contains approximately 200-220 mg of cholesterol. Many researchers have tried to reduce cholesterol level of chicken eggs by the use of genetics, nutrition or pharmacology intervention. Supplementation of chromium to laying hen diets at concentrations of less than 1 ppm have been shown to lower egg cholesterol and also improve the interior egg. The low cholesterol eggs can be produced by feeding an all-vegetarian diet rich in protein and fiber fortified with vitamin E (Manohar *et al*, 2015) [5].

Fat and fatty acid profile

Although, change in the total fat contents in the diet of poultry does not significantly affect the total fat in the eggs but we can change the fatty acid profile of egg by the alteration in the fat in the diet of poultry. Various studies suggests that high amount of Polyunsaturated Fatty Acids (PUFA) in the diet of human beings promote the infant health and reduces the chances of atherosclerosis, heart attack and stroke. The inclusion of safflower oil, marine algae, fish oil (Shimizu *et al*., 2001) [9], fish meal and vegetable oil in feeds of the poultry increases the omega-3 fatty acid content in the egg yolk which is vital nutrient for adult and children.

The beneficial effects of omega-3 fatty acids are faster development and enhanced functioning of brain, less chance of heart attack, better oxygen deliver to tissues and some support in rheumatoid arthritis, inflammatory disorders and other diseases. High content of this fatty acid also increases

the keeping quality and shelf life of the eggs. Studies have also been conducted on the egg having the lower saturated and unsaturated fatty acid ratio by feeding the hen with canola oil.

Pharmaceutical alterations

With the advancement of biotechnology, we can produce genetically modified chickens which then produce the eggs containing the desired compound e.g., insulin for the treatment of diabetic patients.

Specific antigen injects into hen body

↓

Antibody formation starts and flow in blood, then concentrate in egg.

↓

Collection of antibody from the egg and use it in human health care.

Biological compounds:

Like many other animals, chicken can also produce antibodies that can neutralize the antigens of bacteria, viruses etc. These antibodies circulate in the blood and transferred to eggs for the protection of chicks. Researchers are trying to take the advantage of this fact and in future become successful to develop antibodies against battery of antigen and concentrate in egg. We can expect the designer eggs containing the antibodies (anti-venom) against snake venom.

Production of Designer egg

Poultry researchers have been dedicating a considerable amount of their efforts in recent decades to studies with hens in an attempt to lower egg yolk cholesterol to satisfy concerns of health conscious consumer.

Shell colour

Regional consumer preferences determine the shell color. Half of the designer eggs on the market are brown shelled. A brown-shelled egg is a designer egg because it differentiates that egg from the conventional market. In some countries, there is even a market for blue shelled eggs.

Yolk colour

Yolk color can vary from virtually white to orange depending on the deposition of xanthophylls from the feed. Some xanthophylls are yellow, while others are red. Sources of supplemental xanthophylls include corn gluten meal, alfalfa, marigold, peppers and spirulina. Consumers may have a preference for a specific yolk color. Part of this preference may represent a perception that darker yolks have health benefits or originate from healthier chickens. Xanthophylls have been shown to the health conscious consumers are demanding quality poultry products and ready to pay premium price.

Types of designer eggs

- Low Cholesterol eggs
- ω-3 enriched eggs
- Vitamin enriched eggs
- Mineral enriched eggs
- Pigment enriched eggs
- Herbal enriched eggs

Manipulation of fatty acid profile in eggs

The incorporation of ω-3 PUFA into eggs has been used by scientists to alter ω-6: ω-3 ratio towards the desired dietary ratio. As an important part of the diet, the omega 6 to omega 3 ratios in the chicken egg has increased dramatically, from 1.3 under absolutely natural conditions to 19.4 under a standard United States Department of Agriculture (USDA) diet. Since the ratio between omega-6 and omega-3 in eggs can easily be manipulated through diet enrichment, development of omega-3-enriched eggs can contribute to an improved balance between omega-6 and omega-3 in the human diet. Sources of ω-3 PUFA such as fish oils, fish meal5, marine algae 6 or a combination of several of the above can be used as supplements in layer diets. However, supplementation with fishmeal or fish oil can exert a negative influence on the sensory properties of the egg (Manohar *et al*, 2015) [5].

Commercial table eggs contain a high proportion on n-6 PUFA but are poor source of n-3 fatty acids. Therefore, designer eggs production is mainly concentrated on the enrichment of egg lipids with n-3 fatty acids. Attempts to produce n-3 designer eggs could be divided into two parts. The simplest way is to produce an egg enriched in linolenic acid which is a precursor of DHA. For this purpose, the hen's diet is usually enriched with flax seeds, linseeds or their corresponding oils. As a result of such changes in the hen's diet egg yolk is enriched with linolenic acid and the level of DHA is also enhanced. In general, a higher intake of α linolenic acid is protective against fatal ischemic heart disease.

ω-3 (Omega-3 Fatty Acids) enrichment

The omega-3 fatty acids, also called as n-3 fatty acids are a family of polyunsaturated fatty acids which have the first C-C double bond at the third carbon position counting from the omega end of the carbon chain. Important omega-3 fatty acids are derived largely as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) from fish oils and as α linolenic acid (LNA) from plant oil. Omega-3 fatty acids are usually obtained from two sources which can be classified as:

The marine type ω-3 PUFA, DHA and EPA which are more commonly found in deep sea cold water fish (such as salmon, mackerel, herring, tuna, bluefish and anchovies), fish oil and marine algae. Marine algae are an efficient dietary alternative to other n-3 fatty acid sources. A Schizochytrium sp. has been used commercially as an alternative source of omega-3 fatty acids. Scientist found that marine algae contain about 11.2% long-chain n-3 on a dry matter basis Manohar *et al*, 2015) [5]. Comparatively, PUFA of marine algal origin are more stable and active in form than that of terrestrial plant origin. It was also found that the presence of marine algae carotenoids may enhance the oxidative stability of n-3 fatty acid enriched eggs (Mudului *et al.*, 2018) [6].

The terrestrial type ω-3 PUFA, LNA found in canola oil, soybean oil, flaxseed, walnuts, and spinach and mustard greens. As omega-3 fatty acid dietary sources, flaxseed oil is widely used in poultry egg and meat enrichment, due to its high content of LNA9 (50 to 60%) but flaxseed reduces the availability of minerals and also inhibits the activity of proteolytic enzymes.

A protective role of n-3 fatty acids against coronary heart disease (CHD) was firstly proposed. Dietary

recommendations have been made for ω-3 fatty acids, including LNA, EPA and DHA to achieve nutrient adequacy and to prevent and treat cardiovascular disease. The ω-3 fatty acid recommendation to achieve nutritional adequacy is 0.6–1.2% of energy for LNA; up to 10% of this can be provided by EPA or DHA. A dietary level of 500 mg/d of EPA and DHA is recommended for cardiovascular disease risk reduction and for treatment of existing CVD, 1 g/d is recommended and these recommendations have been followed by many health agencies worldwide. Omega-3 (ω-3) eggs are the first product produced by manipulation of egg composition, and enrichment with choline, conjugated linoleic acid, lutein, selenium, vitamins B, D, E and K, and has also attracted substantial attention in relation to egg and meat quality.

The imbalance of dietary ω-6: ω-3 can cause

- Atherosclerosis (hardening and narrowing of arteries due to deposits in arterial walls)
- Thrombosis (blood clot within heart/blood vessels impeding blood flow)
- Arrhythmia (irregular heartbeats)
- Hypertension (elevated blood pressure)
- Rheumatoid arthritis (degenerative disease of joints)
- Visual acuity reduced (impaired vision)
- Brain development affected (learning difficulties)
- Cancer (breast, colon, pancreas, prostate)
- Atopic dermatitis, lupus, psoriasis, migraine, multiple sclerosis
- Bronchial asthma, diabetes mellitus and ulcerative colitis

Many omega-3 fatty acid-enhanced eggs are available in the U.S. market under various brand names such as Gold Circle Farms, Eggplus, and the Country Hen Better Eggs. Omega-3 fatty acid-enriched eggs taste and cook like any other chicken eggs available in the grocery store. However, they typically have a darker yellow yolk. There are also designer eggs on the market that contain a lowered saturated to unsaturated fatty acid ratio. Canola oil is commonly used to alter the ratio of saturated to unsaturated fatty acids. Tampa Farm Services produces an egg said to contain 25% less saturated fat than regular eggs (Mudului *et al.*, 2018) [6].

CLA enrichment

Conjugated linoleic acid (CLA) is a group of positional and geometrical isomers of 18-carbon unsaturated fatty acids with two conjugated double bonds The most commonly occurring CLA isomers in synthetic mixtures are cis-9, trans-11-CLA and trans 10, cis-12-CLA, with minor amounts of trans-8, cis10CLA and cis-11, trans-13-CLA, which are indicative of more severe heating conditions during the synthesis of CLA from linoleic acid (Zhang *et al.*, 2010) [10].

CLAs have been shown to have anticarcinogenic, antiadipogenic, antidiabetic and anti-inflammatory properties. (Bhattacharya *et al.*, 2006) [2] The Pharma Innovation Journal shown that concentrations of CLA in yolk lipids increased linearly as dietary CLA increased. Eggs produced by hens when fed with 5.0% CLA will contain 310 to 1000 mg of CLA per egg which could provide a substantial amount of CLA in human foods to meet the proposed CLA requirement.

DHA enrichment

Docosahexaenoic acid (DHA) is an omega-3 fatty acid that is a primary structural component of the human brain, cerebral cortex, skin, and retina. It can be synthesized from alpha-linolenic acid or obtained directly from maternal milk (breast milk), fish oil, or algae oil. Most of the DHA in fish and multi-cellular organisms with access to cold-water oceanic foods originates from photosynthetic and heterotrophic microalgae, and becomes increasingly concentrated in organisms the further they are up the food chain.

Antioxidants enrichment in eggs

Poultry eggs are rich sources of natural antioxidants like vitamin-E, Se, carotenoid pigments, flavinoid compounds, lecithin and phosvitin but at the same time, are highly susceptible to oxidative rancidity during storage. These antioxidants will protect the fat-soluble vitamins and other yolk lipids from oxidative rancidity. The designer eggs not only contain high levels of the above anti-oxidants but also contain synthetic anti-oxidant like Ethoxyquin and antioxidants of herbal origin such as Carnosine, Curcumin, Lycopene, Quercetin and Sulforaphene, depending upon the herbs used in the poultry diet. (Narahari, 2005) [7] Hence, supplementation of these antioxidants in the diet is essential to maintain the shelf life of the product. Along with antioxidants like Vitamin E and Se, the enzymes like glutathione peroxidase, superoxide dismutase, catalaze constitute an integral part of antioxidant cellular enzyme system in omega-3 enriched products to reduce lipid peroxidation (Mudului *et al.*, 2018) [6].

The dietary supplementation of vitamin E is commonly used in commercial n-3 enriched products to mitigate the oxidation of n-3 FA, thereby preventing the formation of undesirable fishy flavor and warmed over flavor in refrigerated cooked and raw meat. 29 Besides these, other anti-oxidants as chemicals and herbs may be added, to prevent oxidative rancidity. The advantages of enrichment of the egg with anti-oxidants include:

- Decreased susceptibility to lipid peroxidation
- Prevention of fishy odour to the product
- Designer foods could be a good source of antioxidants in human diet.
- Prevents destruction of fat-soluble vitamins
- Prevents denaturation of natural fat-soluble pigments
- Promotes the overall health of the consumers
- For designer egg production, vitamin E and organic selenium can be added as anti-oxidants at levels of 200-400mg/kg and 0.1-0.3ppm, respectively.

Reduction in cholesterol content

A large egg contains about 213 mg of cholesterol per yolk. Yolk cholesterol content in omega-3-enriched eggs obtained from laying hens fed with 10% menhaden fish had 13.6% less yolk cholesterol than did the control eggs. Similarly, birds fed with 1.5% menhaden fish oil or 5% whole or ground flaxseed-based diet, resulting in about a 9% yolk cholesterol reduction. Egg cholesterol levels are very difficult to influence by dietary manipulation, but some improvement has been reported from supplementing with copper and chromium.

Several studies have indicated that supplementation with dietary micro minerals (copper, chromium, zinc, vanadium, and iodine) and/or dietary vitamins (vitamin A, ascorbic acid, and niacin) may change the yolk cholesterol level. Enzymes have been reported to increase the percentage of egg albumen. Supplementation of natural products like garlic, probiolac and

Lactobacillus acidophilus in poultry feed help to reduce egg yolk cholesterol. It was reported that egg and plasma cholesterol levels were reduced by 23 and 22% respectively, through feeding dietary garlic powder.

Feeding dehydrated alfalfa free of choice also produce lean chicken breast meat as alfalfa is a good source of saponins which is hypocholesterolaemic in nature. A reduction of serum cholesterol has been reported in broilers fed with Lactobacillus culture. Dietary supplementation of amino acids like glycine, lysine, methionine and tryptophan can decrease body fat deposition. The carcass and yolk cholesterol levels can be significantly reduced by supplementing herbal plants and products like basil (tulsi), bay leaves, citrus pulp (nirangenin), garlic, grape seed pulp guar gum, roselle seeds, spirulina, tomato pomace (lycopene),and many more herbs in chicken diets will reduce the chicken and yolk fat cholesterol levels by 10-25%. Canola oil, linseed oil, soybean oil and sunflower oil, reduced fat and cholesterol content in cockerel thigh and breast meat. Moreover, these substances act synergistically in reducing the cholesterol levels. Hence a combination of these supplements will be more beneficial, rather than a single substance.

Herbal enriched super eggs

Phytobiotics or plant-derived products containing several plant secondary metabolites can be used in poultry feed to improve the performance of hen and to produce herbal enriched super eggs. Chicken feed will be supplemented with herbs like garlic/onion leaves, spirulina, basil leaves, turmeric powder, citrus pulp, flaxseed, red pepper, fenugreek seeds etc. These super eggs will be having a lower LDL cholesterol, immunomodulator property, antioxidant, anticarcinogenic properties, higher omega-3 fatty acids etc. For example normal egg have vitamin E content of 90-100 µg /g yolk whereas herbal supplemented egg have 220 – 240 µg / g yolk which added to its increased antioxidant property. All these indicating that the overall health promotion in hens as well as possible health promotion in humans is possible by popularizing herbal enriched eggs.

Vitamin E enrichment in Eggs

As ω-3 fatty acid enriched eggs are more susceptible to lipid oxidation, supplementation with vitamin E is generally recommended to stabilize egg lipids against rancidity and extend the shelf life of the product31. Later Galobart *et al*. (2001a) [4] found that supplementation of dietary vitamin E does not have a significant effect on daily feed intake, feed efficiency, egg weight and laying rate. Panda *et al*. (2011) [8] reported that supplementation of vitamin E in layer diets enhance egg production and increase antioxidant properties of egg yolks and plasma of White Leghorn hens during heat stress.

There is an improved feed intake, egg production, vitelline membrane strength (VMS), albumen and yolk height and foam stability24 in heat stressed hens when fed with vitamin E supplemented diet (60 IU vitamin E/kg feed). Some scientists have noticed that dietary vitamin E improved laying hen performance significantly in a cold environment, including feed conversion rate, body weight and egg production. Scientists reported a decline in egg yolk flavour and overall egg acceptability when a higher level of vitamin E (100 ppm vs. 10 ppm) was used along with 20% dietary flaxseed. The recommended that the level of dietary vitamin E in feed should be 100 IU/kg in commercial n-3 fatty acid egg production.

The extra addition of vitamin-E in the diet of hens leads to the following advantages:

- Vitamin E reduces free radicals in blood.
- Decreases risk of cancer and ageing process due to the reduction in the formation of the free radicals formation.
- May reduce the risk of heart disease since it is an antioxidant.
- Vitamin E acts as an antioxidant which results in delay of the development off odours.

Immunomodulating Egg Production

The eggs naturally contain certain specific compound like lysozyme (G1-globulin), G2 and G3 globulin, ovomacro globulin, antibodies etc. The globulin antibodies are natural antimicrobials and immunostimulants in the egg that can be utilized in the cure of immunosuppressed patients like AIDS patient. Chicken egg is abundant in antibodies like "IgY"; which is cheaper and better than mammalian immunoglobulin "IgG". In a 6-week period, a hen produces about 298mg of specific antibodies, compared with only 17mg from a rabbit. This "IgY" can be used to treat human rotavirus, E.coli, Streptococcus, Pseudomonas, Staphylococcus and Salmonella infections.

The IgY level in the egg can be increased by dietary manipulations. The functional feed rich in omega - 3 fatty acids and anti-oxidants itself will increase the IgY level in the egg. Herbal supplementation will further boost the IgY level in the egg. Among the herbs, Basil leaves (Tulasi) at 0.3-0.5% dietary level is having the highest ability to boost the IgY level in the egg1. Other herbs like Rosemary, Turmeric, Garlic, Fenugreek, Spirulina, Aswagantha, Arogyapacha etc., are also possessing immunomodulating properties (Mudului *et al*., 2018) [6].

Mineral enriched designer eggs

Many types of minerals can also be enriched in the production minerals enriched designer eggs. Among these selenium and iodine are one of them followed by chromium and copper. This can be achieved by the dietary manipulation of hen's diet. These trace minerals are very important for human health because the deficiency of these trace minerals leading to development of certain deficiency disease. Normally a hen egg contain almost about 53µg iodine/100g of their edible portion, that is the 33% of the approximate dietary intake but after supplementation potassium iodide i.e., KI at the @ of 5 mg of their feed level of KI does not affect the performance of the hen. It increases the iodine content from 26-88µg in 60 g hen egg tremendously.

Selenium enrichment in eggs

Selenium (Se) is a necessary trace mineral in reducing the oxidative damage of cell membranes of animals and humans. Se is an essential part of a variety of selenoproteins, such as glutathione peroxidase (GSH-Px), and at least six forms of GSH-Px were reported; GSH-Px is involved in cellular antioxidant protection. Inorganic sources (selenate and selenite) and organic sources of selenium supplements (selenium yeast) are used in typical cornsoybean meal based layer diets to develop the Se enriched egg. Organic Se supplementation provides longer duration of freshness qualities of eggs and it is used widely because its absorption

is higher than that of the inorganic form. Inorganic Se has a lower transfer efficiency to eggs than the organic Se. Scientists found that supplementation of organic Se to layer diets significantly improved egg production, egg weight, feed conversion ratio, albumen height, and specific gravity. The use of Sel-PlexTM, organic Se in the layer diet at 0.3 mg/ kg resulted in significantly higher albumen values (Haugh Units) after seven days of storage. She has a sparing effect on vitamin E, such that selenium supplementation can increase the vitamin E content of egg yolk (Mudului *et al.*, 2018) [6].

Scientists found that the body weight, egg production, egg weight and feed conversion ratio decreased significantly at increased Se concentrations when chickens are fed at 0, 5 and 10 ppm Se in the basal diet. The maximum allowable level (0.3 ppm) used in commercial poultry diets is well below toxic levels. Addition of selenium in the eggs may play certain vital roles such as:

- Selenium supplementation helps in reduction of arthritis, cancer, cataract, cholestasis, cystic fibrosis, diabetes, immunodeficiency, lymphoblastic anaemia, macular degeneration, muscular dystrophy.
- It may also help in the protection of one of the most dangerous disease of the world i.e., cancers. It also helps in decreasing the risk of DNA damage that is associated with cancer.
- Its supplementation can also improve blood fluidity by metabolic modification of lipoproteins which may provide and additional protective factor against cardio vascular disease development.
- Se supplement may provide a safe and convenient way through rising antioxidant protection in elderly individuals, particularly those at risk of ischemic heart diseases, involved transient periods of
- Myocardial hypoxia.
- It has beneficial effects in the conditions such as asthma, rheumatoid arthritis etc.
- Selenium enriched eggs can also reduce the risk of osteoporotic hip fracture in elder subjects.

Iodine-enriched designer eggs

In developing country like India, Africa, China and in many other countries of the world, some people are suffering from iodine deficiency diseases therefore iodine enriched eggs could be a good source of iodine in human diet. A typical egg of this type includes approximately 700 µg iodine. Eggs enriched with iodine can also reduce plasma cholesterol in humans and laboratory animals. On the basis of clinical trials conducted by showed that ingestion of one iodine-enriched egg a day for several weeks is relatively safe and devoid any significant adverse effects in healthy individuals. However, these eggs were not effective when used in low fat and low cholesterol diet by hyper lipidemic people. There are some indications of anti-inflammatory and anti-allergic properties of such eggs.

Antioxidants enrichment in eggs

Poultry eggs are rich sources of natural antioxidants like vitamin-E, Se, carotenoid pigments, flavinoid compounds, lecithin and phosvitin but at the same time, are highly susceptible to oxidative rancidity during storage. These antioxidants will protect the fat-soluble vitamins and other yolk lipids from oxidative rancidity. The designer eggs not only contain high levels of the above anti-oxidants but also contain synthetic anti-oxidant like Ethoxyquin and anti-oxidants of herbal origin such as Carnosine, Curcumin, Lycopene, Quercetin and Sulforaphene, depending upon the herbs used in the poultry diet. Hence, supplementation of these antioxidants in the diet is essential to maintain the shelf life of the product. Along with antioxidants like Vitamin E and Se, the enzymes like glutathione peroxidase, superoxide dismutase, catalaze constitute an integral part of antioxidant cellular enzyme system in omega-3 enriched products to reduce lipid peroxidation. The dietary supplementation of vitamin E is commonly used in commercial n-3 enriched products to mitigate the oxidation of n-3 FA, thereby preventing the formation of undesirable fishy flavor and warmed over flavor in refrigerated cooked and raw meat. Besides these, other anti-oxidants as chemicals and herbs may be added, to prevent oxidative rancidity.

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Pigment Enrichment of Yolk and Skin

The color of the yolk is a reflection of its pigment content. In addition, the type of pigment in the egg and its concentration are directly influenced by the dietary concentration of any particular pigment. In many countries, deep yellow or orange colour yolks are preferred over pale yolks. Natural carotenoid pigments like carotenes, xanthophyll, cryptoxanthin, zeaxanthin, lutein present in alfalfa, corn gluten meal, blue green algae - spirulina, marigold petal meal and capsicum will impart rich yellow and orange colours to the yolk (Fraeye, 2012) [3].

The beneficial effects of pigment enrichment in the yolk include:

- It assists in preventing muscular degeneration.
- It is responsible for attractive colour of yolk.
- It acts as antioxidant and anti-carcinogenic agent.
- Lutein is responsible for safeguard to the retina.

Pharmaceutical designer eggs

New biotechnology is being used to develop genetically modified chickens that produce compounds that can be harvested from the eggs. These compounds include insulin for the treatment of diabetes. The hen, like all animals, produces antibodies to neutralize the antigens (viruses, bacteria, etc.) to which she is exposed to each day. These antibodies circulate throughout her body and are transferred to her egg as protection to the developing chick. Immunologists are taking advantage of the fact that the hen can develop antibodies against a large array of antigens and concentrate them in the egg. Specific antigens are now being selected and injected into the hen that develops antibodies against them. As new biotechnology knowledge is gained in this area, designer eggs in the future may be produced that result in a range of

antibodies for treatment against snake venoms to the countering of microorganisms which cause tooth decay.

Table 1: Table shows Nutrient content and Quantity per 100g of egg contents

Nutrient content	Quantity per 100g of egg contents (2 eggs)	
	Ordinary egg	Designer egg
Total saturated fatty acids	3.3g	2.8g
Total unsaturated fatty acids	6.4g	6.9g
MUFA	4.4g	4.4g
PUFA	2g	2.5g
ω-3 fatty acid	0.03g	0.7g
ω-6 fatty acid	1.9g	1.4g
ω-6 /ω-3 ratio	17.3	1.27
EPA+ DHA	0.08g	0.4g
Cholesterol	400mg	320mg
Carotenoids	1.5mg	2.5mg
Vitamin E	2mg	15mg
Selenium	Traces	1.8µg
Chromium	Traces	1 µg

Conclusion

Designer eggs provide options for consumers who want eggs with different nutritional benefits or properties than generic eggs. Designer egg greatly increases the context of functional foods for human health. Manipulating the diet with seeds –oil, marine algae, vitamins and minerals lower egg cholesterol and improve ω-3 fatty acid level in egg. Vitamin and mineral enriched egg diet increases content of micronutrients and antioxidants in eggs. Functional feeds and herbs improve nutraceutical value and appearance of egg. A generic shell egg provides a nutrient dense, high quality, inexpensive source of protein as well as a variety of essential vitamins and minerals, with other functional components. By feeding hens special diets, eggs can offer functions above and beyond the excellent nutrition that they already provide. Value added and health promoting products of egg can be made available to the health conscious consumers.

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