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Designer egg: A new approach in modern health care

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Abstract
In the last decades people became highly aware of the connection between food and health. Food can only be considered functional if together with its basic nutritional impact it has beneficial effects on human health. It must improve general conditions and/or decrease the risk of the disease. Functional foods should be enhanced with added ingredients not normally found in the product, providing health benefits beyond their nutritional value. Functional foods are intended to be consumed as part of the normal diet but offer the potential of enhanced health or reduced risk of disease. Functional food could be rich in vitamins, omega-3 fatty acids or antioxidants. Poultry eggs has a potential to be considered as a functional food because of the high level of conversion of beneficial nutrients from feed to poultry products. Enrichment of eggs is more pronounced than enrichment of meat because of the higher fat content. Current position and future opportunities of poultry products in production of functional food will be consider in this paper

Keywords: Functional food, poultry, eggs, nutritional manipulation, human health

1. Introduction

Indian poultry industry is expanding very fast to meet the increasing demand of the domestic consumers. The poultry eggs are nutrient rich food and now regarded as an inexpensive, convenient and low calorie source of high quality protein with several other essential nutrients. However, 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: • Pre-slaughter or pre-oviposition value addition i.e. value addition before the product is produced. Products like, designer / organic / functional eggs and meat will come under this category which are usually free from residues of pesticides, drugs and other harmful chemicals. Several Designer Eggs (DE) like N3 PUFA, Vitamin E, Selenium, Lutein, Folic acid and Iron rich eggs were developed earlier by many workers. In India Narahari *et al*. (2004) has developed HEDE, which are not only rich in N3 PUFA, Vitamin E, Selenium and Carotenoids; but also rich in herbal active principles like Allicin, Euginol, Natural antioxidants, Quercitin, Murrayanol and others. This experiment was conducted to further enrich the SDE with herbal active principles, by supplementing selective herbs in the hens' feed. Eggs as an integral part of the diet packed with thirteen important vitamins and minerals. Eggs are also considered the highest quality protein, yet compared to other animal protein sources but consumer awareness on the relationship between dietary lipid and the incidence of Coronary Heart Disease (CHD) and salmonella problem changed their attitude towards egg consumption.

Strategies to consider in egg nutrient enrichment [1]

When considering egg enrichment with nutrients, several factors need to be taken into account:

a) Efficiency of nutrient transfer from feed to the egg
b) Availability of commercial sources of effective feed forms of the nutrient
c) Possible toxic effects of nutrients for the laying hens (Vitamin A and D are toxic for chickens at high levels)

d) Amount of nutrient delivered with an egg in comparison with Recommended Dietary Allowance (RDA)
e) Established health promoting properties of nutrients and their shortage in a modern diet. (Justification for vitamin E inclusion is that it is an important component of antioxidant defences, diets are deficient in this nutrient and consumption of high doses is beneficial)
f) Possible interactions with assimilation of other nutrients from the egg
g) Stability during cooking
h) Effect of nutrient enrichment on appearance and taste (Vitamin E, carotenoids and selenium do not affect egg taste but help prevent fishy taste in ω-3 eggs)

2. Egg
Oval reproductive body produced by female of poultry in which nutritious semi-liquid content are packed in hard calcareous shell (may be fertile or infertile).

3. Chicken Egg Components
The egg consists of a yolk at the centre, surrounded by albumen, both enclosed within the shell. The formation and development of the yolk occurs in the hen's left ovary. Following ovulation, egg formation continues in the left oviduct where the albumen and later the shell are deposited. The shell, albumen and yolk make up 9% - 12%, 60% and 30% - 32% of the egg respectively. Respective total solids of the albumen and yolk are 11% - 12% and 50% - 52%. Albumen or egg white comprised of 90 % water and 10% protein. Inside the yolk is the germ cell (or germinal disc). This is the site of cell division if the egg is fertile. The colour of the yolk varies (light yellow or intense yellow etc.) depending upon the laying hen's diet. However the colour of the yolk has no connection with nutritive value of an egg. The shell is 94% calcium carbonate crystals. The porous structure is semi-permeable limiting the passage of air and water. Variability in egg shell color is due to hen's genetics. Shells are more commonly white or brown, but may be blue or green. Color influences regional consumer demand but does not influence egg quality or taste. Several membranes keep egg components organized. An outer shell coating, the cuticle, helps to exclude bacteria and dust. Inner and outer egg shell membranes separating the shell and albumen are transparent protein membranes that provide an efficient defense against bacterial invasion as well as a foundation base for shell formation. The air cell forms, between the outer and inner membranes at the egg's blunt end, as the egg contents cool and contract after oviposition. Air cells grow larger with age. The chalazae, opaque ropes of egg white, hold the yolk in the center of the egg and attach the yolk's casing to the membrane lining the shell. The vitelline membrane, a transparent barrier enclosing the yolk, prevents leakage of yolk contents into the albumen. Egg composition is relatively consistent in terms of total protein, essential amino acids, total lipid, phospholipids, phosphorus, and iron. Other components such as fatty acid composition, mineral contents, vitamins, carotenoids, antioxidants, and cholesterol content are influenced by the diet of the hen and are more variable. These Component percentage differences may be attributable to strain, age, and environmental conditions. Due to the decline in some egg proportions as the hen ages, flocks are replaced after 1 production cycle by younger flocks to avoid such differences. However, molting tends to restore egg proportions of aged hens. Proper production methods also tend to reduce this variation in components and facilitate egg marketing. Generally hen's age, genetics, environment and feed quality especially manipulated with added nutrients play a role in determining egg quality and its healthy nutrients.

Table 1: Chicken Egg Components

Components	Amount
Moisture	76.15g
Protein	12.56g
Total lipid	9.51g
Carbohydrate	0.72g
Cholesterol	372mg
Calcium	56mg
Calorie	143kcal

USDA National Nutrient Database for Standard Reference, Release 23 (2010)

4. Designer eggs
Designer eggs are those in which the content has been modified or designed according to the consumer's choice or present market demand from the standard egg.

5. History of Designer Eggs
Cruickshank (1934) was one of the frist 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, Farell (1998) enriched the eggs with folic acid and iron. Other available designer eggs in the market include eggs enriched with vitamins. In Canada, Leeson and Caston, (2004) produced lutein and selenium enriched eggs which help in preventing eye disorders. In India, Narahari (2005) 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.

6. 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.

6.1 Shell colour
Regional consumer preferences determine the shell color F. Kuhl estimated that 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 blueshelled eggs.

6.2 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.

7. 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. [3] 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 [4], fish meal[5], marine algae [6] or a combination of several of the above [7] 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. Commercial table eggs contain a high proportion on n-6 PUFA (mainly 18:2n-6) 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 alpha-linolenic acid is protective against fatal ischemic heart disease.

7.1 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 αlinolenic acid (LNA) from plant oil [8]. 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. Yongmanitchai and Ward (1989) reported that some marine microorganisms synthesize significant amounts of long-chain fatty acids, particularly DHA and EPA. A Schizochytrium sp. has been used commercially as an alternative source of omega-3 fatty acids (Barclay *et al*., 1998). Herber and Van Elswyk (1996) found that marine algae contain about 11.2% long-chain n-3 on a dry matter basis. 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.
- 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 LNA[9] (50 to 60%) but flaxseed reduces the availability of minerals and also inhibits the activity of proteolytic enzymes [10].

A protective role of n-3 fatty acids against coronary heart disease (CHD) was firstly proposed by Dyerberg and Bang (1979). 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 [11] 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 comonly 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.

7.2 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 (unlike linoleic acid, which has a non-conjugated diene). 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, cis-10CLA 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). CLAs have been shown to have anticarcinogenic, antiadipogenic, antidiabetic and anti-inflammatory properties. [12 13] several studies have 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[14] which could provide a substantial amount of CLA in human foods to meet the proposed CLA requirement.

7.3 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.

Table 2: DHA enrichment in eggs depending on dietary oil supplementation

Oils in diet	Levels of dha (mg)	References
Flax seed oils	74-83	Jiang *et al*(1991),jiang and sim (1993)and Maurice (1994)
Herring meals (12%)in diet	100	Nash *et al* (1995)
Menhaden oil (1.5 %)	106	Marshall *et al* (1994)
Menhaden oil (3 %)	160-178	Hargis *et al* (1991)and Van Elswyk *et al* (1992)
Tuna orbital oil (0.5 %)	180	Leskanich and Noble (1997)

8. 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, Scheideler and Froning (1996) fed birds 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. [17] Enzymes have been reported to increase the percentage of egg albumen. Supplementation of natural products like garlic, probiolac [18] 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. [19] Sim and Bragg (1977) investigated the effect of cholesterol metabolism by feeding plant sterols (phytosterols) to hens and reported a decrease of 16 to 33% cholesterol concentration in either plasma and egg yolk by feeding 2% dietary soysterols with either saturated or unsaturated oil, with or without cholesterol. 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. [20] 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.

9. 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.

Table 3: Active ingredients (in desiner egg) showing effect on human health [21]

Source	Active priniciple	Effect on public health
Garlic, onion and their leaves	Allicin, Allylic sulfide	Lower L.D.L. cholesterol and anticarcinogenic
Sugar beet, grape pulp	Betaine	Reduces plasma homocysteine, which damages arterial walls.
Brocoli, cauliflower, cabbage, radish leaves	Sulphoraphane	Anticarcinogenic and antioxidant
Spirulina, marigold petals, alfalfa, red pepper	Carotenoid pigments	Antioxidant, anticarcinogenic
Turmeric powder	Flavonoid compounds	Antimicrobial, antioxidant
Bay (curry) leaves, Marigold petals	lutein	Antioxidants, Improves vision
Tomato pomace, grape pulp	Lycopene	Lowers LDL (bad) cholesterol, antioxidant, anticarcinogenic
Citrus pulp	Nirangenin	Reduces LDL cholesterol
Flax seed, canola, fish, oils insects, worms	o-3 PUFA	Reduces LDL cholesterol, hypertension, atherosclerosis
Brewery waste, yeast, fermented products	Statin	Lowers LDL cholesterol
Fenugreek, spices	Quercitin,Luteolin, Diosgenin, citogenin	Stimulates insulin secretion, antimicrobial
Seeds, weeds, legumes,Fenugreek	phytosterols	Increases HDL (good) cholesterol, reduces blood sugar
Basil leaves	Eugenol, eugenic acid	Immunomodulators
Milk,eggs and meat products	Taurine	Impede atherosclerotic plaque formation
Brans	Tocotrienols	Decrease LDL cholesterols

10. 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 product[31]. Later Galobart *et al*. (2001a) found that supplementation of dietary vitamin E does not have a significant effect on daily feed intake, feed efficiency, egg weight and laying rate. Puthpongsiriporn *et al*. (2001) and Panda *et al*. (2011) 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 stability[24] in heat stressed hens when fed with vitamin E supplemented diet (60 IU vitamin E/kg feed). Kucuk *et al*. (2003) have noticed that dietary vitamin E improved laying hen performance significantly in a cold environment, including feed conversion rate, body weight and egg production. Leeson *et al*. (1998) 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. Leeson *et al*. (1998) 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 that results in delay of the development off odours.

11. 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 egg[1]. Other herbs like Rosemary, Turmeric, Garlic, Fenugreek, Spirulina, Aswagantha, Arogyapacha etc., are also possessing immunomodulating properties.

12. 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 53 µg 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 26-88 µg in 60 g hen egg tremendously.

12.1 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 (Arthur, 1997). 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 (Wakebe, 1998) 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. Rutz *et al*. (2004) 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. Se has a sparing effect on vitamin E, such that selenium supplementation can increase the vitamin E content of egg yolk.[25] Sodium selenite and selenocysteine result in greater concentrations in the yolk. Selenomethionine results in greater deposition in the albumen. However, a high level of Se is toxic. Attia *et al*. (2004) 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[27].
- 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[23].
- 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. [28]

- Selenium also helps the conversation of thyroxin (T4) to the biological active compound i.e., in the
- triiodothyronine (T3) which plays vital role in the body.

12.2 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 Garber *et al*. 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 hyperlipidemic people. There are some indications of anti-inflammatoryn and antiallergic properties of such eggs.

13. 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. [21] 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.[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.

14. 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. Some of the pigments are having vitamin A activity. Most of these natural pigment sources are used in feeds at 1-5 % levels to increase the yolk colour. The active pigments extracted from these sources are sufficient at 0.05 - 0.1 % level, to give the same level of pigmentation. Turmeric powder at 0.5 kg along with red chilli powder at 1 kg / tonne of feed, not only improve the yolk colour, but also act as anti-microbial agents and anti-oxidants. Fat soluble Azo dyes are also used for pigmentation, but this is banned in many countries.

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.

15. 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 who 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.

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.

Conclusion

Designer eggs provide options for consumers who want eggs with different nutritional benefits or properties than generic eggs. 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.

References

1. Ge0orge Dominic, Murali P, Vinu M. Nampoothiri Dietary Manipulations for Improvement of Egg Quality for Human Consumption Research News For U (RNFU) ISSN. 2014; 14:2250-3668.
2. USDA. National Nutrient Database for Standard Reference, Release. 2010, 23.

https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/nutrient-data-laboratory/docs/usda-national-nutrient-database-for-standard-reference/

3. Simopoulos AP. Symposium: role of poultry products in enriching the human diet with n-3 PUFA: human requirement for n-3 polyunsaturated fatty acids. Poultry Science. 2000; 79:961-970.
4. Shimizu Y, Arai K, Ise S, Shimasaki H. Dietary fish oil for hens affects the fatty acid composition of egg yolk phospholipids and gives a valuable food with an ideal balance of n-6 and n-3 essential fatty acids for human nutrition. Journal of Oleo Science. 2001; 50:797-803.
5. Nash DM, Hamilton RMG, Sanford KA, Hulan HW. The effect of dietary menhaden meal and storage on the omega-3 fatty acids and sensory attributes of egg yolk in laying hens. Poultry Science. 1996: 76:377-383.
6. Herber SM, Van Elswyk ME. Dietary marine algae promotes efficient deposition of n-3 fatty acids for the production of enriched shell eggs. Poultry Science. 1996; 75:1501-1507.
7. Baucells MD, Crespo N, Barroeta AC, Lopez-Ferrer S, Grashorn MA. Incorporation of different polyunsaturated fatty acids into eggs. Poultry Science. 2000; 79:51-59.
8. Abhishek Sahoo, Biswadeep Jena. Designer egg and meat through nutrient manipulation" Journal of Poultry Science and Technology. 2014; 2(3):38-47.
9. Plourde M, Cunnane SC. Extremely limited synthesis of long chain polyunsaturates in adults: implications for their dietary essentiality and use as supplements. Applied Physiology, Nutrition and Metabolism. 2007; 32:619-634.
10. Ravidran V, Bryden WL, Cornegay ET. Phytates: occurrence, bioavailability and implications in poultry nutrition. Poultry and Avian Biology Review. 1995 6:25-143.
11. Gebauer SK, Psota TL, Harris WS, Kr 83:1526-1535.
12. Bhattacharya A, Banu J, Rahman M, Causey J, Fernandes G. Biological effects of conjugated linoleic acids in health and disease. The Journal of Nutritional Biochemistry. 2006; 17:789-810.
13. Wahle KWJ, Heys SD, Rotondo D. Conjugated linoleic acids: Are they beneficial or detrimental to health? Progress in Lipid Research, 2004; 43:553-587.
14. Suksombat W, Samitayotin S, Lounglawan P. Effects of conjugated linoleic acid supplementation in layer diet on fatty acid compositions of egg yolk and layer performances. Poultry Science, 2006; 85:16031609
15. Jiang Z, Sim JS. Fatty acid modification of yolk lipids and cholesterolloweringeggs. In: Egg Uses and Processing Technologies.: new developments. Sim J.S. and Nakai S., Eds. Cab International, Wallingford, UK, 1994, 349-361
16. Leskanich CO, RC Noble. Manipulation of n-3polyunsaturated fatty acid composition of avian eggs and meat. World's Poult. Sci. J 1997; 53:155-183.
17. Elkin RG. Reducing shell egg cholesterol content. I. Overview, genetic approaches, and nutritional strategies. World's Poultry Science Journal. 2006; 62:665687.
18. Panda AK, Reddy MR, Rama RSV, Praharaj NK. Production performance, serum/yolk cholesterol and immune competence of White Leghorn layers as influenced by dietary supplementation with probiotic. Tropical Animal Health and Production, 2003; 35:85-94.
19. Mottaghitalab M, Taraz Z. Effects of garlic powder (*Allium sativum*) on egg yolk and blood serum cholesterol in Aryan breed laying hens. British Poultry Science. 2002; 43:42-43.
20. Ponte PIP, Mendes I, Quaresma M, Aguiar MNM, Lemos JPC, Ferreira LMA. *et al*. Cholesterol levels and sensory characteristics of meat from broilers consuming moderate to high levels of alfalfa. Poultry Science. 2004; 83:810-814.
21. Narahari D. Nutrient manipulations for value added eggs and meat production. Conference of Indian Poultry Science Association and National Symposium, 2005.
22. Panda N, Swain RK, Kaur H, Panigrahi B. Importance of antioxidants, vitamins on immunityand health of animals. Veterinary Nutrition and Health, 2011; 383-392.
23. Venardos KM, Perkins A, Headrick J, Kaye DM. Myocardial ischemia-reperfusion injury, antioxidant enzyme systems, and selenium: a review. Cur. Med. Chem. 2007; 14:1539-1549.
24. Kirunda DFK, Scheideler SE, McKee SR. The efficacy of vitamin E (DL-alpha-tocopheryl acetate) supplementation in hen diets to alleviate egg quality deterioration associated with high temperature exposure. Poultry Science, 2001; 80:1378-1383.
25. Surai PF. Natural antioxidants in poultry nutrition: new developments. In Proceedings of the 16th European symposium on poultry nutrition. 2010, 669-675.
26. Attia MY, Motaal AM, Glnal A, Medany NM. Effect of using different levels of selenium on productive performance of White Hi-line laying hens. Egyptian Journal of Agriculture Research, 2004; 82:1837-1852.
27. Papp LV, Lu J, Holmgren A, Khanna KK. From selenium toselenoproteins: synthesis, identity, and their role in human health.Antioxidants and Redox Signalling. 2007; 9:775-806.
28. Zhang J, RG Munger, NA West, DR Cutler, HJ Wengreen, CD Corcoran. Antioxidnat intake and risk of osteoporotic hip fracture in Utah: and effect modified by smoking status. Am. J Epidemiol. 2006; 163:9-17.
29. Fraeye I, Bruneel C, Lemahieu C, Buyse J, Muylaert K, Foubert I. Dietary enrichment of eggs with omega-3 fatty acids: A review. Food Research International. 2012; 48(2):961-969.
30. Saste Ashwini Shivaji, Dr. T Munegowda, Arpitha, R Recent Advancements in Designer Egg Production Life Sciences International Research Journal 2017; 4(1). ISSN 2347-8691 31.
31. Galobart J, AC Barroeta, MD Baucells, F Guardiola. Lipid oxidation in fresh and spray-dried eggs enrichedwith ω3 and ω6 polyunsaturated fatty acids during storageas affected by dietary vitamin E and canthaxanthin supple-mentation. Poult. Sci. 2001 80:327-337.