PRODUCTION OF DESIGNER EGG THROUGH DIETARY MANIPULATION AND ITS IMPORTANCE : A REVIEW

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ABSTRACT

In recent time, poultry sector is at boom. But along with quantity of egg production, we have to look towards the quality of egg. Now a day, consumers are more health conscious. So they prefer low cholesterol egg. Therefore, producers should give importance for the production of designer eggs, which are enriched with specific nutrients like omega-3 fatty acid, Selenium, iodine, chromium, etc. Also some of the antioxidants can be added to the diet to increase their amount in eggs. So that consumers will be able to prevent themselves from several diseases. Apart from that, some of the herbal products can also be added in the diet of the laying hen to increase nutrient concentration in eggs.

KEY WORDS: Chromium, Designer, Egg, Iodine, Omega-3 fatty acid, Selenium

INTRODUCTION

Among all sectors of veterinary science, poultry industry is one of the fastest growing industries. As per the data of 2012 from FAO, India stands at 3rd position in world in case of egg production. Egg production at the end of the Tenth Plan (2006-07) was 50.70 billion as compared to 66.45 billion at the end of the Eleventh Plan (2011-12). Currently the total poultry population in our country is 729.21 million (as per 19th Livestock Census) and egg productionis around 82.93 billion during 2015-16. The per capita availability (2015-16) is around 66 eggs per annum (Anonymous, 2016-17). Over the last decade, there has been interest in altering the 'composition' of poultry products. Generally, such compositional changes are related to either the quantity of certain nutrients components of poultry egg or its nutritional profile as it relates to human health or consumer demand (Wong, 2007). However, in recent times, decreases in egg consumption have been observed. The decline is attributable to consumer concerns about cholesterol, fat sources, types of fatty acids consumed, and their relationship to coronary heart disease (CHD). The American Heart Association suggests limiting whole egg or egg yolk consumption to three or four per week, including those used in cooking. As poultry meat and eggs are lacking in many minerals and vitamins, fortification with these nutrients can be considered, if it is economically achievable through dietary manipulation. Besides branding, several local egg producers have marketed designer eggs which include enriched ω-3 eggs, selenium, folate, vitamin E and lower cholesterol eggs. The value addition to eggs can either be done prior to oviposition or after oviposition (Ezhilvalavan *etal.,* 2003). Designer or enriched eggs are examples of pre-oviposition value added products. Therefore, several attempts have been made to reverse the decline in egg consumption by changing egg composition through genetic selection or alteration of the laying hen's diet with various nutrients, natural products, non-nutritive factors, or pharmacological agents.

Modified or Enriched egg

Modified or enriched eggs or super eggs are those in which the content has been modified from the standard eggs due to change in the diet of the laying hen. These eggs may be classified as nutritionally enhanced eggs, value added eggs, processed eggs. Etc. A lot of studies have shown that feeding animals with different components has a strong effect on the composition of food. Conjugated linoleic acid has been used in many of these studies (Kim *et al.,* 2016). However, modified fat content of the eggs are marketed as a reduced amount of cholesterol, less saturated fat, elevated amount of omega-a fatty acid, higher vitamin content and high amount of iodine. However, the organic and free-range eggs are marketed as value added eggs. The nutritional content of the organic eggs will be equal to the generic eggs if the feed is of similar quality.

Strategies to consider in egg nutrient enrichment

Some strategies should be adopted for efficient designer egg production (Dominic *et al.,* 2014) such as:

- Efficient nutrient conversion efficiency
- There may be toxicity while feeding some nutrients at high level (eg: Vitamin A and D are toxic at high doses). Therefore, care should be taken during feeding of these nutrients.
- Nutrient should be fed to bird keeping the market demand in view
- Designer egg should be prepared according to recommended dietary allowance for human
- Negative nutrient interactions should be avoided
- While preparing the designer egg with spefic nutrient, taste of the product should be take care
- Some measures should be taken so that nutrients will not be lost while cooking.

Herbal designer egg

In India, Narahari *et al*. (2004) has build up Herbal Enriched Designer Eggs (HEDE) which was not only rich in n-3 PUFA but also had vit-E, Se, carotenoids, certain B-complex vitamins and trace minerals. These eggs were also rich in several herbal active principles like allicin, betaine, eugenol, lumiflavin, lutein, sulforaphane, taurine and a lot of more active principles depending on herb fed to hen. Examples of health-promoting components include garlic, fenugreek and bay leaves. Garlic *(Allium sativum)* has potential hypolipidemic, hypotensive, hypoglycemic, hypothrombotic, hypoatherogenic and galactogenic properties (Bordia *et al.,* 1975, Sklan *et al.,* 1992, Chowdhury *et al.,* 2002). Fenugreek seeds *(Trigonella foenum)* have hypoglycemic, hyperinsulinemic and hypolipidemic (Sowmya and Rajyalakshmi, 1999) properties and also have a unique property to reduce platelet aggregation (Hannan *et al.,* 2003). Alkaloids from bay leaves have antioxidative properties (Tachibana *et al.,* 2003). Chowdhury *et al*. (2002) also observed cholesterol reduction properties ofdietary garlic in laying hens.

Omega-3 fatty acid enriched eggs

Dyerberg and Bang (1979) reported that omega-3 fatty acids would protect the heart from Cardiovascular Diseases (CVD). Advantages of omega-3 fatty acid enriched eggs are:

a)Prevention of coronary heart disease
b)Infant development, reduction of cancer and inflammatory disease
c)Prevention of psychiatric disorders
d)Helpful in improvement of oxygen supply to the tissues
e)Increase in brain function
f)Give relief in treatment of Rheumatoid arthritis
g)Improves skin and relieves arthritis
h)Helpful in curing from inflammatory disorders and improve immune responses

Recently, eggs have gained attention as an alternative to fish and oilseeds as a source of Omega -3 fatty acids. Generally, people tend to avoid egg yolk, but yolk only contains omega 3 fatty acids. The total fat content in the egg yolk cannot be altered; but its fatty acid composition can be altered, by changing the type of oil used in the hen's diet. Omega-3 is an essential fatty acid with a treasure trove of health benefits. Feeding of some oil cakes like flax seed (Linseed), marine algae, fish oil and rapeseed oil will lead to increase in omega-3 fatty acid content of egg (Abubakar *et al*., 2007). Conentent of omega-3 fatty acid in egg can be increased primarily by feeding linoleic acid, which is a precursor for DHA. Linoleic acid protects the consumer from heart diseases (Hu *et al*., 1999). One normal eggs contain only 50-100 mg of omega 3 fatty acids and which can be increased to 500 mg or more with dietary modifications in the hen's diet by feeding flaxseed (linseed) or marine algae or fish oil or rape seed oil (Dominic *et al.*, 2014).

Low cholesterol egg

Now-a-days, lots of people are suffering from cholestrophobia. Therefore, they want to consume less cholesterol diet. So it is the responsibility of producer or designer to produce or design low cholesterol egg. This can be achieved either by reducing the amount of cholesterol per egg, by reducing the size of the yolk or by altering the lipid profile of the yolk.A large egg contains about 200 mg of cholesterol. Low cholesterol eggs can be achieved either by reducing the amount of cholesterol per egg or by reducing the size of the yolk or by altering the lipid profile of the yolk. Parker *et al.* (1999) reported significantly decrease (by 4 mg/g) in the cholesterol content of the yolk comparatively to the control after supplementation of beta cyclodextrin @ 6% in the feed. Chromium, copper, nicotinic acid, statins, garlic, basil (tulasi), plant sterols, N-3 PUFA supplementation to chicken feed will reduce the yolk cholesterol levels significantly. Dietary linseed oil = 2-4%, fish oil (body oil and not liver oil) = 1-2%, garlic = 0.5%, basil = 0.3%, spirulina = 0.2%, bay leaves = 0.5%, nicotinic acid = 200 mg / kg, neomycin = 10 ppm, statins of yeast = 0.5-1%, guar gum = 1%, grape seed pulp / Ttmato pomace (lycopene) = 2-5%, citrus pulp (nirangenin) = 2-5%, chelated copper = 200 ppm, organic chromium = 2 ppm, roselle seeds = 0.5% and many more herbs in chicken diets will reduce the yolk and body cholesterol levels by 10-25% (Dominic et al., 2014). Panaite *et al.* (2016) suggested that supplementing the hen diet with flaxseed meal and camelina meal along with copper as $CuSO_4$ x $5H_2O$ resulted in low cholesterol and higher linoleic acid containing eggs.

Antioxidant eggs

Vitamin E, a fat-soluble vitamin as well as an effective antioxidant can be enhanced by 100 per cent in designer eggs. 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. Seleneim, a mineral responsible for antioxidant property of birds, can be enhanced in egg by supplementing the mineral in diet. Tufarelli *et al.* (2016) suggested that supplementation of organic selenium (2-hydroxy-4-methyl selenobutanoic acid) improved the selenium and vitamin E status of egg yolk. Chantiratikul *et al.* (2017) reported that hydroponically produced Se-enriched kale sprout was more efficient in selenium depositing in egg as compared to that of sodium selenite and selenium enriched yeast. Through designer egg we can improve several anti-oxidant status of egg such as sulforaphene, lycopene, carnosine, curcumin, quercetin etc. through several herbal supplementation in hens diet. The advantages of enrichment of the egg with anti oxidants include:

- Decreased susceptibility to lipid peroxidation
- Prevention of fishy odour to the product
- Vitamin-E reduces the free radicals in blood
- Decreases risk of cancer and ageing process due to the reduction in the formation of the free radicals
- Reduction in risk of heart disease

Mineral enriched egg

Eggs can be enriched with many types of minerals by supplementation in hens feed. Most commonly supplemented minerals are selenium and iodine followed by chromium and copper. These trace minerals are very important for human health because the deficiency of these leads to development of deficiency diseases (Al-Massad *et al*., 2011).

Selenium enriched designer egg

Among 25 countries, where selenium enriched designer eggs are available, Russia stands first. Kralik *et al*. (2016) reported that supplementing selenium enriched wheat to laying hens, improved the micronutrient supply to consumers through eggs. Organic selenium supplementation (0.3 mg/kg) lead to more selenium accumulation in eggs as compared to inorganic selenium supplementation (0.3 mg/kg) or non-supplementation in hens (Rajashree *et al.*, 2014). Selenium is an important constituent of a number of functional seleno-proteins which is mandatory for normal health that may come from different sources like that bread and cereals, fish, poultry and meat. Supplementation of selenium in eggs can decrease the incidence of cancer. Selenium enriched egg consumption may lead to improve anti-oxidant status of the animal and improved reproductive efficiency. Supplementation of Se in eggs can decrease the incidence of cancer (Blot *et al*., 1993; Clark *et al*., 1996). While studying the comparative effect of selenium sources (sodium selenite, Se-enriched yeast, Cytoplex-selenium and Selenomax), Asadi *et al.* (2017) reported that selenomonax had highest efficiency in depositing selenium in egg yolk. Addition of Se in the eggs may play certain vital roles such as:

- Reduction of arthritis, cancer, cataract, cholestatsis, cystic fibrosis, diabetes, immunodeficiency, lymphoblastic anaemia, macular degeneration, muscular dystrophy, etc.
- Helps in reducing the risk of DNA damage that is associated with cancer.
- Supplementation can also improve blood fluidity by metabolic modification of lipoproteins which may provide additional protective factor against cardiovascular disease development.

Iodine enriched egg

In countries, where people suffer from iodine deficiency, iodine enriched eggs will be of high value. Sumaiya *et al.* (2016) reported that supplementation of iodine at 6.5 ppm is economic in producing iodine enriched egg followed by 3.25, 9.75 and 13.0 ppm iodine to laying hens.

Supplementation of iodine in the form of potassium iodide or potassium iodate @ 4000 mg/ton diet increased the iodine concentration of eggs. Saki *et al.* (2012) and Slupczynska *et al.* (2014) also reported increased iodine content in egg due to supplementation of iodinated diet. Garber *et al.* (1993) 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 lipidemicpeople. Yokoyama *et al.* (2016) reported that consumption of iodine enriched egg might lead to reduction in visceral fat in normal individuals.

Other mineral enriched egg

Supplementing the laying hens with zinc methionate @ 150 mg/kg diet led to improve performance of birds and production of zinc enriched egg which could supply 19.45 % of daily requirements of zinc for children from 1-8 years (Bahakaim *et al.*, 2014). In another experiment by Saldanha *et al.* (2009) found that trace mineral levels and sources did not influence any of the studied egg quality parameters. Therefore, they conclude that reducing organic trace mineral supplementation in up to 70% relative to 100% inorganic trace mineral supplementation does not affect egg parameters and therefore, can be applied to the diet of semi-heavy layers in their second cycle of lay. Similar results were observed by Yenice *et al.* (2015), who observed that organic source of Mn, Zn, Cu and Cr supplementation resulted in higher egg concentration of these minerals. Using *Enteromorpha prolifera* and *Cladophora* sp. instead of inorganic trace minerals (Cu, Zn, Co, Mn and Cr) resulted in higher transfer of minerals to egg and enhanced yolk colour, also resulted in improved egg weight and egg shell quality. Therefore, Michalak *et al.* (2010) concluded that that *Enteromorpha prolifera* and *Cladophora* sp. enriched with microelement ions could be potentially used as mineral feed additives in laying hens feeding. Witkowska *et al*. (2014) also observed similar results while using soybean meal (enriched with Cu, Zn, Fe na Cr) instead of inorganic elements in laying hens. Contradicting to this trend of results, Ma *et al*. (2014) reported that supplementing chromium, as chromium propionate (@ 0, 200, 400, and 600 μg/kg) did not affect the egg chromium deposition.

CONCLUSION

Poultry eggs are good source of essential nutrients. The development of nutrient enriched value added poultry eggs greatly increased the context of functional foods for human health. Hence, by manipulating the diet of hen with the different available feed supplements in requisite amounts, value added and health promoting products can be made available to the health conscious consumers. The designing must take into consideration the production facilities, available materials, technical know-how, economic resources of the producers and environmental impacts with welfare issues.

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Table 1: Nutrient content of ordinary and designer/functional eggs

Nutrient Content	Quantity Per 100 g 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
Mono unsaturated fatty acids (MUFA)	4.4g	4.4g
Poly unsaturated fatty acids (PUFA)	2.0g	2.5g
Linoleic acid (ω-6 fatty acids)	1.9g	1.4g
α-linolenic acid(ω-3 fatty acids)	0.03g	0.7g
ω-3 fatty acid (EPA+DHA)	0.08g	0.4g
n6/n3 ratio	17.3	1.27
Unsaturated/saturated fatty acids	1.94	2.46
Cholesterol	400mg	320mg
Carotenoids	1.5mg	2.2mg
Vitamin E	2mg	15mg
Selenium	Traces	1.8μg
Chromium	Traces	1μg

Quantities depend upon their levels in the feed provided (Narahari, 2005)

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

Addition of Oils in Diets	Level of DHA Enhanced 9 mg)	References
Flax seed oil	74-83	Jiang *et al*. (1991), Jiang and Sim (1993) and Maurice (1994)
Herring meal (12%) in the 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 (1997)
Tuna orbital oil (0.5%)	180	Leskanich and Nobel (1997)

Table 3: Active ingredients present in herbs/herbal enriched functional eggs and their function in relation to human health.

Herbs	Principle Active Ingredients	Benefits
Garlic, onion and their leaves	Allicin, Allylic sulfide	Lower LDL cholesterol as well as anticarcinogenic properties
Sugar beet, grape pulp	Betaine	Decrease plasma homocysyeine, which ruptures arterial walls
Spirulina, marigold petals, alfaalfa, red pepper	Carotenoid pigments	Antioxidant and anticarcinogenic
Basil leaves	Eugenol, eugenoic acid	Immunomodulatory properties
Turmeric powder	Flavonoid components	Antimicrobial as well as antioxidant
Bay (curry) leaves, Marigold petals	Lutein	Antioxidant, Improve vision
Tomato pomace, grape pulp	Lycopene	Decrease LDL cholesterol, antioxidant, anticarcinogenic
Citrus pulp	Nirangenin	Diminish LDL cholesterol
Flax seed, canola fish, oil insects, worms	ω-3 PUFA	Decrease LDL cholesterol, hypertension, angina and atherosclerosis
Seeds, weeds, legumes	Phytosterols	Enhance HDL cholesterol, decrease blood sugar
Quercitin, Luteolin, Diosgenin, Citogenin	Fenugreek, spices	Induce insulin secretion, antimicrobial and tonic activity
Brewery waste, yeast, fermented products	Statin	Reduces LDL cholesterol
Broccoli, cauliflower, cabbage, radish leaves, waste	Sulphoraphane	Anticarcinogenic and antioxidant properties
Milk, eggs and meat products	Taurine	Impede atherosclerotic plaque formation
Brans	Tocotrienols	Decrease LDL cholesterol

[MS received : September 25, 2017] *[MS accepted : October 24, 2017]*