

## REVIEW

### THE TABLE EGG: A REVIEW

#### Ovo de consumo: uma revisão

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#### ABSTRACT

This present review intends to provide information and update the reader about diverse aspects of quality and consumption of eggs, the variation among consumer preference worldwide emphasizing the upper status this food represents as source of essential nutrients for human health. This review mainly focus on topics regarding production and quality of table eggs, emphasizing some aspects of the egg market, trend in egg intake and consumers perceptions regarding egg content and nutritious values. Additionally, results from specific studies that provide new findings about the role of enrichment egg components on health, prevention and treatment of diseases are discussed. A novel viewpoint is proposed in this review, highlighting the perspective for an increase of consumption of egg and egg products, mainly in markets where the consumption pattern is known to be low. How the information about shell eggs and its nutrients reach the consumer strongly affect the way this food of higher biological functions takes part in the human diet.

**Index terms:** Enrichment eggs, diet, egg quality, human health.

#### RESUMO

Nesta revisão, os autores buscam informar sobre os vários aspectos relacionados à qualidade e ao consumo de ovos ao nível mundial, reportando as diferenças que existem entre os países e a importância que esse alimento representa para o fornecimento de nutrientes essenciais para nutrir e manter a saúde humana. Ao mesmo tempo, a revisão enfoca os estudos específicos, que indicam as novas descobertas sobre o enriquecimento dos ovos e sua ação auxiliar, no controle de problemas de saúde humana. Existe a perspectiva de incrementos no nível de consumo, principalmente nos países onde a ingestão é baixa e, assim, melhorar a nutrição humana com esse alimento de baixo custo e, no entanto, de alta qualidade nutricional.

**Termos para indexação:** Ovos enriquecidos, dieta, qualidade de ovo, saúde humana.

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#### EGG MARKET: AN OVERVIEW

The world egg production reached 65 million tons (FAO STATISTICS DIVISION-FAOSTAT, 2012), corresponding to 1140 billion of table eggs produced. The average number of layers housed worldwide is projected in 4.93 billion (INTERNATIONAL EGG COMMISSION-IEC, 2012); with China ranked as top leader and an egg production of 28 Mt (43%) and 800-1000 million of laying hens housed. European Union is the second in the rank, with 6.5 Mt (10%) of shell eggs produced and 290 million layers, followed by USA with 5.4 Mt (8.3%) and 276 million layers, India with 3.4 Mt (5.4%) and 133 million layers, Japan with 2.5 Mt (3.8%) and 121 million layers, Mexico with 2.38 Mt (3.7%) and 118 million layers and finally, Brazil with 1.9 Mt (2.9%) and 89 million layers, ranking the 7<sup>th</sup> position. It's noticed that there are differences in production coefficients among countries related to number

of hens housed and eggs metric production (IEC, 2012). In the last 10 years, the global production showed an increase of only 26.9% (FAOSTAT, 2012). This trend in the growth rate of table egg production reveals how heterogeneous is the egg market: even with lower egg consumption, greater increments in housing egg laying hens had occurring (AMERICAN EGG BOARD-AEB, 2012). For example, in the past 12 years could be seen how the increments in egg production occurred: 36% in Africa, 24% in Americas, 32% in Asia, 7.3% in Europe and 33% in Oceania.

Among the countries where the egg consumption (per capita per annum, IEC, 2012) is higher, could be mentioned: Mexico and Japan, 365 and 355 eggs, respectively; China, 350; Hungary, 350; United States, 276; European Union, 250. Egg consumption in Brazil is still lower: 145 eggs per capita per annum, based on total eggs production (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA-IBGE, 2012), and population statistics.

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What should be the causes of these differences in consumption in today's table egg market? In the next topic, this question is elucidated.

### CONSUMER PREFERENCES AND PERCEPTIONS

It could be noticed that per capita consumption of shell eggs showed few variation in the last years and practically did not suggest significant changes; distinct aspects are involved in this stagnation.

They are varied, but the main one is the lack of information concerning the importance of eggs as source of nutrients for human diet and health, as indicated by Patil, Cates and Morales (2005). Consumers usually do not receive accurate message about eggs, its real biological value among protein sources and the way they participate in daily meals or their application in recipes at bakeries (cupcakes, muffins, cookies, cakes, etc).

Bejaei, Wiseman and Cheng (2011) pointed out that in terms of perception and preferences, consumers' perceptions of nutritional value of eggs influence the egg types that they selected. Likewise, most consumers believed that free-run, free-range, and organic eggs have higher nutritional value than regular eggs and selected accordingly whenever they were affordable. For example, according to consumers' opinion, brown regular eggs also have higher nutritional value than white regular eggs.

Topics like cholesterol, foodborne diseases among others are consumers' concern associated with egg consumption. However, most of the data and facts regarding egg consumption and harm or benefits on health circulate among consumers without scientific evidence.

The trend of the modern consumer has converged toward the line of industrial products pre-processed (liquid eggs, pasteurized and dehydrated product line) ready for preparation however, egg raw product has not evolved much in this direction. In countries with higher consumption of eggs, several other forms of supply of products attractive to consumers have been developed, and with this, there was a significant increase in consumption and eggs and eggs' products has been naturally incorporated into dietary habits, as observed in Mexico and Japan. Gradually, the consumer perception has been changing over the years mainly due to the increased access to information on the nutritional quality of foods.

As indicated by Ruxton, Derbyshire and Gibson (2010), as more research is carried out, greater stimulus to consumption of eggs is expected once scientific data, clarifying the effects of food on human nutrition and wellbeing, gives emerging evidence suggesting that eating eggs regularly is a healthy habit associated with satiety, weight loss and better diet quality. Additionally, the

presence of antioxidants found in egg yolk may prevent age-related macular degeneration.

Most of the time incoming information is disconnected and often opposing, which leads to misperceptions of the consumer of eggs on the risk of coronary heart disease (CHD) and that is the case for the myth of egg cholesterol.

One egg contains only 213 mg of cholesterol (EGG BOARD NUTRITION-EBN, 2012), and an adult can produce in your hepatic system around 3000 mg daily (MCNAMARA, 1997), to meet basic metabolic needs of this nutrient.

Results from research conducted by Hu, et al. (1999), Mcnamara, (2002), and Fernandez, (2006) indicated no relationship between dietary cholesterol and egg yolk consumption affecting the increase in the circulating cholesterol (hypercholesterolemia).

Additionally, few studies have presented the link between increases in serum cholesterol levels with increasing intake of eggs. In these surveys (KRITCHEVSKY; KRITCHEVSKY, 2000; MCNAMARA, 2000), the specific effects of cholesterol intake is not isolated, hiding several implications of associated cigarette smoking, excess saturated fats ingestion, alcohol, physical inactivity, family history, among others characteristics resulting in confounding effects, with the differences being attributed solely to cholesterol intake. Several studies linking egg consumption to serum levels of cholesterol are considered methodologically inadequate (SONG; KERVER, 1999; WEGGEMANS; ZOCK; KATAN, 2001; NETTLETON et al., 2008), and these studies did not isolate the specific effects of cholesterol intake.

There are few studies linking egg consumption with CHD. Most studies on CHD like those from Hu et al. (1999), Nakamura et al. (2006), Barraj, Tran and Mink (2009) or researcher cerebrovascular accident, Nakamura et al. (2004), Qureshi et al. (2007), Djousse and Gaziano, (2008) indicate no correlation between these diseases with the ingestion of eggs. Other interesting studies show increases in the plasma high density lipoproteins (HDL) and no effect on LDL (low density lipoproteins) cholesterol (MUTUNJI et al., 2008) with the ingestion of two eggs per day for six weeks and additionally no effect on endothelial function, as a risk marker for cardiovascular diseases (CVD) after ingestion of three eggs per day for 13 weeks (HARMAN; LEEDS; GRIFFIN, 2008).

### EGG CONTENT AND HEALTH

Since 1957, the British Egg Marketing Board recommends the ingestion of eggs at the breakfast in order

to start the day with a high quality protein source (GUTER; LOW, 2008).

The egg is a closed box with an external structure suitable to ensure their internal quality. This box is basically composed of CaCO<sub>3</sub> (98%) in a polycrystalline structure in parallel layers forming the mammillary knob resulting in over 8000 pores serving for gas exchange inside and outside of the egg (NYS et al. 1999).

The interior edible core has two compartments which are the albumen (59%) and yolk (31%), where the main nutrients for human consumption are found (Table 1). The majority of essential nutrients are in the yolk and

especially the fat soluble vitamins, present exclusively in this compartment. Also essential fatty acids and the omega-3 series are present in the yolk.

The egg exhibit the best composition in essential amino acids for human nutrition (SYMONS et al., 2007; LAYMAN; RODRIGUEZ, 2009), being referenced in studies of protein quality as standard 100%, with biological value that reaches 93.7%. Moreover, the development of genetically modified birds which produce functional proteins in the egg is a clear important advance in the production in large scale of substances employed by the pharmaceutical industry.

Table 1 – Egg composition\*.

Nutrient	White	Yolk	% Total in White	% Total in Yolk
Protein	3.6 g	2.7 g	57%	43%
Fat	0.05 g	4.5 g	1%	99%
Calcium	2.3 mg	21.9 mg	9.5%	90.5%
Magnesium	3.6 mg	0.85 mg	80.8%	19.2%
Iron	0.03 mg	0.4 mg	6.2%	93.8%
Phosphorus	5 mg	66.3 mg	7%	93%
Potassium	53.8 mg	18.5 mg	74.4%	25.6%
Sodium	54.8 mg	8.2 mg	87%	13%
Zinc	0.01 mg	0.4 mg	0.2%	99.8%
Copper	0.008 mg	0.013 mg	38%	62%
Manganese	0.004 mg	0.009 mg	30.8%	69.2%
Selenium	6.6 µg	9.5 µg	41%	59%
Thiamin	0.01 mg	0.03 mg	3.2%	96.8%
Riboflavin	0.145 mg	0.09 mg	61.7%	48.3%
Niacin	0.035 mg	0.004 mg	89.7%	9.3%
Pantothenic acid.	0.63 mg	0.51 mg	11%	89%
B6	0.002 mg	0.059 mg	3.3%	96.7%
Folate	1.3 µg	24.8 µg	5%	95%
B12	0.03 µg	0.331 µg	8.3%	91.7%
Vitamin A	0 IU	245 IU	0%	100%
Vitamin E	0 mg	0.684 mg	0%	100%
Vitamin D	0 IU	18.3 IU	0%	100%
Vitamin K	0 IU	0.119 IU	0%	100%
DHA and AA	0	94 mg	0%	100%
Carotenoids	0 µg	21 µg	0%	100%

\*Adapted from the USDA Nutrient Database for Standard Reference, 2012, Release 15. AA and DHA data from NutritionData.com

Kaleri, Xu and Lin (2011) reported that current methods for the production of therapeutic proteins such as monoclonal antibodies used for treatment of diseases like cancer or arthritis are expensive and time consuming then, the use of chickens for mass production of these types of proteins represents an alternative, potentially inexpensive, faster and more efficient. In a study conducted by the previous authors, genes were inserted into the desired pharmaceutical proteins in the poultry gene for albumin, a protein that is up to 54% of egg whites.

The results clearly showed that the albumen from the eggs of the transgenic birds contained the functional recombinant proteins miR24, with potential for treating malignant melanoma, and human interferon b-1a, a complex compound for defense against viruses.

The protein content of an egg (60g) is 6.3 g (Table 1) being distributed in the albumen (57%) and yolk(43%). The consumption of such high quality protein can prevent muscle degeneration which occurs in young athletes, as well as sarcopenia in the elderly (MORAIS; CHEVALIER; GOUGEON, 2006; THALLALKER-MERCER et al., 2007).

Considering the vitamins content, except for vitamin C, the egg contains all other essential vitamins that are 100% bioavailable.

The restriction in egg consumption can increase problems related to human nutrition, mainly vitamins. Eliminating eggs from the diet of the elderly, for example, increased the risk of senile macular degeneration (SCHMIER; BARRAJ; TRAN, 2009). This can occur because the egg contains the carotenoids lutein and zeaxanthin, essential compounds that protect against the age-related macular degeneration (AMD), a major cause of blindness in elderly people.

The contribution of the egg in the daily needs of energy and nutrients was reported by Ruxton, Derbyshire and Gibson (2010). The consumption of three eggs per week for women and four for men account for 2% of energy, 3% protein, 3% saturated fatty acids and 5% monounsaturated fatty acids daily needs.

Additionally, the egg shell has been studied in the control of osteopenia and osteoporosis in postmenopausal women. In these studies, Schaafsma et al. (2002) explored the use of shell eggs powder, enriching milk products, with several noticeable benefits in bone quality.

### **THE EGG SECTOR: QUALITY SPECIFICATIONS**

The table egg industry follows strict quality control rules from the beginning of the creation of replacement pullets to the productive phase of the bird. Throughout the process usually are applied good manufacturing

practices (GMP) following specific process controls, thus ensuring a safe product that reaches the consumer.

The item "quality" took a much broader dimension to consumers today. However, the question would be, "What is egg quality?" It can be defined as a set of desirable characteristics such as, appearance (clean shells, undamaged, well-formed and resistant), size and weight, sensory values (smell and color), nutritional quality, safety (absence of pathogenic microorganisms, toxins, heavy metals), internal quality (consistency, transparency, free of blood and meat spots, and Haugh Unit > 75), air cell (<2 mm); internal structure (membranes, chalaza, yolk centered and viscosity) and factors related to the egg processing industry.

The quality of the egg depends on factors before the laying phase and after oviposition. Hen's health, feed safety and environmental quality are intrinsic factors that define the quality of the laid egg. After oviposition, environmental conditions, grading and pack systems, processing, handling and transportation start to have influence, particularly on the shelf-life and internal quality of the eggs.

The processing stage of the eggs only counteracts possible defects in the exterior (eggshells), when cleaning and disinfection plans are employed.

Once known the connection between the various processes in the production of table eggs, quality control mechanisms as standardization of operating procedures and "from farm to table" concept that comprises the application of GMP as the first step, it will be expected that food safety and quality are ensured in the whole producing chain.

### **ENRICHMENT OF EGGS**

The possibility of enrichment of eggs with specific substances has been studied since the 40s. The composition of the egg is responsive to manipulation of such nutrients in the layer diet, so called "carry-over" effect. In early studies, it was found the increase of certain vitamins in the egg yolk with the increase of dietary supplementation (NABER, 1979). Vitamins A, E, B2, biotin and B12 are markedly influenced by dietary changes (NABER; SQUIRES, 1993a). Also studies were done with enrichment of egg minerals such as iron (BERTECHINI et al. 2000) and selenium (REIS et al. 2009) among others.

The scientific evidence for the importance and function of Omega-3 fatty acids (n-3 PUFA) began in 1979 when it was discovered that Greenland Eskimos, who consumed fish with high levels of these acids (BANG; DYERBURG, 1972), had low rates of cardiovascular

problems. Many studies have been developed which evidenced the physiological effects of n-3 PUFA fats. It was found that the fatty acids of the omega-3 series, eicosapentaenoic acid (EPA), are associated with protection of the cardiovascular health, being connected to the processes of metabolism of plasma lipids (LEAF; KING, 1998). In addition, docosahexaenoic acid (DHA) is fundamental in the formation of nerve tissue and also in good visual and brain tissue development (CRAWFORD; BLOOM; BROADHURST, 1999).

The enrichment of eggs with n3-PUFA series is possible with the inclusion of oils rich in linolenic acid (LNA), EPA and DHA. The first one is found in high concentrations (51%) in flaxseed oil and the last two in marine cold-water fish (menhaden, herring or tuna) oils. The DHA is also found in some species of marine microalgae.

In eggs, 60-65 g of weight, LNA concentration can be increased in 400 to 600 mg per yolk. Concerning EPA and DHA the enrichment gain is lower, being expected accretion levels up to 180 mg per yolk summing both of the two acids. Laying hens' metabolism has the ability to complete the steps of elongation and desaturation of ALA to produce EPA and DHA. Therefore, by providing only ALA in the hen's diet, it is possible to enrich the eggs at levels of 90-115 mg of these two long chain fatty acids. For higher increments is necessary to use fish oils (marine origin) or marine microalgae. In addition to the reported effects, the consumption of eggs enriched with n-3 PUFA significantly increased the plasmatic concentration of n-3 PUFA with marked reduction of the ratio n-6/n-3 PUFA, at recommended levels. While this ratio is 7/1 in regular eggs, in enriched n-3 PUFA eggs, values range around 3.7/1 or less, and therefore meeting the dietary recommendation (SIMOPOULOS, 2008; DECKELBAUM, 2010).

Macular degeneration is the leading cause of blindness in developed countries, resulting in progressive and irreversible loss of central region vision. The most effective prevention to date is increasing our intake of lutein, which accumulates in the macular region of the eye and seems to aid in prevention of such blindness (LEESON; CASTON, 2004). The previous authors indicated that adding lutein to the layers' diet resulted in an increase of egg yolk lutein 5 to 8 times above regular concentrations, and that such enriched eggs will supply a meaningful contribution to our diet.

Another essential nutrient which can be easily manipulated in the egg is selenium (Se). This trace mineral is involved in a number of biological functions, especially

in maximizing the activity of plasma glutathione peroxidase (SARMA; MUGESH, 2005; PRABHAKAR et al., 2005; BORDONI et al., 2008), protecting the endothelial epithelium of arteries, avoiding the formation of atheroma's (NEUNTEUFL et al., 1997; KATZ et al., 2005) and maintaining the integrity of cell membranes, contributing to the reduction of breast, prostate and colorectal cancer (RUSSO et al., 1997; DONG et al., 2003).

The addition of Se-Yeast in the diet of laying hens provided an increase up to 30 mg per yolk (60g), contributing with 60% of the women's daily requirements and 50% of men needs (FISHININ; PAPAZYAN; SURAI, 2008). The increase of 50% in the plasma levels of Se enables the reduction of CHD risk by 24% (FLORES-MATEOS et al, 2006). For other types of cancers, Se exerts protective role in the early stages of the disease (ZENG; COMBS, 2008; ZHUO et al., 2004; BRINKMAN et al., 2006; CONNELLY-FROST et al., 2006).

The Se intake in Brazil through food is very heterogeneous and only some regions (South of Pará and the eastern part of the State of Pernambuco), the consumption is appropriate due to the nature of the soil in these areas. According to Maihara et al., (2004), consumption of Se in Brazil varies from 28 to 37g/person/day, values considered below the recommended dietary needs for humans (COMBS, 2001).

#### FINAL REMARKS

Regardless of the great heterogeneity in shell egg market worldwide, projected scenarios for countries with lower consumption start to see a positive impact when more information about the egg and its value for human nutrition is disseminated.

The importance of eggs as a source of essential nutrients for human nutrition and health has been increasingly valued and recent research on the enrichment of eggs reinforce its benefits in the reduction of health problems and consequent influence on longevity of consumers.

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