Content is avaliable at SCOPUS

Meat Technology — Special Issue 64/2

www.meatcon.rs ▪ www.journalmeattechnology.com

UDK: 636.5.084.52
637.412.053

ID: 126633481

https://doi.org/10.18485/meattech.2023.64.2.39

Review paper

Enrichment of table eggs with selenium through designed feed for laying hens

Dragan Šefer[a], Dejan Perić[a] and Radmila Marković[a]*

[a] *University of Belgrade, Faculty of Veterinary Medicine, Bulevar oslobodjenja 18, Belgrade, Serbia*

ARTICLE INFO

Keywords:
Eggs
Laying hens
Organic selenium
Animal nutrition

ABSTRACT

In recent years, the foods that are used daily in human diet are not only intended to satisfy the requirements in basic nutrients, they are also expected to prevent food-related diseases and help consumers acquire a better immune status. By using specific nutritional strategies, it is possible to produce functional food that, in addition to basic nutrients, also contains components that participate in preserving health and reducing the risk of disease. Selenium, which is used as an additive in vitamin-mineral premixes in feed for laying hens, is present in one of two basic forms: organically bound to amino acids (selenocysteine and selenomethionine) or in the form of an inorganic salt (most often sodium selenite). Deposited selenium in the body is in an inactive state, and in cases of oxidative stress or selenium deficiency in feed, it changes to an active form. The source of selenium in feed mixtures for laying hens has an effect on the selenium content of eggs. By adding organic selenium to laying eggs, amounts of 20–25 µg per egg can be achieved, which is about 30% of the recommended daily intake for humans.

1. Eggs in human nutrition

Consumable chicken eggs represent an exceptional source of nutritionally valuable nutrients and are an inseparable part of a high-quality and well-balanced human diet. At the same time, edible chicken eggs are a moderate source of calories (on average 140 kcal/100g), which makes them a food with a favourable ratio of nutritional value to energy. The production and consumption of eggs in the world has been increasing in recent decades. The consumption of eggs has long been associated with negative effects on human health, mainly due to their cholesterol content. However, it is now known that the level of cholesterol in the serum is influenced by several other factors in consumers, such as genetic predisposition, hormonal status and eating habits, and not only by the cholesterol from eggs. In terms of basic chemical composition, whole egg is a mixture of water, protein, fat, carbohydrates and ash. The content of basic nutrients in eggs is mostly stable (Table 1) and depends on the ratio of egg

Table 1. The basic chemical composition of the whole edible chicken egg (*USDA*, 27; *USDA*, 23)

Nutrient	g/100
Protein (g/100g)	12.56
Fat (g/100g)	9.51
Carbohydrate (g/100g)	0.72
Moisture (g/100g)	76.15
Ash (g/100g)	1.06

***Corresponding author:** Dragan Šefer, *dsefer@vet.bg.ac.rs*

Paper received July 3rd 2023. Paper accepted July 18th 2023.
Published by Institute of Meat Hygiene and Technology — Belgrade, Serbia

white to yolk, while the presence of micronutrients is determined by the influence of several different factors, where the influence of laying hen nutrition is dominant. Water is the most abundant ingredient in the egg, followed by protein, which is evenly distributed in the egg white and yolk, while fats are mostly present in the yolk, but vitamins and minerals mostly occur in the white and yolk.

Egg protein is nutritionally complete because it contains all essential amino acids. Egg whites and yolks contain protein of high biological value and digestibility. The biological value of egg protein (a measure of the building of food protein into tissue protein) is 94 and is the standard by which the biological value of all other proteins is evaluated. One hen's egg contributes only 3% of the energy value of the recommended daily energy intake, which is 2000 kcal, and at the same time provides 11% of the daily protein needs. The contribution of the intake of essential amino acids amounts to 13–31%, depending on the type of essential amino acid. The average protein content in a fresh hen's egg is about 12.5%. Egg yolk contains about 16% protein, which is a complex of low-density lipoprotein (LDL), high-density lipoprotein (HDL), phosvitin and livetin. In the composition of egg white, the share of protein is on average 10–11%, and it consists of albumin and globulin (in the thin egg white), ovalbumin (in the thick egg white), mucin and mucoid (structural part of egg white). Ovalbumin makes up more than 50% of the protein in the egg white, it is rich in essential amino acids, which are crucial for the development of the chicken embryo, but are also an exceptional source of amino acids in human nutrition. Chicken egg white contains numerous proteins with a unique structure and functional properties, such as ovotransferrin, ovomucoid, ovomucin, ovomacroglobulin (ovostatin), ovoflavoprotein, lysozyme, ovoinhibitor, ovocystatin and avidin. Many of these proteins, as well as their breakdown products, have been proven to have biological activities significant for improving human health, such as antimicrobial, antioxidant and immunoregulatory properties.

The lipid content in the whole edible chicken egg is, on average, 10% (French Agency for Food, 2017). The entire lipids in the egg are concentrated in the yolk in the form of triglycerides (65%), phospholipids (28–30%) and cholesterol (4–5%). The composition of lipids in the yolk is determined by various factors, of which diet has the greatest influence. Unsaturated (monounsaturated and polyunsaturated) fatty acids make up approximately 50% of the fatty acid composition of egg lipids. Of the monounsaturated fatty acids, the most abundant is oleic (C18:1 n-9), and of the polyunsaturated, linoleic (C18:2 n-6) and arachidonic (C 20:4 n-6) acids. Saturated fatty acids make up 30–35% of the fatty acid composition of the egg, with the largest share being palmitic (C16:0) and stearic (C18:0) acids. Egg lipids also contain sterols, the most important of which is cholesterol. An edible hen's egg contains an average of 400 mg of cholesterol per 100 g (USDA, 27).

Table 2. Vitamins in whole egg (*Maqbool et al.*, 2017)

Vitamin	µg/100g
Vitamin A (Retinol)	193
Vitamin D (Cholecalciferol)	1.5
Vitamin E (Tocopherol)	1.3
Vitamin K (Phylloquinone)	0.3
Vitamin B1 (Thiamine)	40
Vitamin B2 (Riboflavin)	450
Vitamin B3 (Niacin)	80
Vitamin B5 (Pantothenic acid)	1700
Vitamin B6 (Pyridoxine)	170
Vitamin B9 (Folate)	47
Vitamin B12 (Cobalamin)	0.89

Chicken eggs are a nutritionally valuable source of water-soluble and fat-soluble vitamins. Yolks are primarily a source of the fat-soluble vitamins A, D, E and K, but also contain vitamins of the B complex (B1, B2, B5, B6, B9 and B12). Egg white contains a high concentration of vitamins B2, B3 and B5, but also significant amounts of vitamins B1, B6, B9 and B12 (Table 2). According to literature data, consuming two chicken eggs can satisfy 10–30% of daily vitamin needs.

Edible chicken eggs contain significant amounts of minerals, primarily potassium, sodium, calcium and phosphorus. Also, they are a source of essential microelements, copper, iron, magnesium, manganese, selenium and zinc (Table 3).

Table 3. Minerals in whole egg (*USDA*, 27)

Mineral	mg/100g
Calcium	56
Magnesium	12
Selenium	0.03
Sodium	142
Zinc	1.29
Phosphorus	198
Manganese	0.028
Iodine	0.021
Copper	0.072
Iron	1.75
Potassium	138

2. Functional food

In recent years, the foods that are used daily in human diet are not only intended to satisfy the needs in basic nutrients, they are also expected to prevent food-related diseases and help consumers acquire a better immune status. Functional food cannot be simply defined, since a large number of different food products can be classified as functional foods. That is why the European Commission proposed a working definition that implies that functional food must be composed of natural ingredients, must not be in the form of tablets, capsules or food supplements, and is important for improving health and/or reducing the risk of disease development. A functional food is consumed as part of the daily, usual diet, and its effectiveness must be scientifically proven. Functional food can be natural food, food enriched with a certain ingredient or that has had a certain ingredient removed from it, food in which the properties or bioavailability of one or more ingredients have been changed, or any combination of the above possibilities (*Roberfroid*, 2002). The development of functional products and the functional food market has increased with the development of the science of animal nutrition, as a basic condition for the creation of functional foods. The success of a new functional product on the market does not only depend on its beneficial effect on health, but also on its acceptable taste, appearance and availability to consumers (*Grčević et al.*, 2011). By using specific nutritional strategies, it is possible to produce functional food that, in addition to basic nutrients, also contains components that participate in preserving health and reducing the risk of disease.

3. Role of selenium

Selenium is an essential trace element that has multiple roles in the body due to its participation in biochemical processes. It is a component of 25 selenoproteins. It has a favourable effect on the immune system, preventing the occurrence of inflammatory processes, cancer and oxidative stress and reducing the risk of atherosclerosis and cardiovascular diseases. Selenium plays a role in the protection system of biological membranes against oxidative damage. It performs this role together with vitamin E (*Marković et al*., 2010). Of the total selenium in the body, 40% is present as an active ingredient in the enzyme glutathione peroxidase (GPx). Selenium, together with vitamin E, has the role of an antioxidant, and participates in the conversion of free radicals into inactive and less toxic compounds. Free radicals are present in tissues with intensive oxygen circulation, where they cause peroxidation of phospholipids, by acting on the double bonds of unsaturated fatty acids of phospholipids that are components of cell membranes. Free radicals are created when oxygen is added to those fatty acids, from which a hydrogen atom was previously separated. Free radicals can react with another lipid molecule, from which a hydrogen atom has been separated, and the product is hydroperoxide in the first molecule and a new free radical in the "attacked" lipid molecule. Molecules of lipid hydroperoxides are split to form dialdehydes, most often malondialdehyde (MDA). A series of such reactions leads to damage to the cell membrane structure and even to complete destruction (*Rayman*, 2000).

A series of positive effects of selenium on health resulting from the strengthening of the body's defences (strengthening of immunity, prevention of the formation and progression of arteriosclerosis, preservation of sperm fertility) have been confirmed, but with a rather narrow therapeutic range (in a ratio of 1:8) between the average needs (55 μg/day) and upper limit of safe intake — 400 μg/day (*Backović*, 2005). Relative selenium deficiency in humans is associated with an increased incidence of cardiovascular and other diseases etiopathogenetically related to oxidative stress and immune-mediated inflammation, infertility, and thyroid dysfunction (*Lynne*, 2004). A complete deficit is observed in long-term total parenteral nutrition with preparations without selenium, and in some regions it is associated with the occurrence of endemic Keshan and Kashin-Boeck diseases (*Rayman*, 2000). The addition or restriction of selenium affects the activity and metabolism of neurotransmitters, which causes changes in mood and behaviour in humans and animals (*Backović et al.*, 2002). A low concentration of selenium in the soil, and consequently in the nutrients used in animal feed, can cause a deficiency of this microelement in animals. Deficiency symptoms also occur in humans through foods of animal origin, which significantly weakens the system of antioxidant protection in the body.

4. Production of selenium eggs

The utilization of selenium by animals depends on the chemical form in which it is found in the meal. Selenium, which is used as an additive in vitamin-mineral premixes in feed for laying hens, is present in one of two basic forms: organically bound to amino acids (selenocysteine and selenomethionine) or in the form of an inorganic salt (most often sodium selenite). After entering the body through a meal, selenium is incorporated into tissue proteins, which creates its reserve. Deposited selenium in the body is in an inactive state, and in cases of oxidative stress or selenium deficiency in food, it changes to an active form. The source of selenium in feed mixtures for laying hens has an effect on the selenium content of eggs. By adding organic selenium to laying eggs, amounts of 20–25 µg per egg can be achieved, which is about 30% of the recommended daily intake for humans. For the production of such eggs, it is necessary to add organic selenium in the amount of 0.3–0.5 mg/kg in feed for laying hens. In research carried out at the Department of Nutrition and Botany of the Faculty of Veterinary Medicine, the addition of organic selenium in mixtures for laying hens resulted in a product of a specific composition, called the selenium egg, with 42 µg of selenium in 100 g of egg mass. Based on these results, we can conclude that organic sources of selenium have better biological availability and that the content of selenium in table eggs is more stable. The use of organic forms of selenium in the nutrition of laying hens increases the content of selenium in eggs.

Disclosure statement: No potential conflict of interest was reported by the authors.

Funding: The study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract number 451-03-47/2023-01/200143).

References

Backović, D., Jorga, J., Milovanović S. & Paunović, K. (2002). Essential role of selenium and central nervous system. *Engrami 2002*, 24, 39–47.

French Agency for Food, Environmental, and Occupation Health & Safety, (2017). ANES-CIQUAL French food composition table version (2017). Retrieved on01/11/2019from the Ciqual homepage https://ciqual. anses. fr.

Grčević, M., Gajčević-Kralik, Z., Kralik, G. & Ivanković, S. (2011). Kokošje jaje kao funkcionalna namirnica. Krmiva, 53(2), 93–100.

Lynne, A. D. (2004). Selenium: Essential and toxic but does selenium status have health outcomes beyond overt deficiency? (Editorial). *Medical Journal of Australia,* 180(8), 373– 374.

Maqbool, M. A., Aslam, M., Waseem, Akbar, W. & Zubair, Iqbal Z. (2017). Biological Importance of vitamins for human health: A review. *The Journal of Agricultural Science*, 2(3), 52– 58.

Marković, R., Baltić, M., Šefer, D., Radulović, S., Drljačić, A., Đorđević, V. & Ristić M. (2010). Einfluss erhöhter Mengen an organischem Selen und Vitamin E in der Broilermast auf ausgewählte Parameter der Fleischqualität. *Fleischwirtschaft*, 90, 132–136.

Rayman, M. (2004). The use of high-selenium yeast to raise selenium status: how does it measure up? *British Journal of Nutrition*, 92, 557–573.

Roberfroid, M. B. (2002). Global view on functional foods: European perspectives. British Journal of Nutrition, 88, 133–138.

USDA National Nutrient Database for Standard Reference. Release 27.

USDA National Nutrient Database for Standard Reference. Release 23.