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Uses of Poultry Eggs: Egg Albumen and Egg Yolk

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Abstract: This study reviews the uses of egg albumen and egg yolk. The albumin and yolk account for 60 and 30% of the egg, respectively. Their chemical composition make the egg to be of a high nutritional value to man. Egg albumen (egg white) is a source of complete protein and it contains all the amino acids required by the body for protein synthesis. Although, egg whites are a good source of low-fat, high-protein nutrition, a small number of people cannot eat them because of egg allergy associated with some proteins. Egg allergy is more common among infants than adults and most children outgrow it by the age of five. There is currently no cure for egg allergy. It is usually treated with an exclusion diet and avoidance of foods that may be contaminated with egg. Egg albumen protein (Lysozyme and EDTA) is effective against *Salmonella typhimurium* and Avidin-Biotin System is used as a diagnostic tool. Egg white has been used in the manufacture of edible packing films that could be used for water soluble packets for ingredients in the food, chemical and pharmaceutical industries. Egg white is fining agent that can be used in the clarification and stabilization of wine that involves removing insoluble and suspended materials that cause a wine to be cloudy. Egg white is a natural antioxidant that is added to ground meat to decrease oxidation during cooking. Egg albumen is used by artists as a binder for pigments as an ingredient of waterproof glue and as a varnish. Egg yolk is a major source of fatty acids, vitamins and minerals. It is the part of the fertilized egg which feeds the developing embryo. The hen's diet influences the fatty acids, minerals and vitamins content in eggs. The cholesterol content in egg yolk is significantly reduced by dietary Polyunsaturated Fatty Acids (PUFA). Many vaccines for infectious diseases are produced in fertile chicken eggs (yolk). The vaccines are used for disease control in humans and livestock. However, a method of vaccine production has been developed that is less cumbersome than dealing with chicken eggs and the vaccine production is easy. Egg yolk is used in painting as a component of egg-tempera to make liqueurs and for extraction of egg oil used in cosmetic, nutritional and medicinal uses. Egg oil and lecithin from egg yolk are used in biotechnology, food and pharmaceutical industries. Egg yolk is used in the production of egg-yolk agar that is used in identification of Clostridia. Therefore, the egg comprises of chemicals and components that have multiple uses in biotechnology (tissue culture), chemical, food, pharmaceutical and art (painting and photography) industries.

Key words: Poultry eggs, albumen, yolk, proteins, vitamins, minerals, fatty acids

INTRODUCTION

The egg comprises of the albumen (60%), yolk (30%) and shell/membrane (10%). Egg albumen (also called the egg white or the glair/glaire) is the clear liquid contained within an egg. In chickens it is formed from the layers of secretions of the anterior section of the hen's oviduct during the passage of the egg. It consists of about 10% proteins dissolved in water. Its primary natural purpose is to protect the egg yolk and provide additional nutrition for the growth of the embryo. It is rich in proteins and contains almost no fat, unlike the egg yolk which has a high fat value. The egg yolk is the yellow spherical part of an egg that is surrounded by the albumen. It is the part of the egg which feeds the developing embryo. The egg yolk is suspended in the albumen by one or two spiral bands of tissue called the chalazae. Eggs as a food are utilized as hard/soft cooked eggs, frozen scrambled eggs, omelets and egg patties. The chicken egg is of a high nutritional value to man that is mainly attributed to egg albumen and egg yolk which are the edible components.

They supply all essential amino acids for humans and provide several vitamins and minerals including retinol (Vitamin A), riboflavin (Vitamin B_2), folic acid (Vitamin B_9), Vitamin B6, B12, choline, iron, calcium, phosphorous and potassium. The egg has chemicals and components (Froning, 1998) that have multiple uses in biotechnology, chemical, food, pharmaceutical and art (painting and photography) industries (Germadios *et al*., 1996; Messier, 1991).

USES OF EGG ALBUMEN (EGG WHITE)

Eggs provide a concentrated source of high quality and affordable dietary protein. One large, medium and small egg contains 6.3, 5.5 and 4.8 g of protein, respectively. The protein from eggs is concentrated in the egg white. Egg white is a source of complete protein and it contains all the amino acids required by the body for protein synthesis (Lewis *et al*., 1950). There are many culinary and nonculinary uses for egg whites. Egg white is utilized as food in different forms, liquid, frozen and dried egg products are used as ingredients in foods like cake mixes and salad dressings noodles confectionary products.

Egg whites can replace full eggs or egg yolks in recipes in a two to one ratio to reduce the fat and cholesterol content of a dish but still maintain the high amount of protein. The egg white proteins are conalbumin, ovomucoid, ovomucin, lysozyme, globulins, flavoprotein, ovoglycoprotein, ovomacroglobulin, ovoinhibitor, avidin and cystatin (Li-Chan *et al*., 1995; Powrie, 1973) and have multiple uses (Willam and Cotterill, 1995). Lysozyme and EDTA is effective against *Salmonella typhimurium* on broiler legs (Samuelson *et al*., 1985) and Avidin-Biotin System is used as a diagnostic tool. Natural antioxidants are preferred in the food industry and egg white is a natural antioxidant. Egg white when added to ground poultry meat has been reported to decrease oxidation during cooking (Negbenebor and Chan, 1985). Froning *et al.* (1986) reported that conalbumin is an effective antioxidant when added to ground turkey meat. Germadios *et al.* (1996) prepared edible packaging egg white films that were similar to other protein films. However, egg albumen films were clearer and more transparent than wheat gluten, soy protein isolates and corn zein films. The albumen films could be used for water soluble packets for ingredients in the food, chemical and pharmaceutical industries.

Although, egg whites are a good source of low-fat, high-protein nutrition, a small number of people cannot eat them due to egg allergy. This allergy is a hypersensitivity to dietary substances from the yolk or whites of eggs causing an overreaction of the immune system which may lead to severe physical symptoms for millions of people around the world. It is more common among infants than adults and most children will outgrow it by the age of five. There is currently no cure for egg allergy. It is usually treated with an exclusion diet and avoidance of foods that may be contaminated with egg. Most people who are allergic to hen's eggs have antibodies which react to one of four proteins in the egg white: ovomucoid, ovoalbumin, ovotransferrin and lysozyme. Some research on lysozyme and ovotransferrin suggests that perhaps, one of the causes of the allergy is from the chelating capacity of the proteins with metals, especially those of heavy metals. However, little scientific information is available currently on the direct relationships of the heavy metals in hen eggs and egg allergy. Allergic reactions against egg white are more common than reactions against egg yolks.

In addition to true allergic reactions, some people experience food intolerance to egg whites. Egg whites which are potent histamine liberators, also provoke a non allergic response in some people. In this situation, proteins in egg white directly trigger the release of histamine. The condition is considered food intolerance instead of a true allergic reaction. Some people with this condition tolerate small quantities of egg whites. They are more often able to tolerate well-cooked eggs such as found in cake or dried egg-based pasta than loosely cooked eggs such as fried eggs or uncooked eggs. Egg white is fining agent that can be used in the clarification and stabilization of wine. In winemaking, fining is the process where a fining agent is added to the wine to create an adsorbent, enzymatic or ionic bond with the suspended particles, making them a larger molecule that can precipitate out of the wine easily and quickly.

Clarification and stabilization of wine involves removing insoluble and suspended materials that cause a wine to be cloudy. The most common organic compounds used as fining agents include egg whites, casein gelatin and isinglass obtained from the bladders of fish. Many of the unwanted suspended particles in wine possess either a positive (+) or a negative (-) electrical charge while in a low pH, colloidal state. Therefore, it is possible to precipitate these particles by introducing materials which will have an opposite electrical charge when in the wine. When such particles are introduced, they are attracted to and combine with the oppositely charged suspended particles already in the wine (Advanced winemaking basics in 2002). The result is relatively large and massive combined particles, usually with a neutral charge (the positive and negative charges having cancelled each other) that readily precipitate in the wine and even drag other suspended material with them as they fall. There are numerous negatively charged particulates in wine including tannin, phenolics, anthocyanins, yeast and bacteria. These are removed using positively charged fining agents such as gelatin, albumin (in egg white), casein, isinglass, chitin (Chitosan) and sparkolloid. Egg white is an excellent fining agent for removing haze caused by excessive tannin (Keller, 2002). The albumen has been used as a traditional artist's material as a binder for pigments as an ingredient of waterproof glue and as a

varnish (Messier, 1991). The egg white is a suitable medium for the fabrication of prints and negatives (the albumen print).

USES OF EGG YOLK

The yolk is yellow in colour due to lutein and zeaxanthin which are yellow or orange carotenoids (xanthophylls). The colour does not indicate the nutritive value. As a food, yolks are a major source of fatty acids, vitamins and minerals. It is the part of the fertilized egg which feeds the developing embryo. The hen's diet influences the fatty acids (Larbier and Leclercq, 1994), minerals (Li-Chan *et al*., 1995) and vitamins (Alterman, 2008) content in eggs. Egg yolk contains all of the egg's fat and cholesterol and about one fifth of the protein. The yolk proteins, phosvitins and lipovitellins have distinct roles. Phosvitins are important in sequestering calcium, iron and other cations for the developing embryo. They have a high concentration of phosphate groups providing efficient metal-binding sites in clusters. Lipovitellins are involved in lipid and metal storage and contain a heterogeneous mixture of noncovalently bound lipid, most being phospholipid. Increased cardiovascular risk is associated with high cholesterol in eggs. However, this is not supported by the majority of epidemiological studies.

The cholesterol content in egg yolk is significantly reduced by dietary Polyunsaturated Fatty Acids (PUFA). One way to increase the Conjugated Linolenic Acid (CLA) content in eggs is through supplementation of the layer diet with CLA. Conjugated linolenic acid has a wide range of health-beneficial effects including anticarcinogenic, antiatherosclerotic, antiatherogenic, anti-diabetic, immune stimulatory effects, influencing both fat metabolism and protein deposition. Free-ranged hens were reported to lay eggs that had 1/3 less cholesterol, 1/4 less saturated fat and 21 times more omega-3 fatty acids than conventional-battery raised hens (Heidi, 2010).

The hens feed vitamin content influences egg vitamin composition (Squires and Naber, 1992, 1993a, b). Dietary vitamin transfer efficiency to the egg varies from 5-80% for the different vitamins and is influenced by the form in which the vitamin is offered. The influence of the hens diet on egg vitamin composition enables the enrichment of eggs for human health benefit (Nau *et al*., 2010). Free-ranged hens produce eggs with 2/3 more Vitamin A, 3 and 7 times more Vitamin E and β-carotene respectively (Heidi, 2010). A large, medium and small chicken egg contain approximately 70, 60 and 53 μg of Vitamin A, respectively. Chicken eggs are one of the few natural sources of Vitamin D which is contained exclusively in the yolk. One large egg provides contains 0.6 μg of Vitamin D; medium and small eggs contain 0.5 μg. A large or medium egg contains approximately 0.6 μg of Vitamin B12. The body requires Vitamin A to maintain healthy skin and bones and to support normal immune system function. Vitamin D is essential for the growth and strength of bones and Vitamin B_{12} is essential for red blood cell production in bone marrow, the assembly and maintenance of the insulating material (myelin sheath) that enables signal transmission between the brain and nerves.

The iodine and selenium content of the egg may vary depending on the hen's diet while the iron content of eggs shows minimum variability with the hen's dietary iron content (Naber, 1979). Elvehjem *et al*. (1929) reported that adding iron and copper to the hen's diet did not affect their content in the egg while adding iodized linseed markedly increased the iodine content of the egg (Wilder *et al*., 1933). Laying hens fed the usual way with additional autoclaved linseed, minerals, vitamins and lutein to provide the extra components produced eggs that were rich in phosphorous had 2.5 times more iodine and 4 times more selenium. Minerals are vital in the body bone development as catalysts in metabolic reactions, transmission of nerve impulses, maintenance of acid/base balance and as a component of haemoglonin.

Serum antibodies of hyperimmunised hens are efficiently transferred and accumulated in the yolk (Fichtali *et al*., 1994). There are efficient techniques for separating these antibodies from the yolk. Antibodies from eggs can be efficiently used to treat mastitis in dairy cows and may also have potential in treating AIDS (Coleman, 1998). Egg yolk membranes may be utilized as an aid in tissue culture (Burley and Vadehra, 1989). Egg lecithin combined with Vitamin B12 may slow the progress and possibly prevent Alzheimer's disease (Sugaro, 1998). Many vaccines for infectious diseases are produced in fertile chicken eggs. Antibodies from the egg may be used against microorganisms in humans and livestock. The influenza vaccine virus is grown in eggs because the virus grows well in eggs and eggs are readily available. This vaccine production is performed in 9-12 days old fertilized hen's eggs. The vaccine virus is injected into thousands of eggs and the eggs are then incubated for 2-3 days during which time the virus multiplies. The egg white which now contains many millions of vaccine viruses is then harvested and the virus is separated from the egg white. The partially pure virus is killed with chemicals. The outer proteins of the virus are then purified and the result is several 100 or 1000 L of purified virus protein that is referred to as antigen, the active ingredient in the vaccine (GAR, 2009). The immune system fights the flu by recognizing the virus proteins (antigens). The antigen

causes the immune cells that recognize these proteins to replicate so that they are primed to respond to a later attack by this virus.

A large amount of vaccine such as would be needed in an influenza pandemic requires lots of eggs. Therefore, scientists have found a better way to produce the vaccine. A study suggests that vast quantities of vaccine might be more easily made in insect cells than in eggs. In the new approach, instead of growing a virus in an egg and injecting people with a killed version, the strategy in the researches for more than a decade, involves harvesting just one viral protein. Researchers at Protein Sciences Corporation genetically modified a virus that infects caterpillar cells to produces hemagglutinin, a coat protein of the influenza virus that triggers antibodies. The method is much less cumbersome than dealing with chicken eggs and because the vaccine is so easy to produce. Egg yolks contain an antibody called antiglobulin (IgY). Antiglobulin/Immunoglobulin Y is a type of immunoglobulin which is the major antibody in bird, reptile and lungfish blood. It is also found in high concentrations in chicken egg yolk. As with the other immunoglobulins, IgY is a class of proteins which are formed by the immune system in reaction to certain foreign substances and specifically recognize them.The antibody transfers from the laying hen to the egg yolk by passive immunity to protect both embryo and hatchling from microorganism invasion.

Egg yolk is used in painting as a component of egg-tempera. Egg tempera paint is made from artist quality finely ground dry pigments, egg yolk and water. The standard medium is pure yolk which is free from the white. If egg white is included in the medium it will cause the paint to dry more rapidly and to drag on application. With egg tempera it is possible to use almost anything to make pigment. Tempera artists often grind and mix their own pigments. The egg yolk acts as the binder and will stick almost any pigment to many different surfaces. This means that one does not rely only on the colors offered by paint companies. Egg yolk is used in the production of egg-yolk agar that is primarily used to detect the production of lecithinase and lipase by Clostridia. It is also used in the Nagler test for the presumptive identification of *Clostridium perfrigens*. Egg yolk can be used to make liqueurs such as Advocaat or eggnog. Advocaat (or advokat) is a rich and creamy liqueur made from eggs, sugar and brandy. It has a smooth and custard-like flavor. Its contents may be a blend of egg yolks, aromatic spirits, sugar or honey, brandy, vanilla and sometimes cream (or evaporated milk). Egg yolks are used to extract egg oil which has various cosmetic, nutritional and medicinal uses. Egg oil and lecithin from egg yolk are used in the food, pharmaceutical and biotechnology (tissue culture) industries (Sim, 1994). This is oil derived from the yolks of hard-boiled eggs. This oil is good for healing cuts and wounds and if taken internally helps lower cholesterol levels. The dose is a few drops daily in water. It is externally applied as a salve for wounds.

CONCLUSION

Egg albumin (egg white) and egg yolk make the poultry egg to be of high nutritive value and are primarily used as food by man. Egg white is a good protein source and contains all the amino acids required by the body for protein synthesis. Although, egg whites are a good source of low fat, high protein nutrition, a small number of people cannot eat them due to egg allergy and intolerance. The yolk is a major source of fatty acids, vitamins and minerals in the egg. The hen's diet influences the fatty acids, minerals and vitamins content in eggs. Egg albumin and yolk also have non-food uses in vaccine production, wine making, biotechnology, photography, painting, chemical and pharmaceutical industries.

In the developed countries, the egg industry and technology is well established while in developing countries eggs are mainly used for food. Adoption of egg technologies that utilize egg white and yolk for non-food uses will lead to production of more products from eggs. This product diversification will translate into a variety of choices, increased shelf life, enhanced affordability, employment creation, competitive egg prices and higher returns from egg production.

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