16 Chicken Eggs and Human Health

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16.1 INTRODUCTION AND HISTORY

Eggs, a hallmark of avian and reptilian species, are most commonly consumed by humans from chicken (Gallus gallus or Gallus domesticus). The chicken is believed to have evolved from the jungle fowl.\(^1\) Consumption of eggs dates back to ancient times, when China was a major early adopter while other cultures still thought it was wasteful to eat the eggs rather than allow them to hatch.\(^2\) As far back as 246 BCE, the Chinese had developed egg incubators with a capacity for a staggering 56,000 eggs each.\(^3\) By the nineteenth century, boiled eggs became a breakfast staple for many (Figures 16.1 and 16.2).\(^4\)

Concerns about cholesterol content of eggs and dietary cholesterol’s potential association with the development of atherosclerosis led to a near 25% drop in demand for fresh eggs during the 1980s.\(^1\) Later developments in scientific research indicated that the association between dietary cholesterol and risk of cardiovascular disease was less clear than once thought. While egg consumption may potentially lead to a slight increase in low-density lipoprotein cholesterol, it can also raise cardioprotective, high-density lipoprotein cholesterol.\(^4\) Much of the early research was done on animals that not only had a high intake of dietary cholesterol, but saturated fats as well.\(^4\) In 2015,
the United States Department of Agriculture, in its eighth edition of *Dietary Guidelines*, dropped recommendations for a quantitative limit on dietary cholesterol intake, noting that eating patterns may be a more important predictor than a specific amount of one component of the diet. The report goes on to mention that while eggs are higher in cholesterol, they are not higher in saturated fat and can be consumed as a source of protein.\(^5\) This is supported by an animal study where rats given a diet with added egg yolk saw a 21.27% reduction in total cholesterol, a 41.56% reduction in LDL cholesterol, a 44.73% decrease in triglycerides, and a 138.33% increase in HDL cholesterol compared to a group of rats given a diet with added pork belly oil (which is higher in saturated fat).\(^6\)

The latest research even points toward a protective effect of egg consumption on cardiovascular disease risk. A 2018 study that followed 500,000 Chinese adults between 2004 and 2008 found a significant association between moderate egg consumption and a reduced risk of cardiovascular disease.\(^7\) This may be explained by the beneficial effect of egg consumption on HDL cholesterol. In addition to the animal study cited above, a human trial found that consuming one egg per day for 4 weeks resulted in a significant increase in HDL cholesterol \((p < 0.05)\), with the beneficial effect being sustained when consuming two or three eggs per day.\(^8\) A 1 mg/dL increase in HDL cholesterol is associated with an estimated 2% and 3% reduction in coronary heart disease risk for men and women, respectively.\(^9\)

Today, the egg industry is thriving. The total population of egg-laying hens globally is estimated to be 6.5 billion.\(^10\) A 2013 International Egg Commission report puts per capita consumption on average at approximately 200 eggs per year, with the highest country being Mexico, with a per capita consumption of 350 eggs per year.\(^10\)
The egg enjoys diverse applications for humans and pets. In cooking, eggs have a variety of functional purposes. Some include as a:

- Binder in foods such as meatloaf
- Leavening in sponge cakes
- Emulsifier in mayonnaise
- Clarifier in soups
- Crystallization retardant in boiled candies

In the early twentieth century, using eggshells to settle coffee was common, as stated in the *Kansas City Star* in 1922, “The eggshell is the established agent, handed down from mother to daughter for generations. Its necessity for coffee making is as established as the necessity of coffee itself for breakfast.”

Pet products have widely incorporated eggs, as one 2017 report indicates that over 25% of dry dog food recipes contain dried egg. Lastly, the egg has also emerged as a source of promising compounds for nutraceutical products.

### 16.2 STRUCTURAL COMPOSITION

An egg consists of a calcified outer shell that can be found in a variety of colors, including white, brown, or blue-green, and depends upon the breed of chicken that produces them. Inside the egg, the albumen is surrounded by the inner and outer shell membranes, which serve as a barrier against the infiltration of bacteria into the egg. The innermost portion of the egg, the yolk, is anchored by the chalazae, which are twisted strands of egg white. The color of the yolk is normally yellow but is dictated by the feed of the hen (Figure 16.2).

### 16.3 NUTRITIONAL COMPOSITION

Eggs are a highly nutritious food product. Eggs are a good source (10%–19% daily value) of protein, riboflavin, vitamin B12, and zinc. According to the American Egg Board, eggs are considered the most economical source of high-quality protein, and on an analysis of grams per protein per dollar spent, eggs rank higher than both chicken breast and ground beef. Eggs are also an excellent source (20%+ daily value) of biotin, pantothenic acid, iodine, selenium, molybdenum, and choline. Because the source of cholesterol in eggs is the yolk, it has not been uncommon for consumers to eat egg products prepared only from egg whites due to historical misconceptions about the safety of dietary cholesterol. Although the egg white does contain some of the protein, riboflavin, and selenium, by skipping the yolk, consumers miss out on much of the good and excellent sources of nutrients mentioned above. A proportional breakdown of the nutrient composition of the white versus the yolk is presented in Figure 16.3.

### 16.4 INSIDE AND OUT: EGGS NUTRACEUTICALS AND FUNCTIONAL FOODS

#### 16.4.1 Chicken Eggshell

Traditionally, eggshells have been considered to be of no value and have been discarded in landfills with no pretreatment. In the United States alone, it is estimated that the poultry industry produces 600,000 tons of eggshell per year as a byproduct. The composition and utility of eggshell, however, have become hard to ignore for its potential in both nutraceutical and functional food applications. Each chicken eggshell has been reported to contain approximately 2 g of calcium in the form of calcium carbonate, which makes up approximately 95% of the shell (Figure 16.3).
16.4.1.1 Research

Eggshell matrix proteins, which constitute approximately 1% of the shell, have been demonstrated in an in vitro study to support the absorption of calcium by human intestinal epithelial cells.\textsuperscript{20} Research in piglets with various diets led researchers to theorize that eggshell powder may have compounds beneficial to the absorption of calcium, similar to those identified from casein phosphopeptides.\textsuperscript{21} In another study, researchers noted that an additional advantage eggshell sourced calcium may have over a purified calcium carbonate is the presence of strontium.\textsuperscript{22} For each gram of eggshell powder consumed, a 15%–40% increase over normal daily intake of strontium is achieved.\textsuperscript{22} Human studies have found that supplementation with eggshell calcium increases bone mineral density (BMD), both in healthy postmenopausal women\textsuperscript{22} and in subjects with osteopenia or osteoporosis.\textsuperscript{23} In a 1999 study by Schaafsma and Pakan,\textsuperscript{23} one man and nine women between the ages of 51 and 82 with confirmed osteoporosis or osteopenia were administered a dairy-based supplement that included 3.0 g of eggshell powder, 400 IU vitamin D3, and 400 mg magnesium (among other nutrients) for varying periods of between 4 and 8 months. Ten healthy women from a previous study involving bone mineral density were used as a control but were not evaluated concomitantly with the intervention group. Results indicated that mean BMD of the lumbar spine, total proximal femur, and trochanter all increased significantly compared to the control (\(p < 0.05\)).

In a 2002 study by Schaafsma et al.,\textsuperscript{22} 85 healthy post-menopausal women were randomly assigned to one of three interventions: eggshell powder with magnesium, vitamin D3 and vitamin K\textsubscript{1} (phyloquinone), purified calcium carbonate with the same concomitant nutrients, or a placebo powder with 2.5 g of skimmed milk powder twice daily for 12 months. Results indicated that only the formulation with eggshell powder saw a significant improvement in the BMD of the femoral neck compared to the placebo group (\(p = 0.013\)).

16.4.1.2 Nutraceutical and Pharmaceutical Formulation

For formulation of nutraceuticals and functional foods, eggshells have several important properties. With calcium carbonate, the primary component of eggshells, having a high density of elemental calcium (approximately 40%), formulators can provide supplemental calcium at lower inputs compared to other forms of calcium. Furthermore, commercially available eggshell calcium (ESC and ESC Organic, ESM Technologies, LLC, Carthage, MO) has managed to deliver 100% of the daily value for calcium while being 50 times below the limits set by California Proposition 65 for
lead. One more recently developed potential application for eggshell calcium is for nutraceutical and pharmaceutical tableting. A 2017 study evaluated the capabilities of eggshell calcium as a compression excipient for tablet formulations and found it can achieve good tablet properties when combined with a 50-µm particle size, pharmaceutical grade microcrystalline cellulose at a 1:1 ratio, a 0.25%–0.75% stearic acid content, and a ratio of 30% of drug/active compound to direct compression excipient (DCE). Another study evaluated the feasibility of eggshell as an excipient in both fast- and sustained-release acetaminophen tablets. Fast-release acetaminophen was found to be acceptable when using untreated eggshell powder, while three different treated forms of eggshell powder (water, ethanol, and chloroform) were found to be acceptable for sustained-release formulation.

16.4.1.3 Functional Food Formulation
One study evaluated the applications of eggshell calcium in various foods prepared by a professional chef that were sampled by a group of 10 volunteers. Results indicated that breaded fried meat, bread, pizza (see Figure 16.4), and spaghetti prepared with mixer milled or rolling pin and sieve-processed eggshell powder resulted in minimal or no changes in flavor or texture.

16.4.2 Eggshell Membrane
Between the calcified shell and the albumin lies the eggshell membrane (ESM). Eggshell membrane is bilayered with a mesh-like structure formed by fibrous protein such as collagen Type I. Eggshell membrane contains other compounds as well, including glycosaminoglycans, for example, dermatan sulfate, chondroitin sulfate, and hyaluronic acid. This protein-containing composition, while desirable for nutraceutical applications, is what makes eggshell waste undesirable for landfills. The eggshell membrane attracts rats or other vermin to the landfill as a source of food.

As with the eggshells, eggshell membrane met the same fate of being discarded in landfills—particularly since it largely remains attached to the inside of the shell after breaking. Within the past two decades, commercial efforts to separate the eggshell membrane from the shell while retaining the integrity of both ingredients for ingestion by humans and pets has been successful (ESM Technologies, LLC, Carthage MO).

16.4.2.1 Research
16.4.2.1.1 Joint Health
Much of the research for joint health conducted thus far has examined the commercial preparation referred to as Natural Eggshell Membrane (NEM) (ESM Technologies, LLC, Carthage MO). NEM

![Figure 16.4](image-url) Looking for extra calcium? A preliminary culinary trial suggests eggshell powder can be incorporated into pizza with minimal perceived sensory changes.
is produced by partially hydrolyzing ESM via a gentle enzymatic process to support gastrointestinal absorption.\textsuperscript{29} An analysis of the processed material revealed a high concentration of protein, as well as up to 1% glucosamine (by dry weight), up to 2% chondroitin sulfate, 2% hyaluronic acid, and 25% Type I collagen.\textsuperscript{30} Natural Eggshell Membrane has been the subject of research for supporting joint health dating back to 2009.\textsuperscript{30} Since then, NEM has been the subject of numerous clinical trials and is well tolerated. A toxicological evaluation in rats demonstrated no acute toxicity at doses up to 2000 mg/kg body weight, and the same was found with repeated dosing over 90 days.\textsuperscript{31}

The first human study on NEM in 2009 investigated the use of 500 mg/day for 4 weeks in an open-label, single-arm study in 11 adults with mild or moderate pain due to joint or connective tissue disorders. Results indicated by day 7 there was a significant improvement in flexibility in the affected joint/tissue areas compared to baseline ($p = 0.038$), while at 30 days the improvement in flexibility remained significant ($p = 0.006$), but there was also a significant reduction in general pain ($p = 0.007$) and range of motion (ROM) associated pain ($p = 0.021$). A second trial examined NEM (at the same dose) with 28 subjects using a double-arm trial design where a second formulation of NEM underwent a 2.5-fold greater degree of hydrolysis, but it was found that both were similar in effectiveness. Therefore, the groups collapsed into one using the original formulation and found similar results to the first trial, where a significant reduction in pain was noted ($p = 0.0001$).\textsuperscript{30}

A follow-up human study in 2009 was a multicenter, randomized, double-blind, placebo-controlled trial with 67 subjects. Subjects received 500 mg of NEM daily or a placebo for 8 weeks. Results demonstrated that within 10 days, the NEM-supplemented group saw a significant reduction in Western Ontario and McMasters Universities (WOMAC) Osteoarthritis index subscale of pain ($p = 0.036$) and stiffness ($p = 0.024$). These improvements remained statistically significant at the end of the study (60 days) ($p < 0.05$).\textsuperscript{32}

A later human study in Germany evaluated the effects of 500 mg of NEM daily in a multi-site, open-label clinical trial with 44 subjects with mild or moderate pain related to hip or knee osteoarthritis for 60 days. Results indicated that that on a 10-question patient questionnaire, 7 of the 9 questions related to pain demonstrated significant improvements as compared to baseline occurring in as little as 10 days ($p < 0.05$), with all 10 questions (including one related to stiffness) significantly improving at 30 and 60 days.\textsuperscript{33} A study conducted in Italy with a similar open-label design but with 25 subjects with mild to moderate pain from knee osteoarthritis were administered 500 mg of NEM daily for 30 days. Results indicated that on a 10-questionnaire related to osteoarthritis, there was a significant reduction in pain and stiffness at 10 days ($p < 0.05$) and 30 days ($p < 0.05$). Furthermore, within the first 10 days, there was a significant reduction in analgesic use ($p = 0.017$).\textsuperscript{34}

Perhaps the most exciting discovery surrounding NEM was elucidated in the most recent trial. For the first time, NEM was demonstrated to provide joint health benefits in a population with truly healthy joints. In a single-center, randomized, double-blind, placebo-controlled trial, 60 healthy, postmenopausal women were administered 500 mg/day NEM or a placebo for 2 weeks. During the study, participants performed an exercise program of 50–100 steps per leg every other day. In addition to the beneficial effects on reducing pain and stiffness, as seen in the previous trials, there was also a significant reduction in a urinary marker of cartilage degradation, known as C-terminal cross-linked telopeptide of type-II collagen (CTX-II), at both weeks 1 ($p = 0.002$) and 2 ($p = 0.042$) in comparison to the placebo group. In fact, the NEM group achieved levels below baseline, while the placebo group saw increases in both the first and second week.\textsuperscript{29} This effect of NEM has been seen across multiple species, including rats\textsuperscript{35} and dogs.\textsuperscript{36}

Not only does NEM provide symptomatic relief, but it also provides joint protection in healthy adults engaging in physical activity, demonstrating its application as a “joint maintenance” nutraceutical for long-term use.

There are multiple mechanisms by which NEM likely exerts its chondroprotective benefits as well as its effects on joint pain and stiffness. \textit{In vitro} research has demonstrated that NEM supports a balanced inflammatory response via a reduction in tumor necrosis factor-$\alpha$,\textsuperscript{37} while a study in rats found NEM administration via oral gavage significantly reduced interleukin-1$\beta$ (IL-1$\beta$) in rats with
inflammation induced via lipopolysaccharide (LPS) injection, which may explain improvements in joint stiffness. Additionally, in a study in rats with arthritis induced by monosodium iodoacetate injection, NEM administration led to a significant reduction in prostaglandin E2 (PGE\(_2\)) at all dosage levels tested in comparison to the control (\(p < 0.01\)). PGE\(_2\) is involved in the signaling of pain in both the spinal cord and peripheral tissues, which may explain the ability of NEM to modulate joint pain. Lastly, a mechanism that may explain benefits of NEM in the long term is its bimodal immunomodulatory effect. An in vitro study revealed that eggshell membrane hydrolysates activated nuclear factor kappa-light-chain-enhancer of activated B-cells (NF-\(\kappa\)B), a signaling protein that is a regulator of immune function, in peripheral blood mononuclear cells (PBMCs) and human leukemic monocytes (THP-1). A persistent exposure of the body to NEM may result in an oral tolerance effect, wherein repeated exposure could reduce excessive or unneeded peripheral immune responses to certain protein antigens. An excessive uncontrolled immune response to these protein antigens may play a role in arthritis.

16.4.2.1.2 Digestive Health

An up-and-coming application of eggshell membrane that appears to still be in the early stages of development is for digestive health. An in vitro study evaluated the effects of filtered fractions of eggshell membrane hydrolysate on human intestinal epithelial Caco-2 cells treated with hydrogen peroxide (to induce oxidative stress). Multiple fractions of the eggshell membrane hydrolysate were found to significantly inhibit the secretion of interleukin-8 (IL-8) and significantly increase glutathione (GSH) levels, demonstrating that these fractions have antioxidant effects. In another in vitro study, Caco-2 cells pre-treated with eggshell membrane hydrolysate had significantly reduced IL-8 secretion after stimulation with TNF-\(\alpha\) (\(p < 0.05\)). The same study followed up with a controlled animal trial in mice where eggshell membrane hydrolysate was administered via oral gavage for 14 days before inducing colitis using dextran sodium-sulphate (DSS). Results indicated that supplementation significantly reduced the DSS-induced weight loss, symptoms of colitis, and interleukin-6 (IL-6) secretion (\(p < 0.05\)).

16.4.2.1.3 Cardiovascular Health

The antioxidant effects of eggshell membrane hydrolysate don’t just have implications for digestive health. A study revealed that pre-treating rats and cardiomyocytes with a specific eggshell membrane hydrolysate (SP2) provided a protective effect against ischemia/reperfusion and hypoxia/reoxygenation injury.

16.4.2.1.4 Metabolic Health

Emerging evidence also points to the potential of eggshell membrane in supporting metabolic health as well. A patent was granted for the use of eggshell membrane in the treatment of glucose metabolic disorders. The patent describes a patient who experienced an improvement in blood sugar control and a decline in fasting glucose after using approximately 500 mg/day of NEM for 90 days. Although a definitive mechanism has not been identified for this beneficial effect, there are two pathways by which eggshell membrane powder may support metabolic health. Another patent filed reported that administration of a powder (containing eggshell membrane and eggshell calcium as active components) to a mouse increased PGC1\(\alpha\) in brown fat. PGC1\(\alpha\) is described as a “master regulator of mitochondrial biogenesis” and in brown fat has been reported to be essential for thermogenesis. Additionally, a study examining rats administered eggshell membrane hydrolysate suggested it may have a protective effect against hepatic fibrosis. The liver plays a key role in glucose homeostasis.

16.4.2.2 Nutraceutical Formulation

NEM brand eggshell membrane has been employed in a variety of nutraceutical applications since 2006. It has been used in capsules, softgels, and soft chews, as well as pet applications, including chewable tablets for dogs and top-dressing powder for horses.
16.4.2.3 Functional Food Formulation

A more recent development is the use of NEM brand eggshell membrane in protein and snack bars. As a very stable ingredient requiring little manufacturing overage, it can provide functional joint health benefits on the go for health enthusiasts looking for a healthy snack as well as for athletes to incorporate into their dietary regimen when they are consuming protein to support protein synthesis or incorporating additional carbohydrate to support glycogen replenishment.

16.4.3 Chicken Egg White (Albumen)

16.4.3.1 Egg White Protein

The importance of protein, especially for athletes, has been gaining momentum in recent years. A position stand by the International Society of Sports Nutrition recognized not only that athletes engaging in regular physical training have increased dietary protein needs compared to sedentary individuals, but that dietary protein intake as high as 1.4–2.0 kg/day may support adaptations to exercise training. The committee also noted there were no concerns in healthy active individuals that this level of protein intake would present any issues relating to kidney or bone health.

In just 15 grams of egg white protein, there is 1341 mg of leucine, 837 mg of isoleucine, and 1096 mg of valine, which are all essential amino acids (EAAs). Leucine in particular is promising because it has been demonstrated to enhance anabolic signaling in young men and women. In addition to EAAs, egg white protein also contains branched chain amino acids, some of which have been implicated in having beneficial effects on exercise performance and muscle recovery from exercise. Egg white protein is a popular source of protein, especially in sports nutrition products.

Hydrolyzed egg whites have shown enhanced anabolic markers in animal models as well as greater markers for lipolysis. Interestingly, blending hydrolyzed egg whites with hydrolyzed whey resulted in higher biochemical markers and longer stasis than either by itself.

16.4.3.2 Lysozyme

A compound found within the albumen is lysozyme. Lysozyme is an enzyme involved in hydrolyzing the linkage of particular components within some bacterial cell walls. Lysozyme has bacteriolytic properties, which makes it a natural fit for applications including as a food preservative and has been indicated for use as an enzyme in mouthwashes for gingival health and halitosis. Recently, lysozyme has been used in dietary supplements, with one in vitro study suggesting that in combination with other ingredients, lysozyme may play a role in ameliorating small intestinal bacterial overgrowth syndrome (SIBOS).

16.4.3.3 Egg Protein Peptides

Perhaps one of the most promising new areas of research for egg products that has yet to be fully explored are egg protein peptides. One such peptide, NWT-03, prepared from the hydrolysis of lysozyme protein using alcalase enzyme, has been suggested to have both ACE (angiotensin converting enzyme) and DPP4 (dipeptidyl peptidase 4) inhibitory effects, which may have implications for cardiovascular and metabolic health. In a dose-finding study with a crossover design, 92 subjects (with normal, high-normal blood pressure, or mild hypertension) were administered 1, 2 or 5 g/day NWT-03 or a placebo for 7-day segments with a 5-day washout between conditions. Results indicated that in subjects with mild hypertension, the 2-g dose significantly reduced daytime systolic blood pressure (SBP) \( (p = 0.006) \), daytime diastolic blood pressure (DBP) \( (p = 0.009) \), 36-hour SBP \( (p = 0.015) \), and 36-hour DBP \( (p = 0.035) \) in comparison to the placebo condition. Additionally, the 5 g dose significantly reduced night-time SBP \( (p = 0.008) \) and night-time DBP \( (p = 0.020) \) compared to the placebo condition.
16.4.3.4 Ovotransferrin

Another constituent of the egg albumen is ovotransferrin. Ovotransferrin belongs to a group of compounds known as transferrin iron-binding glycoproteins, which includes lactoferrin (from bovine milk) and serum transferrin (found in humans). Its iron-binding properties may deprive bacteria of necessary iron for function, which contributes to its antibacterial properties. Additional research is necessary to explore the application of ovotransferrin and peptides from its hydrolysis for human health including potential antiviral, antioxidant and anti-inflammatory effects.

16.4.4 CHICKEN EGG YOLK

16.4.4.1 Choline

Choline is an essential nutrient that serves two major purposes, including acting as a source of methyl groups for various components of metabolism and to serve as substrate for the synthesis of two phospholipids that are essential for cell membranes, phosphatidylcholine and sphingomyelin. In 2016, for the first time, in FDA's final rule for the revision of nutrition and supplement facts panels (81 FR 33741), FDA published a reference daily intake for choline of 550 mg. Almost 90% of individuals 2 years or older fail to consume adequate choline on a daily basis. A single yolk from a large egg contains 126 mg choline, which is approximately 23% of the daily value (DV). Choline is readily available as a dietary supplement.

16.4.4.2 Macular Carotenoids

Lutein and zeaxanthin are two macular carotenoids present in the eye that may be important factors in preventing age-related macular degeneration (AMD). A meta-analysis revealed that dietary consumption of lutein and zeaxanthin may be associated with a lower risk of late age-related macular degeneration. One study found that lutein from lutein-enriched eggs was significantly more bioavailable than lutein from spinach or dietary supplements (p < 0.05), which may be due to egg's cholesterol content. Five weeks of consuming one egg per day significantly increased both serum lutein and zeaxanthin levels (p < 0.001) in older adults, while another study in older adults taking cholesterol-lowering medication found that not only was there a significant increase in both serum lutein and zeaxanthin (p < 0.05) but also significant increases in macular pigment optical density (MPOD, a non-invasive eye test) at three retinal eccentricities (p < 0.05). The application of this to dietary supplements remains to be seen.

Additionally, scientists have discovered these antioxidants are also present in the brain. Lutein and zeaxanthin levels in the brain of older adults have been positively associated with cognition. Interestingly, lutein is found in higher concentrations in the infant brain than the elderly brain—leading researchers to wonder if lutein influences cognitive development in children. Studies looking at the relationship between brain lutein, as measured using MPOD, and cognition in children found that MPOD concentration was positively associated with academic performance.

16.4.4.3 Fertilized Egg Yolk Isolate

Recently, a new nutraceutical ingredient has been marked for enhancing strength and lean muscle mass. Derived from fertilized egg yolks, preliminary research in rats demonstrated that exercise combined with fertilized egg yolk isolate supplementation significantly reduced activin IIB receptor mRNA (p < 0.05), suggesting an inhibitory effect on the myostatin pathway. Myostatin signaling occurs through activin type II receptors. Myostatin has an inhibitory or limiting effect on muscle mass. Inhibition of this pathway has gained popularity as a target for increasing muscle mass as a result of the “double-muscled” appearance of some animals that have had genetic mutations in the coding sequence of myostatin, such as the Belgian Blue and Piedmontese cattle breeds.
16.5 CONCLUSIONS

Despite the long history of domesticating chickens, raising them for eggs, and using them for food, the exploration of the benefits of eggs and the bioactive constituents and corresponding pathways that lead to better health are only just beginning to be understood. What was once thought of as a simple food product now enjoys many diverse applications, with more being discovered with each new year.

REFERENCES