The Novel Egg −
Opportunities for Flax in Omega-3 Production

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Introduction

Imagine hearing your doctor say, “Enjoy eggs for breakfast every morning and reduce your risk of heart disease.” This medical advice may sound like a joke compared to the recommendations by doctors 30 years ago, who suggested that high egg consumption contributed to heart disease**.** However, the recent development of eggs as foods having preventative and health-benefitting effects, above and beyond the human body’s basic nutritional needs, is a reality.

Attempting to fill a niche market as well as strengthen the healthy image of eggs, poultry research has aimed to develop omega-3-enriched eggs as a way of raising the level of omega-3 fatty acids in the population’s diet. The success of this research has created an exciting opportunity to incorporate and deliver flax seed-based eggs into the rapidly growing functional food market and onto the plates of today’s health-conscious consumers**.** Functional foods are those which contain or, have been modified to include, a component which is considered healthy or which promotes good health.

Research into the nutritional improvement of eggs is not a recent endeavor. Beginning in the 1930s, it was shown that the polyunsaturated fatty acid (PUFA) content of egg yolks could be manipulated by changing the level of PUFAs in the hen’s diet. Forty years later, a link between PUFAs and heart disease was established when it was noted that Greenland Eskimos eating an omega-3 PUFA-rich seafood diet had fewer incidences of heart disease. In recent years this connection has gained support and recognition from researchers and egg producers alike, who have been working together to improve the omega-3 PUFA content of eggs by incorporating flax seed into the laying hen diet.

By feeding flax seed to the hen, the omega-3s of the flax (in the form of alpha-linolenic fatty acid (ALA), combined with the hens’ own conversion of ALA to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), allow the egg to be enriched with higher-than-normal omega-3 levels. An omega-3- enriched egg would offer consumers a tasty and versatile food product and an easy way of improving the currently low level of omega-3 PUFAs in the diet.

With the newly published recommended intakes (called Adequate Intakes) of essential fatty acids, and specifically of ALA, by the Institute of Medicine (IOM) in 2002 consumers are reminded of the importance of this essential omega-3 fatty acid. One omega-3–enriched egg provides a significant portion of the Adequate Intakes of ALA for all age groups.

For the consumer, it is a decision of whether to purchase flax-derived omega-3-enriched eggs based on perceived health benefits, the taste and appearance of cooked eggs, and price. For the egg producer, there are issues of feeding regimens, hen performance, egg production, egg sensory quality and economics. The sections below address these and other key issues, beginning with a backgrounder on fatty acids and continuing with a discussion of the nutritional aspects of omega-3 fatty acids. The increased omega-3 fatty acid content of these enriched eggs is the primary marketing tool for catching and keeping the consumer's commitment to buy these novel foods.

Backgrounder on Omega-3 Fatty Acids

Fatty Acids

Fatty acids are organic compounds found in virtually all foods. When discussing flaxseed nutrition, nutritionists distinguish between fatty acids in three ways: By saturation, by family, and by essentiality. First, fatty acids can be saturated, meaning they contain no double bonds. If the fatty acids are monounsaturated, they contain one double bond; if they are polyunsaturated, they contain two or more double bonds. Flaxseed contains mostly polyunsaturated fatty acids.

Second, fatty acids are classified into families. Two families of fatty acids that enter into discussions about flaxseed nutrition are the omega-3 and the omega-6 families of fatty acids. The omega-3 fatty acids are a separate, distinct group of fatty acids from the omega-6 fatty acids. In other words, omega-3 fatty acids cannot be converted to omega-6 fatty acids and vice versa. Flaxseed is high in omega-3 fatty acids (see Table 1).

Finally, comes the distinction between essential and non-essential fatty acids. Two fatty acids are essential for humans; they must be obtained from the fats and oils in foods because our bodies cannot make them. Alpha-linolenic acid (ALA or LNA, as it is sometimes abbreviated) is the primary member of the omega-3 family. Linoleic acid (LA) is the primary member of the omega-6 family of fatty acids. Alpha-linolenic acid and linoleic acid are called essential fatty acids. Flaxseed contains both of these essential fatty acids, but it is particularly rich in ALA.

Table 1. Types of Fatty Acids Found in Foods

Fatty Acid	Number of Double Bonds	Saturation	Common Food Sources
stearic acid	0	saturated	most animal fats, chocolate
oleic acid	1	monounsaturated	olive oil, canola oil
linoleic acid	2	polyunsaturated	vegetable oils like sunflower, corn, and safflower oils; meats from grain-fed livestock
alpha-linolenic acid	3	polyunsaturated	flaxseed, flaxseed oil, canola oil, soybean oil, walnuts; small amounts in meats like beef and pork and in eggs

NOTE: A way to think about saturation is to think about passengers on a bus. If a bus is saturated, all the seats are taken and there are no empty seats on the bus. If it is monounsaturated, there is one empty seat. If the fatty acid is polyunsaturated, there are at least two empty seats on the bus. For example, the linoleic acid bus has two empty seats.

Fatty Acids in Flaxseed

Flaxseed is an excellent source of omega-3 fatty acids. The omega-3 fatty acid in flaxseed is alpha-linolenic acid (ALA), which makes up about 57% of total fatty acids in flaxseed. Indeed, flaxseed is the richest source of ALA in the North American diet. Linoleic acid, an omega-6 fatty acid, comprises about 16% of total fatty acids. Flaxseed contains a mixture of fatty acids, consisting of about 9% saturated fatty acids, 18% monounsaturated fatty acids and 73% polyunsaturated fatty acids.

The Omega-3 Fatty Acids

Omega-3 fatty acids are increasingly in the news because there is growing concern that North Americans are not getting enough omega-3 fatty acids in their diets to achieve the important health benefits now associated with these fats. For this reason, the poultry industry developed a novel egg enriched with omega-3 fatty acids. The omega-3–enriched egg and other such products are intended to help North American consumers increase their intake of omega-3 fatty acids. The sections below provide information on key topics that will help you understand omega-3 fatty acid nutrition issues.

Health Effects of Omega-3 Fatty Acids

The omega-3 fatty acids have many beneficial health effects that make them useful in preventing and managing chronic conditions such as non-insulin-dependent diabetes, kidney disease, rheumatoid arthritis, high blood pressure and coronary heart disease. They help reduce risk of coronary heart disease in adults by lowering serum lipids and preventing clot formation, and they appear to reduce chronic disease risk by blocking inflammatory reactions (1). Key health benefits of the three main omega-3 fatty acids— alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)—are described below.

ALA - Populations with high intakes of ALA (alpha-linolenic acid) have a low risk of coronary heart disease and stroke. In the Lyon Diet Heart Study, participants who ate a Mediterranean-type diet rich in ALA had a 70% reduction in their risk of heart attack compared with a control group who ate their usual Western-type diet (2, 3). In the Health Professionals Follow-up Study, which began in 1986 with a group of more than 51,000 middle-aged and elderly men, those men with the highest ALA intakes had the lowest risk of heart attack and fatal heart disease (4). Other large-scale population studies such as the Multiple Risk Factor Intervention Trial (5, 6) and the Nurses' Health Study (7) found the risk of having a stroke or fatal heart attack decreased as the intake of ALA increased.

In clinical studies, ALA is as effective as monounsaturated fat and linoleic acid in decreasing blood total cholesterol and low-density lipoprotein cholesterol (LDL) (8). High blood levels of total cholesterol and LDL are risk factors for coronary heart disease.

EPA – EPA, which is the abbreviation for eicosapentaenoic acid, is the precursor of a group of biologically active compounds called eicosanoids. Eicosanoids control inflammatory reactions. Their release is a normal response to injury, and their actions are required to help repair damaged tissue. However, not all eicosanoids are alike. The eicosanoids derived from EPA tend not to promote inflammation. This is one reason why nutrition experts advise consumers to eat more omega-3 fatty acids: A diet rich in omega-3 fatty acids produces more beneficial eicosanoids and less inflammation and decreases the risk of chronic diseases. By comparison, the eicosanoids derived from omega-6 fatty acids tend to overstimulate the immune system and may contribute to chronic diseases like cancer, stroke, diabetes and coronary heart disease (9)—the number one killer of adults in Canada and the United States.

DHA - DHA, short for docosahexaenoic acid, is required for the proper growth and development of the fetus and infant. Specifically, it aids in the development of the nervous system, brain and eye (10). The gray matter of the brain and cells of the retina have the highest concentration of DHA of any tissue in the body (11). The demand for DHA is highest during the latter part of pregnancy and in the first few months of infancy (12).

Conversion of Omega-3 Fatty Acids

Animals and humans convert essential fatty acids to other fatty acids important in human health. For example, the essential fatty acid ALA is converted to EPA and DHA. The conversion of ALA to EPA and DHA is affected by many factors and differs among species. Chickens are pretty good at converting ALA to EPA and DHA, whereas humans are not. Scientists do not agree on the amount of conversion that occurs in humans—one estimate is as low as 0.2% ALA converted to EPA (13) and one is as high as 6% converted to EPA (14). It will likely be several years before the conversion issue in humans is resolved fully.

Food Sources of Omega-3 Fatty Acids

Flaxseed oil is the richest source of omega-3 fatty acids in the form of ALA in the North American diet, with ALA constituting 57 % of its total fatty acids. It is flaxseed's rich ALA content that is exploited by egg producers to achieve significant increases in the omega-3 fatty acid content of eggs. ALA is also found in small amounts in meat and fish. The main sources of ALA are oil seeds like flaxseed, vegetable oils like canola oil and soybean oil, and a few other foods like walnuts and purslane.

EPA and DHA are not found in plants; they are found in algae and fish, particularly fatty fish such as salmon, mackerel, herring and fresh tuna. Omega-3–enriched eggs are good sources of the essential omega-3 fatty acid ALA and the other key omega-3 fatty acids, EPA and DHA.

Recommended Adequate Intakes of Omega-3 Fatty Acids

The Institute of Medicine (IOM) published recommended intakes of essential fatty acids in September 2002, acknowledging the essential nature of ALA in the human diet and the contribution of all omega-3 fatty acids to human health (15). The IOM is a nonprofit organization that operates under the umbrella of the U.S. National Academy of Sciences. It has set recommended intakes for calcium, iron, and B vitamins, along with other vitamins and minerals, and, in this recent report, for macronutrients like protein, carbohydrate, and fat. The IOM's recommended intakes were developed in cooperation with Health Canada and will replace the Canadian Recommended Nutrient Intakes (RNIs).

In its 2002 report, the IOM recommended certain intakes (called Adequate Intakes) of ALA for infants, children and adolescents, and adults—the first time a North American agency has made a recommendation for this essential omega-3 fatty acid. The Adequate Intakes of ALA for various age groups, except infants, are shown in Table 2.

Table 2. Adequate Intakes of Alpha-Linolenic Acid (ALA) for Children, Adolescents, Adults and Pregnant and Lactating Women[1]

Life Stage	Age	Adequate Intake of ALA	Contribution of One Omega-3 Enriched Egg to the Adequate Intake of ALA
	years	*grams/day*	*%*
Children (both sexes)	1-3	0.7	49
	4-8	0.9	38
Boys and Men			
	9-13	1.2	28
	14-18	1.6	21
	19+	1.6	21
Girls and Women			
	9-13	1.0	34
	14-18	1.1	31
	19+	1.1	31
Pregnant	14-50	1.4	24
Lactating	14-50	1.3	26

[1]Source: Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*. Washington, D.C.: National Academies Press, 2002, pp. 8-34 – 8-39.

Note that an Adequate Intake was set only for ALA. Adequate Intakes were not set for EPA and DHA. The reason for this is that, strictly speaking, ALA is the only true "essential" omega-3 fatty acid in our diet. Remember, an essential nutrient (like ALA) is one that must be obtained from foods because our bodies cannot make it. Because EPA and DHA can be made from ALA, they are not considered "essential" nutrients in the strictest sense. [When EPA and DHA are called "essential fatty acids" in the medical literature, the authors usually mean that EPA and DHA are "important" or "vital."] Accordingly, the IOM set recommended intakes for ALA and indicated that other omega-3 fatty acids in our diet (like EPA and DHA) can contribute to the recommended ALA intake.

Omega-3-enriched Eggs Help Meet Adequate Intakes for ALA

One omega-3–enriched egg provides on average about 0.34 grams of ALA and 0.13 grams of EPA + DHA. By itself, an omega-3–enriched egg provides a significant portion of the Adequate Intakes of ALA for all age groups. For young children under the age of 3 years, for example, one omega-3–enriched egg provides half (49%) of the Adequate Intake (see Table 2). For boys and men, one omega-3–enriched egg provides roughly one-quarter (21-28%) of the recommended Adequate Intake. For girls and women, an omega-3–enriched egg provides about one-third (31-34%) of their Adequate Intake of ALA.

Translating Nutrition Recommendations into an Omega-3̃Rich Diet Plan

The overall goal of current dietary recommendations is to increase the omega-3 fatty acid intake of the North American population. For consumers, this means choosing foods every day that are rich in omega-3 fatty acids. Translating this goal into a diet plan rich in omega-3 fatty acids is challenging for several reasons.

First, the most consistent message from government agencies and health organizations regarding the omega-3 fatty acids is to eat more fish. For example, the *Dietary Guidelines for Americans*, published in 2000, specifically mention fatty fish such as salmon, tuna and mackerel because they "contain omega-3 fatty acids that are being studied to determine if they offer protection against heart disease" (16). The American Heart Association (AHA) recommends eating two servings of fish per week to boost EPA and DHA intake (17). The AHA's recommendation appeared in an article published in *Time* magazine, reinforcing the message that fatty fish are special foods providing protection for the heart (18).

One problem with the recommendation to "eat more fish" is the growing concern about the sustainability of fish stocks in the coming decade (19, 20) and methylmercury contamination of popular fish species like swordfish, bass and king mackerel (21). Furthermore, the "eat more fish" message is impractical for most North Americans. Large-scale U.S. dietary surveys show that only 3% of Americans aged 11 years and older eat fish daily (21). Most U.S. adults eat, on average, only 0.4 ounces per day or roughly 1 serving of fish per week (22). Doubling their fish intake to two servings weekly may be difficult for many Americans, especially given the expectation that one of these servings be a fatty fish like salmon, mackerel and herring. Many people find the cost and taste of fatty fish to be barriers to eating more of them.
Another problem with the "eat more fish" message is that consumers may not translate the message into proper food choices. For example, fast-food fish sandwiches are popular menu items, but they are usually deep-fried in an omega-6–rich vegetable oil. A typical fast-food fish sandwich made with tartar sauce and cheese contains 8.4 grams of linoleic acid per sandwich (23), providing roughly one-half the recommended Adequate Intake for this omega-6 fatty acid in a single food. Because of its high omega-6 content, the fast-food fish sandwich is better enjoyed as a treat and not as a dietary staple.

Omega-3̃ Enriched Eggs Fill the Gap

Given the desirability of increasing omega-3 fatty acid intake, how can consumers plan a diet that meets current omega-3 intake recommendations? In today's marketplace, the best strategy is to eat omega-3–enriched eggs derived from hens fed flaxseed.

Omega-3–enriched eggs make a significant contribution to ALA and total omega-3 intakes. Eating one omega-3–enriched egg daily adds about 0.34 grams (equivalent to 340 milligrams) of ALA and 0.5 grams (500 milligrams) of total omega-3 fatty acids to the dietary intake. U.S. adults currently eat on average about ½ regular chicken egg per day (22). Many consumers will find it easier to double their egg intake (using the omega-3–enriched egg to increase their daily omega-3 fatty acid intake) than to double their fish intake to two servings per week. Eggs are an affordable protein source and have been a staple in the North American diet for decades. Plus, they are more versatile than fish in terms of how they can be incorporated into the diet—eggs can be eaten alone, hard-boiled, scrambled, poached or fried, or they can be mixed into muffin and quick bread mixes, bread doughs, cakes, cookies, casseroles, meat loaf and other mixed dishes or stirred into soups and fried rice.

A question to ask here, however, is whether it is appropriate to eat one egg daily, particularly if there is a concern about high blood cholesterol levels. The American Heart Association (AHA) (17) does not specify a desirable egg intake, but it states that "consuming 3-4 egg yolks per week in cooking or as a meal allows you to follow the AHA eating plan without exceeding the total cholesterol recommendation" (24). In other words, consumers can eat one egg per day, provided their total cholesterol intake does not exceed 300 milligrams daily. Because a regular egg provides about 213 milligrams of cholesterol, most consumers will find it challenging to eat an egg daily and also keep their total cholesterol intake below 300 milligrams.

Research studies suggest, however, that some consumers can add an egg to their daily diet plan. For example, three studies reported that most adults who follow a low-fat, low-cholesterol diet plan similar to the AHA's Step I diet (25) or a regular diet (26, 27) can eat between 4 and 12 omega-3–enriched eggs per week without an increase in blood total or LDL-cholesterol levels. Other studies suggest that eating 3-14 regular eggs per week has no effect on blood lipid levels (28), especially if the dietary intake of saturated fat is low (29, 30). Some adults, however, appear to be sensitive to dietary cholesterol and their blood total and LDL-cholesterol levels will increase with egg consumption. These adults are advised to have regular blood cholesterol checks by a doctor (25).

Comparing Omega-3-Enriched Eggs with Regular Eggs

Omega-3–enriched eggs provide about 12 times more omega-3 fatty acids than regular eggs, based on an average omega-3 content of 0.5 grams in omega-3–enriched eggs versus 0.04 grams in regular eggs, as shown in Table 3. Because of their increased omega-3 fatty acid content, omega-3–enriched eggs contain more polyunsaturated fatty acids than regular eggs. While the omega-3 content may vary substantially between different brands, the number of calories and amount of protein and total fat in omega-3–enriched eggs is similar to that of regular eggs. Some omega-3–enriched eggs contain slightly less cholesterol than regular eggs.

Table 3. Comparison of the Nutrient Content of Omega-3–Enriched Eggs and Regular Eggs[1]

Nutrient	Omega-3-Enriched Eggs	Regular Eggs[2]
Energy	74 calories[3]	75 calories
Protein	6.2 g[3]	6.2 g
Total Fat	4.8 g[3]	5.0 g
Saturated Fat	1.5 g[4]	1.6 g
Monounsaturated Fat	2.1 g[4]	1.9 g
Polyunsaturated Fat	1.3 g[4]	0.68 g
Total Omega-6 Fatty Acids	0.78 g[4]	0.64 g
Total Omega-3 Fatty Acids	0.50 g[5, 6]	0.04 g
Cholesterol	182 mg[4]	212 mg

[1] Abbreviations: g = grams, mg = milligrams.
[2] Nutrient content obtained from US Department of Agriculture Nutrient Database, Release 15, available at www.nal.usda.gov/fnic/foodcomp.
[3] Average of two brands of omega-3-enriched eggs.
[4] Average of three brands of omega-3-enriched eggs.
[5] Average of five brands of omega-3-enriched eggs.
[6] On average, an omega-3-enriched egg contains about 0.34 grams of ALA and 0.13 grams of EPA + DHA. One omega-3-enriched egg contains a total of about 0.5 grams (500 milligrams) of omega-3 fatty acids. (The figure for total omega-3 fatty acids includes several minor omega-3 fatty acids, in addition to the main omega-3 fatty acids, ALA, EPA and DHA).

Key Points about Omega-3-Enriched Eggs

1. On average, an omega-3–enriched egg provides about 0.34 grams of ALA, 0.13 grams EPA + DHA, for a total of about 0.5 grams (500 milligrams) of omega-3 fatty acids.
2. By itself, an omega-3–enriched egg provides roughly one-quarter (21-28%) of the Adequate Intake of ALA for boys and men and about one-third (31-34%) of the Adequate Intake of ALA for girls and women.
3. Omega-3–enriched eggs are an important source of ALA, the essential omega-3 fatty acid.

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