Producing Omega-3 Enriched Eggs

by Desmond Balance, B Sc (Agriculture) University of Manitoba

In recent years, researchers and egg producers have worked together to improve the omega-3 polyunsaturated fatty acid (PUFA) content of eggs by incorporating omega-3 rich-foods like flax seed into the laying hen diet.

Incorporating Flax Seed into Laying Hens' Rations

Whole or Milled Flax Seed

As with traditional feed grains, the form in which flax seed is fed impacts egg production and hen performance (Choi et al. 1986, Vilarino et al. 1996). Flax seed form also affects the amount of omega-3 polyunsaturated fatty acid (PUFA) incorporated into the egg. Differences in the omega-3 content of eggs from laying hens fed whole versus milled flax seed have been reported, with many researchers suggesting that omega-3 yolk deposition is more efficient when the flax is milled prior to inclusion in the diet. For example, one study indicated that feeding 10% milled flax seed yielded 16.2mg ALA/g yolk (Van Elswyk 1997) while the same amount of whole flax seed yielded approximately 13.5mg alpha-linolenic fatty acid (ALA) per gram of yolk. Such differences may be explained in that milled seeds are better digested than whole seeds, releasing more omega-3 PUFAs to be deposited in the egg yolk.

Other Feed Considerations

Other factors, such as size of operation and the availability of commercially milled flax seed, influence the form of flax seed fed to laying hens for omega-3 egg production. For example, while many feed mills supply milled flaxseed to egg producers, other egg operations use an on-site mill to mill the flax seed prior to hen feeding. In contrast, Manitoba Agriculture encourages small egg producers to feed whole flax seed to their hens. Its recommendations are based mainly on concerns that milled flax seed will be less stable when exposed to the barn environment (Manitoba Agriculture and Food Web Site 2001). All in all, regardless of the form, as long as the hens are able to digest the flax seed and obtain the omega-3 PUFAs, omega-3 egg production is possible.

USE OF GRIT - While one study claims no difference in the yolk omega-3 content from whole versus milled flax seed feeding (Scheideler and Froning 1996), the use of grit throughout the trial may be the reason. By providing grit to hens fed whole flax seed, digestion is improved. Egg-yolk-omega-3 levels are equal in birds fed whole flax seed with 0.5% grit and birds fed a milled flax seed ration (Scheideler and Froning 1996).

FLAX SEED STABILITY - Studies show that milled flax seed is very stable, with a shelf-life between 6 and 12 months (Flax Council of Canada 1999), long outlasting the length of time feed generally sits, waiting to be fed to the hens.

PELLETING AND HEAT TREATING - Up-and-coming processing methods, such as heat treating and pelleting of milled flax seed, may expand feeding options for commercial producers of omega-3 eggs. Although in the initial stage of research, such processing could potentially increase the amount of omega-3 PUFAs deposited into the egg yolk as well as improve flax seed digestion and overall hen performance. However, further research is needed in support of these methods.

FATTY ACID COMPOSITION OF FEED MILL FLAXSEED - A comparison of the fatty acid composition of 23 samples of flaxseed over a six-month period from various feed mills in Ontario, Canada, showed a very consistent fatty acid composition in the flaxseed, regardless of the feed mill from which it came (Bean and Leeson 2001). The percentage of ALA in the samples, expressed as a percentage of the total weight of fatty acids in the whole flaxseed, ranged between 51% and 59% (Bean and Leeson 2001).

Other Feeding Strategies

Other feeding strategies have been studied to ensure that the nutrient availability of the flax seed and the feed efficiency of the hen is maximized. (Table 1).

Table 1*:* **Results of laying hen feeding trials on ways to improve flax seed digestion and feed efficiency by the hen.**

Feeding Strategy	Why tested?	Result	Reference
Calcium/Vitamin D supplementation of flaxseed diet	Concerns of poor shell quality	- No added shell strength with Calcium/Vitamin D supplementation - Comparable shell quality to traditional egg	Novak and Scheideler 1998
Enzyme supplementation of flaxseed diet	To improve nutrient availability of flaxseed	- No significant effect on bird performance up to 21 days (10% flaxseed in diet) - Reduction in gut viscosity at 41 weeks with enzyme inclusion in flax diet - Potential for improved protein and calcium availability	Chavez 2001 Scheideler and Jaroni 1998

Flax Seed Ration Inclusion Rates

People can rely on flax-fed hens and their efficient omega-3 egg production for a direct, abundant and readily available source of alpha-linolenic fatty acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The manipulation of ALA, DHA and EPA levels in flax-based eggs is well-understood.

In general, as the amount of flax seed in the hens' diet increases, the levels of yolk ALA and DHA also increase (Caston and Leeson 1990, Van Elswyk 1997). EPA is not as responsive to flax seed inclusion and yolk levels tend to shift only within a narrow range (Van Elswyk and Aymond 1994).

In Ontario, Canada some field reports indicated a failure to achieve 300 mg of omega-3 fatty acids per egg when hens were fed 8 to 10% flaxseed (Bean and Leeson 2001). (In Ontario, eggs must contain at least 300mg of omega-3 fatty acids in order to be classified as omega-3-enriched..)

DURATION OF FEEDING - Omega-3 levels in the eggs stabilize between days 9 and 12 (Sim and Cherian 1994) of flax-feeding, but hens require a continuous flax-based diet to maintain the health-benefitting levels of omega-3 PUFAs in their eggs. In fact, a 20% reduction in ALA and DHA levels of eggs has been reported following just one week of feeding a flax-free diet to hens previously given the flax-based diet (Van Elswyk 1997).

STRAIN OF BIRD - Although studies in this area are limited, some researchers have reported that Hisex White hens deposit approximately 30% more ALA in their eggs that the Hy-Line, DeKalb or Babcock hens (González-Esquerra and Leeson 2001). Other studies, however, suggest there is no effect of strain on ALA or DHA yolk deposition (Scheideler et al. 1998). Since genetic differences for feed intake and egg weights are known to be present between strains (Scheideler et al. 1998), the same may be true for yolk composition, supporting the need for further research. A recent study showed egg, shell, and yolk weights were heavier in brown hens compared to white ones (Bean and Leeson 2002). The same study showed no difference in egg production between brown and white hens.

Characteristics of Omega-3 Eggs

Some effects of dietary flax seed on egg production, egg-shell quality and yolk have been noted. Currently the most widely accepted trend in eggs from flax-fed hens is a reduction in egg weight, yolk weight and egg-shell quality, regardless of the level of flax seed in the diet.

Egg and Yolk Weights

Lighter egg weights tend to be linked with the lower body weights of flax-fed hens (Scheideler et al.1994, Caston et al. 1994), with one study reporting up to a 3.6g decline in egg weight from hens fed a 20% milled flax seed diet. Yolk weights have also been reported as being 1 to 2 g lighter from layers fed 5% or 15% flax seed diets as compared to traditional yolks (Scheideler and Froning 1996). One study has even shown that hens fed whole flax seed produce larger yolks than those fed milled flax seed, regardless of the level of flax seed included in the diet (Scheideler and Froning 1996). Yolk weight was significantly reduced ($P < 0.05$) in hens fed flaxseed (Bean and Leeson 2002).

Shell Quality

Omega-3 egg production with flax-feeding has been associated with reduced shell quality for whole and milled flax seed at all inclusion levels (Scheideler and Froning 1996). Since some studies, however, have reported no change in egg weight or shell quality from flax-based diets, more research into the true effects of flax on egg characteristics is necessary (Jiang et al. 1991).

Effects of Flax Rations on Hen Performance

As with the introduction of any new diet, the effect of feeding flax seed to laying hens and its influence on flock performance and production must be carefully considered. Numerous studies have examined the effects of a flax-based diet on laying hen performance. While weight gain, feed intake and egg production may be less encouraging than with a traditional diet, the generous price premiums available for specialized omega-3-enriched eggs are significant and contribute to the ability of producers to stay competitive in this growing market.

Body Weight and Feed Consumption

Although results remain debatable, a common trend with feeding flax to laying hens is a decrease in body weight. Mature flocks fed 10% and 20% flax seed diets have been reported as weighing 270g and 530g less than hens fed a traditional layer ration (Caston et al.1994), regardless of whether whole or milled flax seed was used (Scheideler and Froning 1996). Another study showed lighter weight birds in a flax-fed flock compared to the control flock (Bean and Leeson 2002). This may be due to a) a laxative effect of the flax seed, causing an increased rate of digestion and reduced nutrient absorption, and/or b) the assumption that the flax seed diet contains more energy that it actually does (González-Esquerra and Leeson 2001). Both explanations support the increased feed intake by the hen (González-Esquerra and Leeson 2001). By eating more, the hen ensures that her nutrient and energy stores are sufficient for optimal omega-3 egg production. Yet, another study showed significantly less feed intake in hens fed flaxseed (Bean and Leeson 2002).

Egg Production

Results of egg production by flax-fed hens vary considerably. One study reports that mature hens fed 5 to 15% milled or whole flaxseed diets had an average egg production of 88.9% compared to the 83.1% for hens on a traditional layer ration (Scheideler and Froning 1996). Another study noted that 22-week-old layers fed 5% and 15% milled or whole flax seed, experienced a decrease in egg production over time (Aymond and Van Elswyk 1995). A further study indicated that feeding a 15% full flax seed diet to mature hens had no effect on egg production (Jiang et al. 1991). This result was replicated in another study which showed flaxseed did not affect egg production from either brown or white hens (Bean and Leeson 2002). With such varied results in egg production, more research in this area is required.

Marketing Omega-3 Eggs

Without a doubt, the omega-3 egg market is rapidly expanding as more and more consumers become aware of the benefits of omega-3 PUFAs in their diet..

However, just as with any new business opportunity, entering into flax seed, omega-3 egg production requires consideration of more than just the profits to be made. The expenses involved with feeding flax seed, the marketing opportunities and the availability of price premiums for these specialized eggs are some of the areas that entrepreneurial egg producers will have to take into account before beginning omega-3 egg production.

Sensory Quality

Since consumers tend to eat foods that appeal to them and do not offend their sense of smell or taste, omega-3 egg producers must consider the effects of feeding flax seed on the sensory qualities of the egg. An omega-3 egg that does not smell or taste "normal" will not be purchased, regardless of how healthy it may be. Omega-3-enriched eggs "flax seed style" are widely accepted in the marketplace.

The idea of using flax seed for omega-3 egg production began when sensory studies reported strong "fishy flavours" from fish oil-based omega-3-enriched eggs, despite fish oil inclusion rates as low as 3% (Leskanich and Noble 1997). The "fishy" smell is widely believed to be caused by the high levels of omega-3 PUFAs deposited in the yolk from the fish oil. Feeding fish oil primarily increases the yolk DHA and EPA levels which can become rancid quickly and produce off-odours and flavours. As a result flax seed was introduced as a potential alternative for preventing off-tasting omega-3 enriched eggs. Although flax seed also has a high oil content, the type of PUFAs deposited into the egg are primarily ALA, known for having greater stability and a slower onset of rancidity (González-Esquerra and Leeson 2001).

Vitamin E Supplementation

Supplementing the laying hens' diet with Vitamin E has proved to be of benefit because of its ability to reduce PUFA rancidity and overall off-flavours (Sim 2002). With Vitamin E supplementation, consumers are unlikely to find a noticeable difference between flax-based omega-3 enriched eggs and normal eggs. In fact, one study reported that taste panellists were unable to distinguish between omega-3 eggs, enriched with up to 20% flax seed and 10mg Vitamin E/kg feed, and normal eggs (Leeson et al. 1998).

In fact, not only does Vitamin E affect the sensory qualities of omega-3 eggs, but supplementing the hens' diet with Vitamin E at ten-times her normal requirement has been reported to cause a 2% increase in hen/day egg production (Scheideler and Froning 1996). With studies indicating

that Vitamin E enrichment of eggs can be as high as eight times their normal content (Van Elswyk 1997), these omega-3- and vitamin-enriched eggs are truly functional foods. The egg with notice of the vitamin E enrichment has added value from a consumer's standpoint, a definite plus in the marketplace.

Considering the Economics

While concerns regarding flax seed and omega-3 egg production will differ between egg producers, Table 2 attempts to answer some of the basic questions involving the omega-3 functional food market.

Table 2. Economic Considerations for the Egg Producer

Questions/Concerns	Answers as of today...
What are some additional costs of feeding flax seed?	♦ Feed consumption levels of flax-fed hens may be higher ♦ If feeding whole flax seed, the use of grit, although a minor cost, is highly recommended. ♦ If feeding ground flax seed, the feed company will likely charge for the processing ♦ Vitamin E supplementation may be an extra cost, but it is a reclaimable cost as it adds an extra value from consumers' viewpoint
Do producers generally buy prepared feed or mix it themselves?	♦ While most producers purchase a flax-based, complete feed, flax supplements for on-farm mixing are also available. (Bruce Mollison, personal communication)
What is the Canadian market for omega-3 egg?	♦ Currently, omega-3 egg production makes up 15% of the Canadian shell egg market. With increasing consumer demand for these healthy eggs, opportunities in this niche market are growing steadily.
Are price premiums available?	♦ Yes

REFERENCES

Aymond WM and Van Elswyk ME. 1995. Yolk thiobarbituric acid reactive substances and n-3 fatty acid in response to whole and ground flaxseed. *Poultry Sci.* 74: 1388-1394.

Caston LJ, Squires EJ, Leeson S. 1994. Hen performance, egg quality, and the sensory evaluation of eggs from SCWL hens fed dietary flax. *Can. J. Animal Sci.* 74: 347-353.

Caston LJ and Leeson S. 1990. Research note: Dietary flax and egg consumption. *Poultry Sci.* 69: 1617-1620.

Chavez ER. 2001. Processing and enzyme supplementation for poultry diets containing flaxseed In: *Flax Council of Canada Research Program.*

Choi JH, So BS, Ryu KS, Kang SL. 1986. Effects of pelleted or crumbled diets on the performance and the development of the digestive organs of broilers. *Poultry Sci.* 65: 594-597.

Flax Council of Canada. Flaxseed Storage and Baking Stability. 1999. Available online at www.flaxcouncil.ca.

González-Esquerra R and Leeson S. 2001 Alternatives for enrichment of eggs and chicken meat with omega-3 fatty acids. *Can. J. Animal Sci.* 81: 295-305.

Jiang Z, Ahn DU, Sim JS. 1991. Effects of feeding flax and two types of sunflower seeds on fatty acid compositions of yolk lipid classes. *Poultry Sci.* 70: 2467-2475.

Leeson S, Caston L, Maclaurin T. 1998 Organoleptic evaluation of eggs produced by laying hens fed diets containing graded levels of flaxseed and vitamin E. *Poultry Sci.* 77: 1436-1440.

Leskanich CO and Noble RC. 1997. Manipulation of the n-3 polyunsaturated fatty acid composition of avian eggs and meat. *World's Poult. Sci. J.* 53: 155-183.

Manitoba Agriculture and Food. 2001. Increasing omega-3 fatty acids in eggs from small chicken flocks. Available online at www.gov.mb.ca/agriculture/livestock/poultry/fatty.html.

Novak C. and Scheideler SE. 1998. The effect of calcium and/or vitamin D_3 supplementation of flax based diets on production of parameters and egg consumption. *Proc.Flax Inst.:* 35-42.

Scheideler SE. 1998. Use of degummed flaxseed in layer diets. *Proc.Flax Inst.:* 32-34.

Scheideler SE, Cuppett S, Froning G. 1994. Dietary flaxseed for poultry: production effects, dietary vitamin levels, fatty acid incorporation into eggs and sensory analysis. *Proc.Flax Inst.:* 87-95.

Scheideler SE and Froning GW. 1996. The combined influence of dietary flaxseed variety, level. Form, and storage conditions on egg production and composition among vitamin E-supplemented hens. *Poultry Sci.* 75: 1221-1226.

Scheideler SE and Jaroni D. 1996. Use of enzymes in poultry rations containing flaxseed. *Proc.Flax Inst.:* 97-100.

Scheideler SE, Jaroni D, Froning G. 1998. Strain and age effects on egg composition from hens fed diets rich in n-3 fatty acids. *Poultry Sci.* 77: 192-196.

Sim JS and Cherian G. 1994. α-Linolenic acid for designing poultry products for human consumption: Canadian designer eggs and nutritional significance. *Proc.Flax Inst.:*106-122.

Sim JS. 2002. Designer Egg Concept: Perfecting Egg Through Diet Enrichment with Omega-3 PUFA and Cholesterol Stability. In: *Egg Nutrition and Biotechnology*, eds JS Sim, S Nakai, W Guenter. CAB International. pp. 135-150.

Van Elswyk ME. 1997. Nutritional and physiological effects of flax seed in diets for laying fowl *World's Poult. Prod.*. 53: 253-264.

Vilarino M, Picard ML, Melcion JP, Faure JM. 1996. Behavioural adaptation of laying hens to dilution of diets under mash and pellet form. *Br. Poult. Sci.* 37: 895-907.