THE INTERACTIVE IMPACT OF DIETARY PUFA ON THE DEPOSITION OF DHA IN THE EGG YOLK

E. DELEZIE[1], G. HUYGHEBAERT[1], K. RAES[2], L. MAERTENS[1] and S. ARNOUTS[3]

Summary

Nutritional literature has indicated the role of dietary fat in the incidence of cardiovascular and other general diseases, e.g. the balance between the fatty acids of the n-6 and n-3 series. The objective of the present study was to determine the effect of the interactive impact of dietary PUFA on the deposition of DHA in the egg yolk.

This trial consisted of 32 treatments where several combinations of coconut fat, HO sunflower oil, soy oil, flax seed oil and fish oil were supplemented at two dietary concentrations, so creating a relative wide variation in dietary PUFA-concentration. A bi-factorial response surface modelling was used to relate the egg yolk DHA-% to dietary concentration of C18:2, C18:3, EPA and DHA.

Dietary lipid composition had a major impact on egg yolk fatty acid profile, whereby yolk DHA varied from 1.7 up to 3.7%. The bi-factorial analysis revealed that (1) yolk DHA was linearly related to dietary DHA but slightly related to dietary C18:3 and EPA, 2; (2) C18:3 and EPA were a much less efficient DHA-precursor than DHA and (3) the conversion of C18:3 and EPA to DHA was much less efficient than the transfer of dietary DHA.

I. INTRODUCTION

Data summarized by the WHO/FAO indicate that chronic diseases rise to approximately 60% of the deaths reported around the world with an important impact on the cost to national health services for treating them. Almost half of the deaths arising from chronic diseases are attributable to cardiovascular disease, although the rapid increase in obesity/type 2 diabetes-related metabolic syndrome. It has been recognised that diet plays a major contribution to the risk factors for chronic disease because of the association of fatty acid profile with chronic diseases (Dolocek, 1992; Leaf and Kang, 1998; Simopoulos, 1999). It is also considered that the consumption of n-3 PUFA in most western populations is sub-optimal and benefits in relation to chronic disease would be gained from increased consumption. The objective of the present study was to determine the interactive impact of dietary PUFA as a sustainable tool on the deposition of DHA in the egg yolk.

II. MATERIALS and METHODS

Two wheat-corn-soybean based experimental diets of equal nutritional value were used, only differing in supplemental fat, respectively 3 (low fat) and 6 % (high fat) with 5.2 and 8.1% total fat, respectively. Sixteen different mixtures of added fat were constituted in order to obtain a high variable fatty acid profile, with similar profile both at the 3 and 6% inclusion level. The 3 major fats were soybean oil (with 54% C18:2), flaxseed oil (with 50% C18:3) and fish oil (with EPA & DHA at 12.5%). High oil sunflower oil was used as a C18:1-balancer at 2 levels (0 and 25% of the added fat). Furthermore coconut fat (with 68% C12:0+C14:0) was used as a balancer with medium chain vegetable saturated fatty acids. In

[1] ILVO Animal Science Unit, Melle, Belgium. gerard.huyghebaert@ilvo.vlaanderen.be
[2] University College of West-Flanders, Dep. PIH, Kortrijk, Belgium.
[3] University Gent, Faculty of Veterinary Medicine, Merelbeke, Belgium.

this way a relative wide dietary variation in fatty acid profile and dietary PUFA-concentration was achieved.

Table 1. Dietary fat level and supplements of the 5 types of fats (%)

Treatment n°	Dietary fat level	Coconut fat	H-oleic sunflower oil	Soybean oil	Flaxseed oil	Fish oil
1	high	5.5	0	0	0	0.5
2	high	4.5	0	0	0	1.5
3	high	4	0	0	1.5	0.5
4	high	4	0	1.5	0	0.5
5	high	2.5	0	1.5	1.5	0.5
6	high	3	0	1.5	0	1.5
7	high	3	0	0	1.5	1.5
8	high	1.5	0	1.5	1.5	1.5
9	high	4	1.5	0	0	0.5
10	high	3	1.5	0	0	1.5
11	high	2.5	1.5	0	1.5	0.5
12	high	2.5	1.5	1.5	0	0.5
13	high	1	1.5	1.5	1.5	0.5
14	high	1.5	1.5	1.5	0	1.5
15	high	1.5	1.5	0	1.5	1.5
16	high	0	1.5	1.5	1.5	1.5
17	low	2.75	0	0	0	0.25
18	low	2.25	0	0	0	0.75
19	low	2	0	0	0.75	0.25
20	low	2	0	0.75	0	0.25
21	low	1.25	0	0.75	0.75	0.25
22	low	1.5	0	0.75	0	0.75
23	low	1.5	0	0	0.75	0.75
24	low	0.75	0	0.75	0.75	0.75
25	low	2	0.75	0	0	0.25
26	low	1.5	0.75	0	0	0.75
27	low	1.25	0.75	0.75	0	0.25
28	low	1.25	0.75	0.75	0	0.25
29	low	0.5	0.75	0.75	0.75	0.25
30	low	0.75	0.75	0.75	0	0.75
31	low	0.75	0.75	0	0.75	0.75
32	low	0	0.75	0.75	0.75	0.75

For this trial a flock of medium weight laying hens (ISA-brown/ 45-50 weeks of age) was used. Each dietary combination was fed to 3 pens and 3 layers per pen. The experimental period consisted of a 3-week adaptation and a 2-week steady state period. During the latter period, egg yolks were analyzed twice at 7-d interval for fatty acids (in mg/g yolk & as % FA) according to Raes et al. (2002). At the same time all conventional zootechnical data were recorded.

A bi-factorial response surface modelling was used to relate mathematically the egg yolk-DHA (Y; as % total FA) to related fatty acids (X_1 & X_2; in mg/100 g diet) (Khuri and Cornell, 1987; Statgraphics version 5, 1991). For each model, there are 2 figures, the surface (the response in terms of yolk DHA in % total yolk FA and the 2 input variables in mg/100 g diet) and contour figure (the 2 input variables in mg/100 g diet and yolk DHA in %-total yolk FA with values ranging from 1 to 6 %), respectively.

III. RESULTS and DISCUSSION

The main results of the bi-factorial response surface modelling are presented in figures 1 and 2 with the n-3 fatty acids C18:3, EPA and DHA as the input fatty acids.

There were only minor non-significant differences in zootechnical performance and gross egg composition (yolk-share & -fat content). This means that the dietary fatty acid concentration can be directly related to the yolk fatty acid profile. The yolk DHA % was nearly unaffected by the medium chain saturated fatty acids and oleic acid. The bi-factorial response surface modelling showed an almost linear response in yolk fatty acid profile without any significant interactive impact by the paired fatty acids.

The regression model relating yolk-DHA % to C18:2 and C18:3 was not significant. Nevertheless there was a tendency showing that the DHA-deposition was positively related to dietary C18:3n-3 but inversely related to dietary C18:2n-6. However, this regression model was significant in a previous trial (Huyghebaert et al., 2007). Therefore, it is recommended to balance the respective precursor parent PUFA-molecules since the same elongase/desaturase enzyme system is used for the conversion to their LC-PUFA.

The regression equation in figure 1 is:
Egg yolk-DHA % = 1.91-0.0067*EPA+0.014*DHA (R^2=0.70; MSE=0.29; P<0.001)
DHA-deposition was slightly negatively related to dietary EPA but positively to DHA; the conversion-efficacy was much lower (more than 100%) for EPA than for DHA (Figure 1). In a previous trial (Huyghebaert et al., 2007), the conversion-efficacy into egg yolk DHA was also much lower (-90%) for EPA than for DHA.

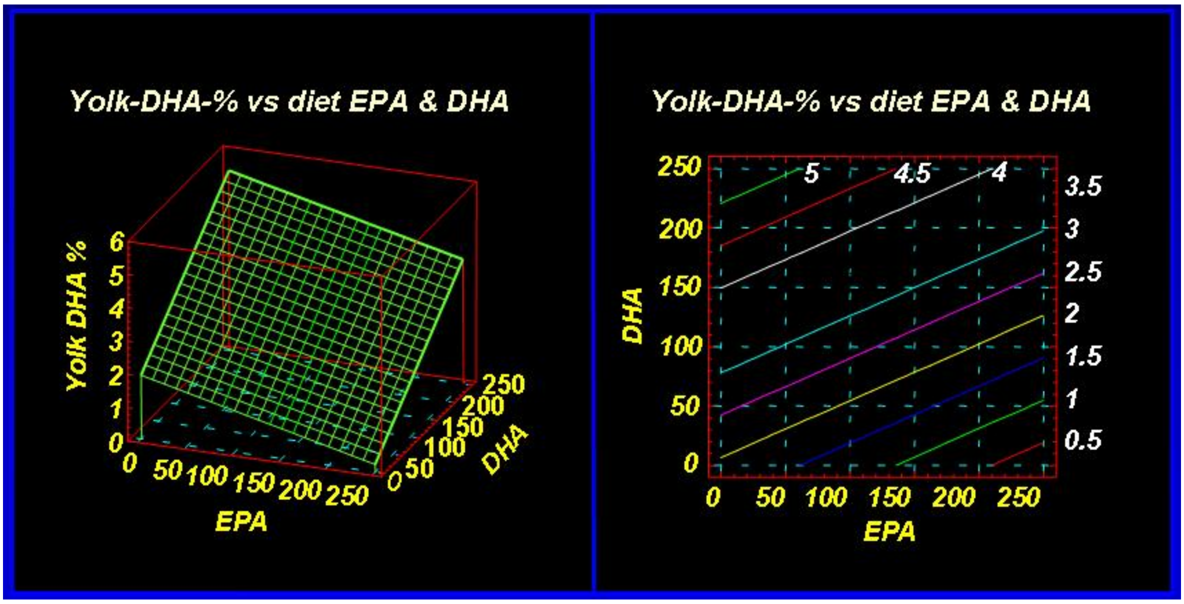

Figure 1. The impact of dietary EPA & DHA on egg yolk-DHA-%

The regression equation showed in figure 2:
Egg yolk-DHA % = 1.95-0.00011*C18:3+0.0076*DHA (R^2=0.70; MSE=0.29; P=<0.001).
DHA-deposition was slightly negatively related to dietary C18:3n-3 but positively to DHA. It is clear that the conversion-efficacy was much lower (more than 100%) for the n-3 parent molecule C18:3n-3. The response in a previous trial (Huyghebaert et al., 2007) also

demonstrated that the conversion-efficacy into egg yolk DHA was much lower (-90%) for C18:3 than for DHA.

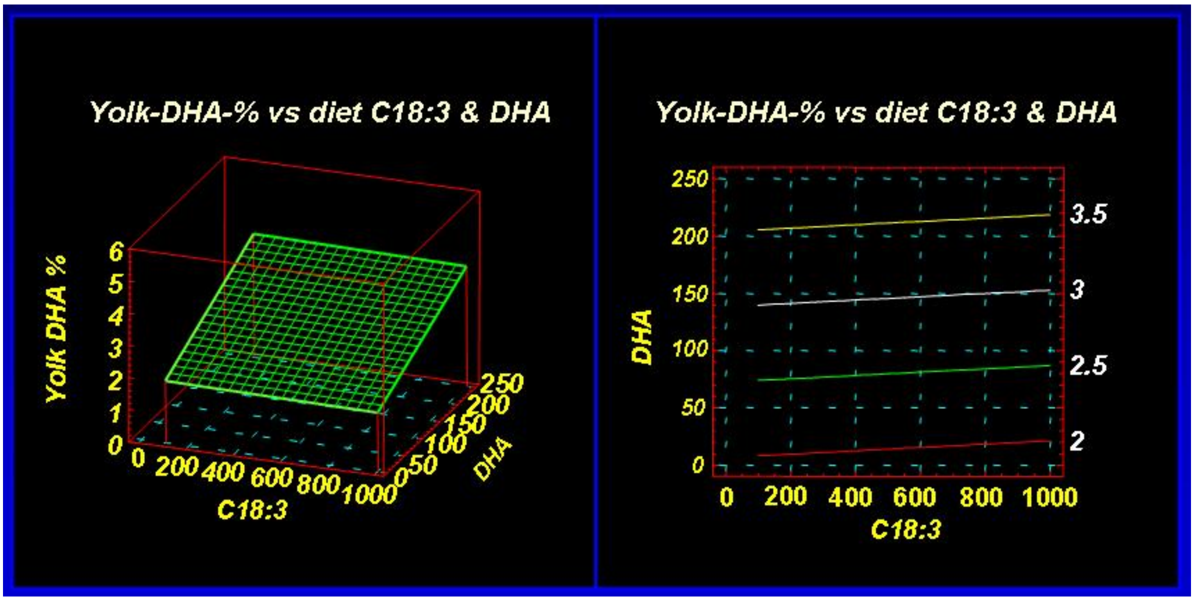

Figure 2. The impact of dietary C18:3n-3 & DHA on egg yolk-DHA %

The present experiment clearly demonstrated that the egg yolk can be upgraded with n-3 PUFA. Thereby differences in n-3 fatty acid profile and conversion efficacies in the laying hen (& human beings) might not be overlooked. Without doubt the development of 'designer' animal products based on an enhanced content of polyunsaturated fatty acids is universally viewed as an opportunity to promote the image of animal production, whilst at the same time positively contributing to human health and welfare.

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