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# CHEMICAL COMPOSITION AND FATTY ACID PROFILE IN WHOLE BODY OF CHICKENS IN RESPONSE TO INCREASING LEVELS OF DIETARY POLYUNSATURATED FAT

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## Introduction

The amount and type of fat in chickens are an important issue for meat consumers. There is a tendency towards reducing saturated fat consumption, related to a higher incidence of cardiovascular diseases (Srinath Reddy and Katan, 2004). The use of vegetable oils in poultry diets permits the enrichment of animal tissues with polyunsaturated fatty acids (PUFA), that have positive effects on health, especially n3 PUFA (Wolfram, 2003). On the other hand, the fat source used in chicken diets has effect not only on the fatty acid profile of the tissues but also on the total amount of body fat. Oils rich in PUFA have higher metabolizable energy (ME) than animal fats. This would lead one to think that PUFA-rich oils intake cause higher fat deposition because more energy is available to store in triglycerides. However, recent studies show that the use of PUFA causes a decrease in abdominal fat pad of chickens (Crespo and Esteve-Garcia, 2001) and in total body fat accretion (Sanz et al. 2000). In these works they have used different fat sources, such as tallow, sunflower or linseed oil. This way, fat sources rich in PUFA are compared to those rich in saturated fatty acids. The aim of this experiment was to study chemical composition, gross energy content and fatty acid profile in the whole body of chickens (including blood and feathers) in response to a dietary n3 PUFA gradient. But this gradient has been achieved not by using different fat sources but by increasing PUFA-rich dietary fat inclusion level.

## Material and Methods

The experimental trial received prior approval from the Animal Protocol Review Committee of the Universitat Autònoma de Barcelona. All animal housing and husbandry conformed to the European Union guidelines.

A total of 96 Ross female broilers of 1 day of age were distributed into 4 treatments of 12 replicates each. The animals were housed in 48 cages under standard conditions of temperature, humidity and ventilation. The diets were formulated according to the requirements recommended by the NRC (1994) (table 1).

The 4 experimental treatments were the result of adding a mixture of linseed and fish oil (ratio 4 to 1) at the following inclusion levels: 2% (O2), 4% (O4), 6% (O6) and 8% (O8). The concentration of PUFA in the experimental diets was 27, 38, 48 and 59 g PUFA/kg of diet respectively. Almond husk was used to dilute energy density in the high fat treatments.

Feed and water were provided ad libitum. Body weight and food consumption were measured during the experiment. Feed samples were taken during the experiments for Weende analysis and fatty acid content.

At the end of the experimental period (from 6 to 40 days), two animals per cage were killed by lethal injection (sodium pentobarbitate, 200 mg/kg). The whole animals were frozen, cut, and ground with a cutter (Tec-Maq model cut-20, INTEFISA). After that, samples from each animal were taken, freeze-dried, ground and stored at –20°C until further analyses.

Fatty acid content from feeds was determined by GC following the methology described by Sukhija and Palmquist (1988). Fatty acid quantification and profile of the whole body was determined as described previously by Carrapiso et al. (2000). Nonodecanoic acid (C19, Sigma-Aldrich) was used as internal standard in both cases. The sum of individual fatty acids (g/kg) was used as a measure of body fattening (total fatty acid content, TFA).

Water, ashes and crude protein (CP) content of the whole animal was determined following the guidelines described in the AOAC (1995). Gross energy (GE) content was quantified using an adiabatic bomb calorimeter (IKA-calorimeter C4000 adiabatic).

## Statistics

Statistical analysis was carried out with ANOVA where the input factor was dietary fat level. Data were treated using the proc GLM procedure of SAS package (SAS® Institute. 2000). Differences between treatment means were tested using Tukey's correction for multiple comparisons. In all cases, P values ≤ 0.05 were considered significant.

**TABLE 1.** Composition and chemical analysis of the diets.

| Ingredients (%) | Dietary treatments[1] | | | |
|---|---|---|---|---|
| | O2 | O4 | O6 | O8 |
| Maize | 58.49 | 52.68 | 46.86 | 41.02 |
| Soya 48 | 35.49 | 36.42 | 37.34 | 38.24 |
| Added oil[2] | 2.00 | 4.00 | 6.00 | 8.00 |
| Almond husk | 0.00 | 2.92 | 5.81 | 8.76 |
| Dicalcium phosphate | 1.75 | 1.76 | 1.76 | 1.77 |
| Calcium carbonate | 1.08 | 1.07 | 1.06 | 1.05 |
| Salt | 0.57 | 0.57 | 0.57 | 0.57 |
| Vitamin mineral mix[3] | 0.40 | 0.40 | 0.40 | 0.40 |
| DL-Methionine | 0.18 | 0.19 | 0.19 | 0.20 |
| L-Lysine | 0.05 | 0.03 | 0.02 | 0.00 |
| **Chemical analysis (%)** | | | | |
| Dry matter | 88.26 | 89.08 | 89.42 | 90.28 |
| Crude protein | 21.31 | 21.82 | 21.48 | 21.85 |
| Crude fat | 4.45 | 6.30 | 8.40 | 9.91 |
| Crude Fibre | 3.22 | 5.45 | 7.93 | 9.86 |
| Ash | 5.79 | 6.10 | 5.85 | 6.20 |
| ME (kcal/kg)[4] | 3000 | 3003 | 3006 | 3007 |

[1]O2: 2% of added oil; O4: 4% of added oil; O6: 6% of added oil; O8: 8% of added oil.
[2]Linseed and fish oil mixture in a ratio 4:1.
[3]Vitamin and mineral mix per kg of feed: Vitamin A: 12000 IU; Vitamin $D_3$: 2400 IU; Vitamin $K_3$: 3 mg; Vitamin $B_1$:2.2 mg; Vitamin $B_2$: 8 mg; Vitamin $B_6$: 5 mg; Vitamin $B_{12}$: 11 µg; Folic acid: 1.5 mg; Biotin: 150 µg; Calcium pantotenate: 25 mg; Nicotinic acid : 65 mg; Mn: 60 mg; Zn: 40 mg; I: 0.33 mg; Fe: 80 mg; Cu: 8 mg; Se: 0.15 mg.
[4]Estimated values.

## Results and Discussion

Chemical composition and Gross Energy (GE) content of the whole chicken are shown in table 2. Water, CP, ash and TFA content of the whole chicken were not affected by varying inclusion levels of added polyunsaturated fat ($p>0.05$). Expectedly, GE content of the animal was not affected by treatment either .

The energy to protein ratio is one of the most important dietary factors affecting fat deposition. In this trial, the experimental diets were formulated to be isocaloric and isoproteic, so it was the same ratio for all treatments. However, it is generally accepted that increasing fat inclusion has an "extra-caloric" effect, because it improves nutrient utilisation by the chicken (Mateos and Sell, 1980) so more energy would be available. It is possible that the extra energy coming from increasing fat inclusion causes higher body fat deposition. Results concerning the effect of fat inclusion level upon body fat have been contradictory. Deaton et al. (1981) fed isocaloric and isoproteic diets to broilers with increasing added animal fat levels (4, 7 and 10%) and both abdominal and body fat increased. Donaldson (1985) used increasing amounts of cottonseed oil (from 2 to 8.6%) and found no differences in body fat content of broilers. More recently, Vilà and Esteve-Garcia (1996) used different inclusion levels (from 0 to 12%) of acid fats (tallow and sunflower oil), and showed that abdominal fat pad weight increased with fat inclusion but only when feeding tallow acid oil. There were no differences in the animals receiving sunflower acid oil, even though the energy to protein ratio increased.

However, fatty acid profile of the whole body of chickens was affected by the inclusion level of PUFA-rich oil. PUFA content of the whole chicken increased (30.4, 38.8, 46.9 and 53.5 g PUFA/kg for the O2, O4, O6 and O8 treatments respectively, $p<0.05$) while saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) content decreased, and this decrease was more marked for the MUFA (34% and 24% of decrease for the SFA and the MUFA content respectively).

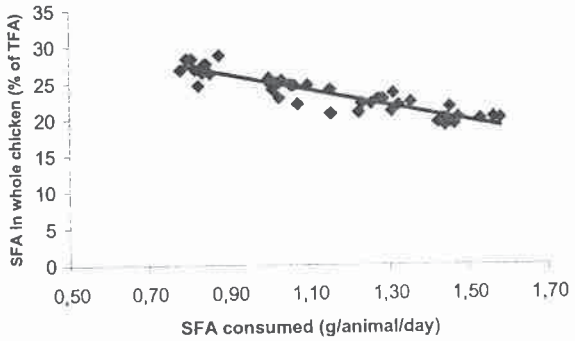
Regression equations between SFA, MUFA and PUFA consumption and their respective deposition (expressed as % of TFA) have been made and are shown in figures 1, 2 and 3. SFA and MUFA equations were calculated by linear regression ($y = ax+b$) while PUFA data were fitted to an exponential equation of the type $y=a-a\cdot e^{-bx}$, where a is the maximum level that can be reached and b the accretion fractional rate.

**TABLE 2.** Effect of inclusion level of added oil on chemical composition (% FM) and gross energy content of the whole body.

| | O2 | O4 | O6 | O8 | p-value | RSD |
|---|---|---|---|---|---|---|
| Water | 67.64 | 68.06 | 68.12 | 67.75 | NS | 1.101 |
| CP | 20.31 | 20.38 | 20.51 | 20.35 | NS | 0.776 |
| Ash | 2.43 | 2.48 | 2.49 | 2.61 | NS | 0.277 |
| GE (Kcal/Kg) | 2272 | 2271 | 2253 | 2245 | NS | 164.9 |
| TFA | 10.49 | 10.19 | 10.51 | 11.08 | NS | 1.683 |

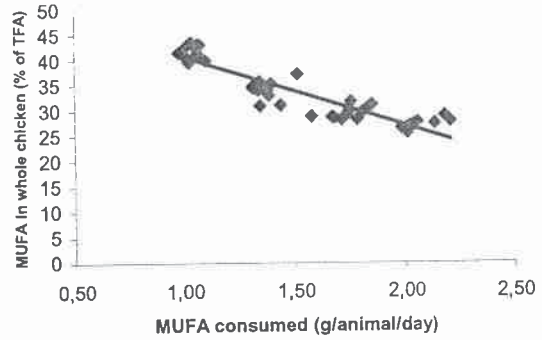
Total body fat has two origins: exogenous (dietary) and endogenous (*de novo* fatty acid synthesis). Only SFA and MUFA can be synthesized. Thus, when dietary fat inclusion level is low, the animal synthesizes SFA and MUFA. As oil inclusion level increases, *de novo* synthesis decreases and body fat composition reflects more that of the diet. In this case, it is reflected in a higher amount of PUFA coming directly form the diet at the expense of SFA and particularly MUFA. MUFA are more affected than SFA due to the need to maintain an adequate ratio of unsaturated (MUFA+PUFA) to saturated (SFA) fatty acids to maintain physical properties of biological membranes. The combination of exogenous and endogenous fat is the reason of the constant body TFA content in spite of the different inclusion levels of dietary fat.

**FIGURE 1.** SFA concentration in the whole body of chickens (%) in response to SFA intake.



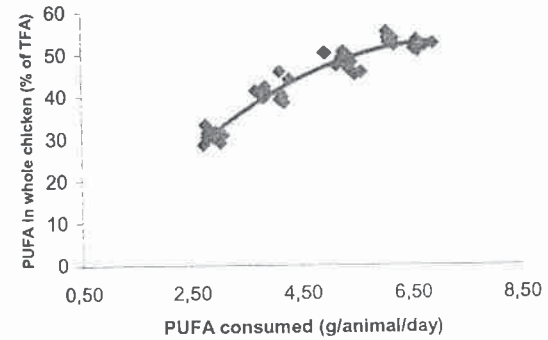

$Y = 35.34 - 10.19 \cdot X$
$R^2 = 0.85$

**FIGURE 2.** MUFA concentration in the whole body of chickens (%) in response to MUFA intake.




$Y = 54,37 - 13.64 \cdot X$
$R^2 = 0.85$

**FIGURE 3.** PUFA concentration in the whole body of chickens (%) in response to PUFA intake.




$Y = 73.69 - 73.69 \cdot e^{-0.199 \cdot X}$

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