Canthaxanthin fixation in rainbow trout Oncorhynchus mykiss: effect of dietary phospholipid content

A. ABAT, R. CASTILLO and G. CHOUBERT

SUMMARY

Colour and canthaxanthin concentration in the muscle of rainbow trout were studied in a feeding trial with three different phospholipid levels. Rainbow trout with an initial mean body weight of 190 g were fed, ad libitum, 2 meals/day in triplicate, the experimental diets supplemented at a rate of 80 mg canthaxanthin/kg diet combined with three different phospholipid levels (0, 4, and 8 %) were furnished during 6 weeks. At each sample time (2, 4, 6 weeks) canthaxanthin concentration in the muscle of trout showed no significant differences (P ≥ 0.05) between the different dietary groups. Phospholipids added to the diet were not found to enhance the deposition of canthaxanthin in the muscle of the trout. Colour measurements gave results somewhat different except for the a* colour parameter. Higher values (P ≤ 0.05) for lightness, chroma and hue angle were always obtained for trout fed the high dietary phospholipid content (8 %). On the other hand colour of the muscle of trout fed the low dietary phospholipid level (4 %) showed no significant differences (P ≥ 0.05) with control fish for lightness and chroma, but a significant difference was noted for the hue angle. It has been concluded that the addition of phospholipids to the diet of trout may have a positive effect on colour parameters without any effect on canthaxanthin concentration.

KEY-WORDS: phospholipids - canthaxanthin - flesh colour - trout.

Introduction

Canthaxanthin, a carotenoid pigment, is commonly used in intensive rearing fish farms to enhance the natural colour of the flesh of rainbow trout. This lipid soluble compound is not synthesized by the fish and must be supplied with the diet. The digestibility of canthaxanthin is low (20 - 40 %, CHOUBERT and LUQUET, 1979).

Phospholipids combine within the same molecule both the hydrophilic (water affinity) phosphate chain and the hydrophobic fatty acid chains. They are therefore surface active and play an important role as emulsifying agent, thus promoting the absorption of lipids and lipid soluble compounds (O’DOHERTY et al., 1973).

The purpose of this study was to investigate whether dietary phospholipids may enhance the absorption of canthaxanthin and therefore may increase flesh pigmentation in the rainbow trout.
Materials and methods

Fish. Rainbow trout *Oncorhynchus mykiss* with a mean body weight of 190 g were settled in 9 tanks (1 m in diameter), set in parallel (30 fish/tank). The tanks were gravity fed with spring water (Temperature = 17 ± 1°C, O₂ = 8-9 mg/l, pH = 7.4, Cl⁻ = 22.5 mg/l, Ca²⁺ = 75 mg/l) at a rate of 5 volume changes per hour.

Diet. The composition of the experimental diets is given in Table I. Phospholipids (soja lecithin, DAFA LPR, Nikerson s.a., Marne-la-Vallée, France) were added to the diet at a rate of 0, 4, and 8 %. The diets were supplemented with 80 mg of canthaxanthin (Carophyll® red, F. Hoffmann-La Roche, Basel, Switzerland)/kg of diet. Phospholipids were mixed with the other ingredients before pelleting through a 4.5 mm dye without steam (Simon Heesen pelleting machine, Boxtel, The Netherlands). Fish were hand fed *ad libitum* 2 meals per day during 6 weeks.

Analyses. At each sampling time (2, 4, 6 weeks) 15 fish per diet were randomly sampled. The latero-dorsal muscle was removed. Colour measurement was then processed and the sample was frozen (-20°C) until canthaxanthin analyses.

The colour of the flesh was processed with a chromameter (Minolta Co. Ltd, Osaka, Japan) at three different points of the muscle, above the lateral line : 1) behind the head, 2) below the dorsal fin and 3) near the tail. The measures have been accomplished at the beginning and at the end of the experiment, according to CHOUBERT et al. (1997). The apparatus was calibrated prior the measurements with a white plate standard reference (Minolta Co. Ltd, Osaka, Japan).

The measurement of colour attributes was carried out by applying the chromameter onto the muscle. After flashing, L*, a*, and b* reflected light values were recorded. From a* and b* values the hue (H°ab = tan⁻¹b*/a*) and the chroma (C°ab = (a°²+b°²)¹/₂) were calculated according to WYSZECKI and STILES (1967).

Calculation. Data were processed through ANOVA (independent group analysis) followed by the Tukey multiple comparison test (SAS, 1985) ; the significance level was \( P \leq 0.05 \).

Results

Data concerning colour measurements are given in Table II. No phospholipid effect (\( P \geq 0.05 \)) was reported for the a* colour parameter while higher data (\( P \leq 0.05 \)) for luminosity, chroma and hue were always obtained for trout fed the highest dietary phospholipid content (8 %). On the other hand, the colour of the muscle of trout fed the lower dietary phospholipid level (4 %), compared with control, showed no significant difference for luminosity and chroma, but a significant difference was noted for the hue.

Canthaxanthin concentration in the muscle of trout fed different amount of phospholipids are reported for each sampling time (Figure 1). Canthaxanthin concentration in the muscle of trout showed no significant difference (\( P \geq 0.05 \)) between the 3 dietary groups. Therefore there was a tendency for high dietary phospholipid level (8 %) to enhance canthaxanthin concentration in the flesh during the first 2 weeks.

### Table I: Composition of the experimental diets.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>PL0 (wt%)</th>
<th>PL4 (wt%)</th>
<th>PL8 (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>58</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Gelatinized corn starch</td>
<td>13.5</td>
<td>13.5</td>
<td>13.5</td>
</tr>
<tr>
<td>Crude corn starch</td>
<td>24</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Soja lecithin (1)</td>
<td>0</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Vitamin mix (INRA)(2)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mineral mix (INRA)(2)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sodium alginate</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fish oil</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Canthaxanthin (3)</td>
<td>80 ppm</td>
<td>80 ppm</td>
<td>80 ppm</td>
</tr>
</tbody>
</table>

(1) DAFA LPR, Nickerson s.a., Marne-la-Vallée, France
(2) Labbé et al., 1993.
(3) Carophyll(r) red, F. Hoffmann - La Roche, Basel, Switzerland
Discussion

It is well known that canthaxanthin is less absorbed than astaxanthin by rainbow trout. It is for this reason that canthaxanthin was chosen to study the effect of phospholipids, if any, on a compound which is not well absorbed by the fish. Lecithin increased the digestibility and absorption of fat in man (O’DOHERTY et al., 1973).

In our experiment, phospholipids added to the diet were not found to enhance the deposition of canthaxanthin in the muscle of rainbow trout. Moreover phospholipids did not have any effect on the $a^*$ colour parameter while the higher amount of phospholipids (8 %) in the diet led to higher colour parameter.

Literature does not report comparative studies on the effect of phospholipids on flesh pigmentation in fish. On the other hand, in poultry, the use of phospholipids in the diet of broiler gave conflicting results: the addition of 2 % lecithin to broiler ration did not significantly influence their pigmentation (RATCLIFF et al., 1959), while soybean lecithin added to broiler diets depressed the deposition of carotenoid pigments in the flesh (WILLIAMS, 1962). More recently it was claimed that inclusion of lysolecithin in the diet of laying hens led to the increasing of pigment conversion from 16.1 % to 26.8 % (CALTRON et al., 1998).

It has been concluded from our experiment, that the addition of phospholipids to the diet of the trout may have a positive effect on colour parameters except $a^*$, however, there is no response concerning canthaxanthin concentration in the muscle of the fish.
Acknowledgements

The authors wish to thank Y. Hontang, F. Terrier and F. Sandres for the maintenance of the experimental animals. The authors are grateful to Nikerson s.a. (Marne-la-Vallée, France) for providing us with the soja lecithin (DAFA LPR), Produits Roche France (Neuilly-sur-Seine, France), for the canthaxanthin beadlets, and to F. HOFFMAN-LA ROCHE (Basel, Switzerland) for carotenoid standards.

References


