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Nutritional effects on dark fillet spots of Atlantic salmon (*Salmo salar* L.)

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Dark fillet spots represent the greatest and most costly quality deviation of farmed Atlantic salmon. The problem is present in all significant salmon producing countries. On average every fifth salmon fillet has dark hyperpigmented myotomes. The focal spots are typically 3 cm wide, localized in the belly area of the fillets. Dietary composition affects prevalence, spot size and degree of hyperpigmentation.

Appearance

More than 90% of the spots are observed in the cranioventral fillet part. Most spots are grayish-black, but they can vary in appearance from red – black – grayish.

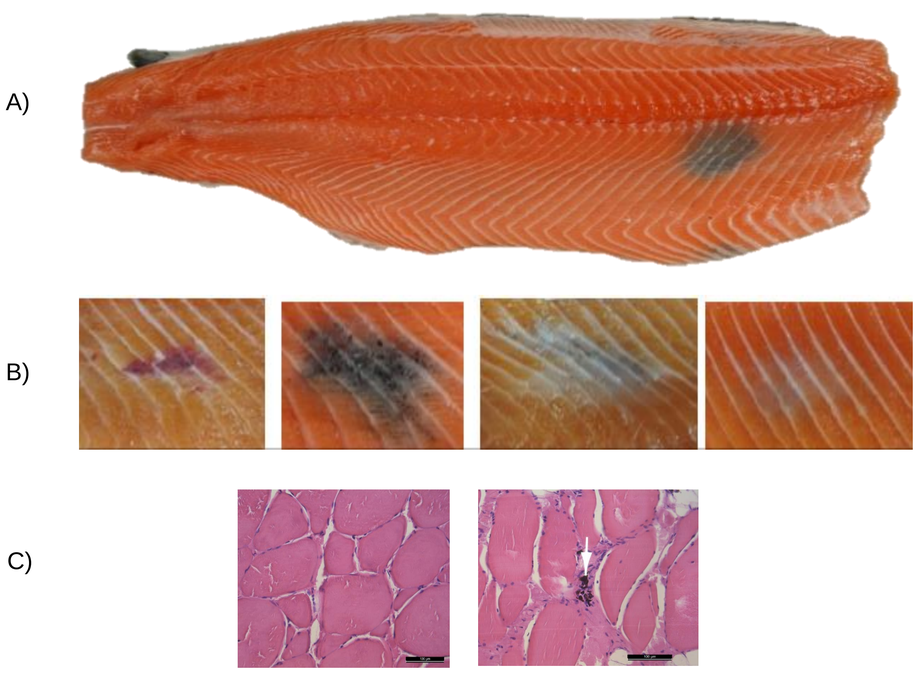

Figure 1. Images illustrating A) Fillet with a dark spot in the most frequently affected area B) Different appearance of fillet spots C) Micrographs of normal (left) and hyperpigmented myotomes (right: muscle tissue with some inflammation and pigmented cells indicated by arrow head)

Prevalence

The number of salmon fillets with dark spots has increased significantly in recent years. The prevalence varies within and between farming regions. In Norway the prevalence increased from 5% in 1995 to an average level of 19% since 2014.

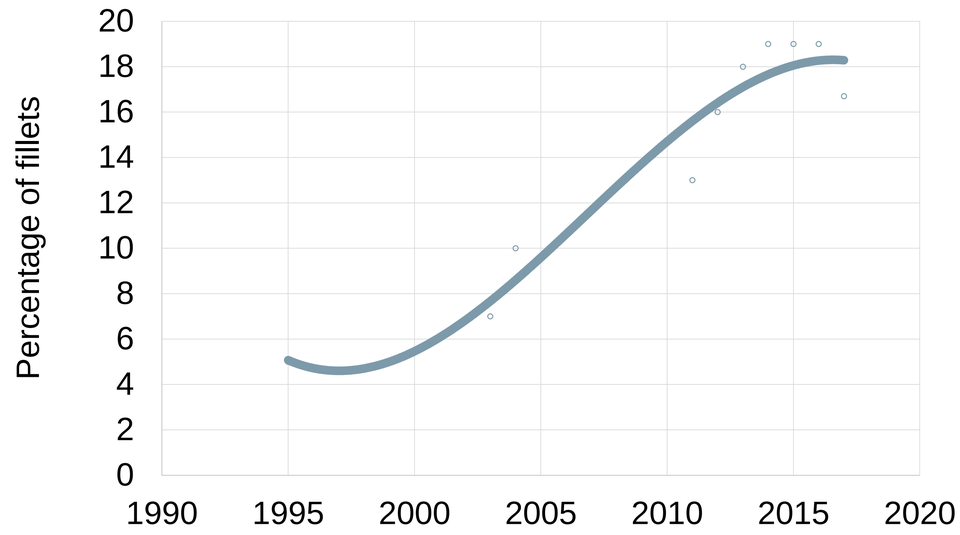

Figure 2. Time trend in the prevalence of dark spots in salmon fillets from 1995 – 2017 Data sources:.Koteng 1992; Mørkøre et al. 2015

Aim

To give an overview of existing knowledge on nutritional effects on dark fillet spots of Atlantic salmon.

Experiments and results

<u>Small scale</u>

Feeding trials were carried out with farmed Atlantic salmon (*Salmo salar* L.) in triplicate 125m^3 net pens per dietary treatment. Crude protein and lipid content of the diets were 35 – 37% (Figure 3).

I. The fish were fed a commercial diet or the same diet added dl-α-tocopherol acetate (vitamin E; 300 vs. 800 mg/kg) and organic selenium (Se; 0.4 vs. 0.6 mg/kg), copper (12 mg/kg $CuSO_4$) or $ZnSO_4$ (Zn; 100 vs 230 mg/kg) for ten weeks prior to harvest in August 2014 (weight increase 2.5 kg to 3.8 kg). Supplementation of Vit E + Se resulted in fewer (0.2 vs. 0.6; P = 0.03) and Cu in increased number of dark stained myotomes (0.9 vs. 0.6; P = 0.05). Zn had no significant effect on the number of dark stained myotomes (0.4 on average)

II. The fish were fed a commercial feed or the same feed added dl-α-tocopherol acetate (vitamin E; 300 vs. 800 mg/kg)+organic selenium (Se; 0.4 vs. 0.6 mg/kg)+ ROVIMIX® STAY-C®35 (Vit C 50 vs. 400 mg/kg). The feeding period was the same as for Experiment I. The fish were harvested in March 2015 (weight increase from 3.6 - 4.2 kg). Salmon fed Vit E + Vit C + Se had significantly fewer dark stained myotomes compared with the control (0.6 vs. 0.9; P = 0.04).

III. Life-long study with heterotrophic marine microalgae as fish oil replacement in salmon feeds; *Schizochytrium sp*. (Alltech) with 60% lipid and ~13% protein (DHA 25% of f.a.). All fish oil was replaced by Algalmeal; the amount of EPA+DHA (1.25%) and n3/n6 ratio were similar in the experimental diet and the control diet. The fish were harvested in January 2017 (body weight 3 kg). Salmon fed the diet supplemented with the marine microalgae had significantly fewer dark stained myotomes compared with the control (0.02 vs. 0.5; P = 0.04).

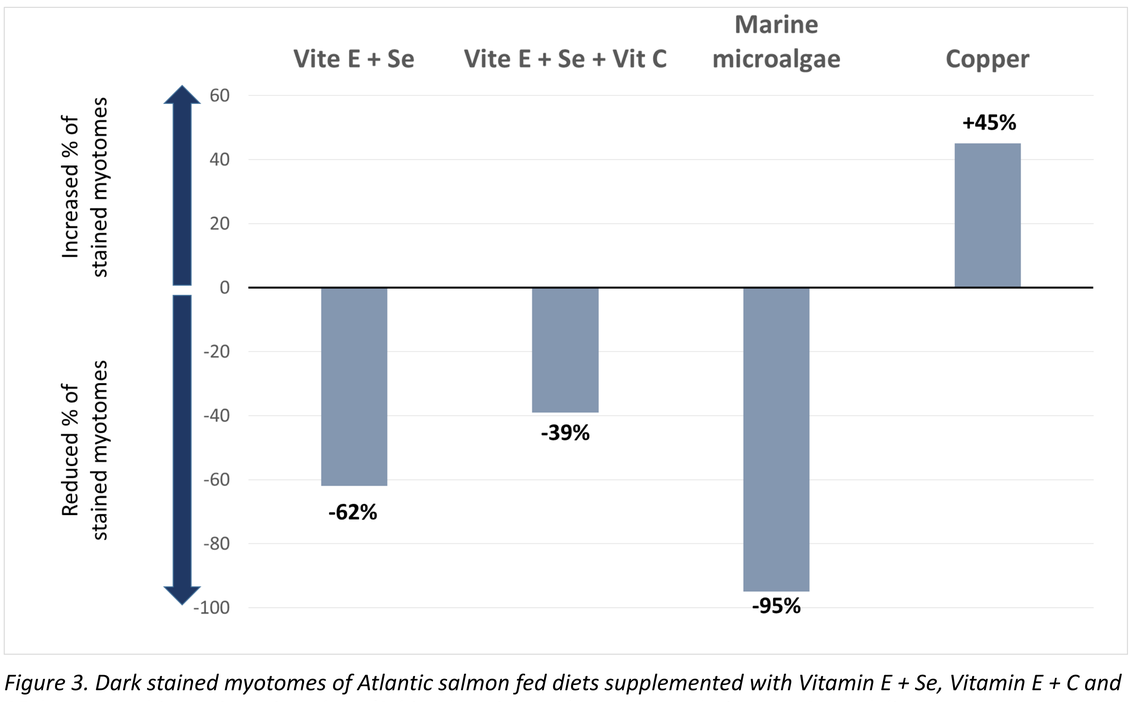

Figure 3. Dark stained myotomes of Atlantic salmon fed diets supplemented with Vitamin E + Se, Vitamin E + C and SE, heterotrophic marine microalgae (Schizochrytrium sp.) or copper relative to a Control diet.

<u>Large scale</u>

- Reducing EPA + DHA from 8 to 5% of total fatty acids in salmon feed during the seawater phase resulted in increased prevalence of dark spots (28% vs. 21.5%) (Sissener et al. 2016).
- Salmon fed diets supplemented with krill have generally lower prevalence of dark spots
- Organic produced salmon have generally lower prevalence
- Protein-rich diets can reduce losses during disease outbreaks (PD, HSMI), and reduce the prevalence and severity of hyperpigmentation

References: Mørkøre et al. 2015. Mørke flekker i laksefilet. Kunnskapsstatus og tiltak for å begrense omfanget. (ISBN 978-82-8296-322-0) 79 s. Nofima rapportserie(34/2015). Sissener et al. 2016. Reduced n-3 long chain fatty acid levels in feed for Atlantic salmon (*Salmo salar* L.) do not reduce growth, robustness or product quality through an entire full scale commercial cycle in seawater. Aquaculture 464, 236-245. Koteng, A., 1992. Markedsundersøkelse, Norsk laks. Technical report, Fiskerinæringens Landsforening, Bergen, Norway. Mørkøre, T. et al. 2016. Melaninflekker i laks infisert med både PRV og SAV. Nofima rapport 31/2016 (FHF#901216.)

- Nutritional components found to decrease dark hyperpigmentation of salmon fillets: Antioxidants, EPA + DHA/marine fish oil
- Ingredients found to decrease dark hyperpigmentation of salmon fillets: marine microalgae, krill

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