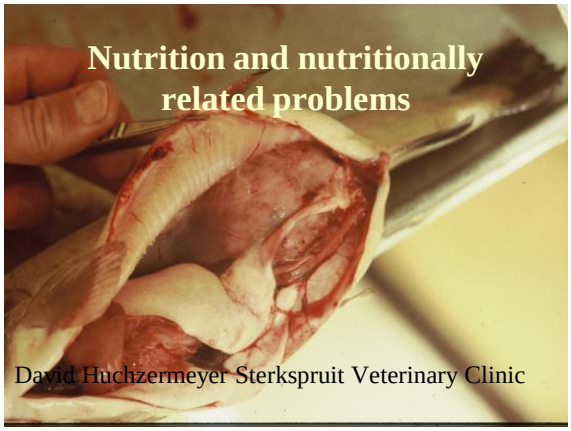


Protein

- Requirement 2 to 4 times higher than in mammals
- Natural food of most fish is 50 to 70 % P
- Complete dry diets have 30 to 50 % P
- High essential amino acid requirement
- Variation in P requirement with age (from fry to adulthood)

Lipids

- Energy source
- Source of essential fatty acids needed to maintain structure and integrity of phospholipid cell membranes
- Dietary requirement for linoleic and linolenic acid of 1 % of diet
- Fish can digest lipid completely
- Fish oils are high in ω3, vegetable oils are high in ω6

Protein:energy

- Fish feed to a set energy intake
- With a high protein:energy ratio, carbohydrate is poorly utilized by many fish especially trout.
- If energy:protein ratio is too high, protein intake is restricted and poor growth is attained.
- A minimum of 4 % polyunsaturated fats are needed by trout. The remainder can be saturated

Carbohydrate

- Non-essential cheap source of energy
- Included at 25 % dCHO
- Single function as energy source
- Fish appear to be insulin deficient
- CHO readily digested and absorbed as glucose – used as energy.
- Excess deposited as glycogen in the liver
- Poorly converted back to glucose even with starvation

Starvation

- Red muscle – high activity of glucose hexakinase
- White muscle – low activity of glucose hexakinase
- With starvation glycogen levels are maintained in fish (used up in mammals)
- First fatty acids, then non-essential amino-acids, then glucose

Food conversion ratio

= Feed intake (dry food)
weight gain (live weight)

Vitamins and minerals

- Premix is usually added at 2 to 5 % of the ration.
- Almost total dietary dependence on vitamins in intensive aquaculture
- 11 water soluble – cannot be stored by fish
- 4 fat soluble – can be stored by fish
- **Vit. C and E are most unstable**
- Losses due to processing, storage and leaching

Minerals

- Absorbed directly from water
- Calcium – sufficient in water if > 20 ppm
- Phosphorous – insufficient levels in water to meet dietary requirements

Methods of feeding, FCR and effluent

- Feed at optimum FCR
- Ammonia and phosphate in effluent originate almost completely from fish meal component of diet
- Suspended solids in effluent derive from indigestible material in faeces and uneaten food.
- Biological oxygen demand is a measure of the oxidising capacity of the waste products in the water.

The pollutant effect of cage farming salmonids

(Philips,M.:Beveridge,M. Fish Farmer, May/June 1986, 17-19).

- For every ton of feed fed into salmonid cages
- approximately 8.3 kg of **phosphorous** entered the water as soluble waste, and 18.7 kg of phosphorous passed into the water as solids ending up in the sediments beneath the cages.
- approximately 63.85 kg of **nitrogen** entered the water as soluble waste, and another 39.95 kg of nitrogen was added to the sediments as solid waste.

Pigments

- Included at 400 ppm in diet
- Canthaxanthin – carophyll red
- Astaxanthin – carophyll pink
- Slaughter fish – feed from 100 gram onwards
- Brood stock - feeding prior to breeding season

Nutrient deficiencies

- Protein quality – essential amino-acids – tryptophan, methionine and lysine
- Lipid quality – essential fatty acid deficiency – rancid or peroxidized fats
- Vitamin deficiency – leaching losses particularly vit. C.

Protein quality

- Poor – loss of appetite

Deficiency

- Tryptophan – scoliosis, cataract
- Methionine – cataracts
- Lysine – dorsal fin erosion

Lipid quality

- Essential fatty acid deficiency:

– reduced growth

- caudal fin erosion
- shock syndrome
- fatty livers

Lipid quality

- Rancid or peroxidized lipid:
- dark colouration
- Anaemia
- Gill clubbing
- Yellow livers
- Ceroid deposition and fatty degeneration in liver

General deficiency and toxicity

Scoliosis

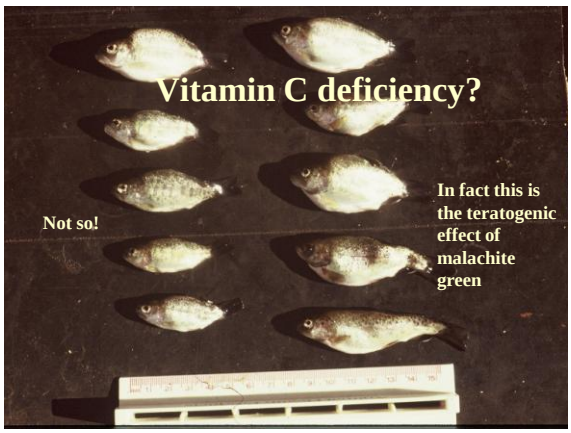
- Deficiency - thiamine, tryptophan, Vit. C, E and magnesium
- Toxicity – cadmium, lead

Fatty liver

- Deficiency – thiamine, choline, essential f.a., essential a.a.

Cataracts

- Deficiency – riboflavine, biotin, zinc, methionine, tryptophan
- Toxicity – mercury, choline

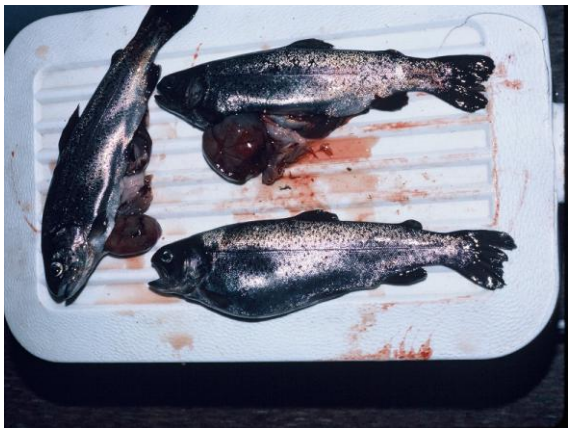


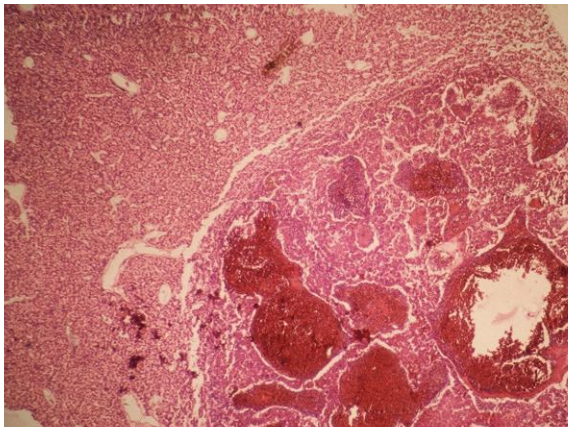
Spinal deformity – vitamin C deficiency

Omega 3 fatty acid deficiency and ascobic acid deficiency

Aflatoxicosis

- *Aspergillus flavus*
- **Fish are very sensitive to aflatoxin**
- **Liver tumours, typically hepatoma, but renal tumours may also occur**
- **Indicates poor food storage or use of contaminated feed ingredients**





Zinc deficiency cataract

- Mineral imbalance in diet. Poor quality fish meal with high ash content (white fish meal substituted for herring meal)
- Zinc and calcium compete for the same absorption sites
- Correct by increasing dietary zinc inclusion

Lipoid liver degeneration

Caused by:

- low levels of dietary vitamins as result of processing loss and long storage times
- long storage times resulting in oxidation of long chain fatty acids (measured as peroxidation value of the diet)

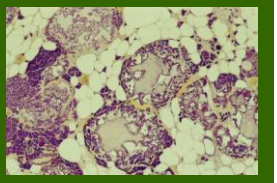
Results in:

Irreversible liver damage

Lipoid liver degeneration

- Common in ornamental fish
- Seen when expired diets are fed to salmonids
- When vitamin premix is omitted from salmonid diet

Pansteatitis



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