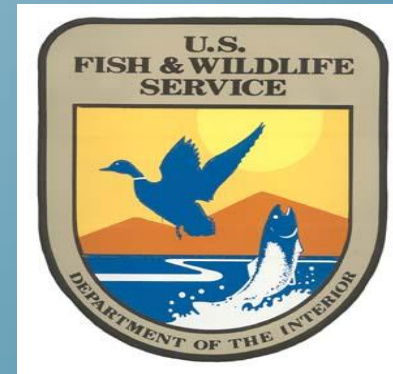


Effects of Dietary Lipid Source and Ultraviolet Radiation on Growth and Fatty Acid Profile of Steelhead, *Oncorhynchus mykiss*

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Background

- Fish oil is an important ingredient in fish feed.

COMPLETE FEED FOR SALMON & TROUT

GUARANTEED ANALYSIS

Crude Protein (min)	50%	Crude Fiber (max)	1.0%
Crude Fat (min)	16%	Phosphorus (min)	1.5%

INGREDIENTS

Fish Meal, Krill Meal, **Fish Oil**, Water, Blood Meal, Glycerol, Wheat Flour, Wheat Gluten, Glucono Delta Lactone, Lecithin, A Vitamin/Mineral Premix Containing: Vitamin A, Vitamin D3, Ascorbyl Polyphosphate (C), Vitamin E, Inositol, Zinc Sulphate, Nicotinic Calcium Pantothenate, Manganese Sulphate, Riboflavin, Pyridoxine Hydrochloride, Thiamine Mononitrate, Menadione Sodium Bisulfite Complex (Vitamin K), Copper Sulphate, Folic Acid, Calcium Iodate, D-Biotin, Sodium Selenite and Vitamin Supplement, Brewer's Yeast, Vitamin E Supplement, Astaxanthin, Betane, Ethoxyquin (Antioxidant).

Background

Complete Feed for Salmonids

GUARANTEED ANALYSIS

Crude Protein (min)	52	%	Crude Fiber (max)	1.0	%
Crude Fat (min)	20	%	Phosphorus (min)	1.2	%

INGREDIENTS: Fish Meal, Fish Oil, Wheat Flour, Wheat Gluten, Dried Fish Solubles, Dried Whey Powder, Porcine Gelatin, Mono Ammonium Phosphate, A Vitamin/Mineral Premix Containing: Vitamin A Acetate, Vitamin D3 Supplement, Ascorbyl Polyphosphate C, Vitamin E Supplement, Inositol, Zinc Sulphate, Nicotinic Acid, Calcium Pantothenate, Manganese Sulphate, Riboflavin, Pyridoxine Hydrochloride (B6), Thiamine Mononitrate, Menadione Sodium Bisulfite Complex (Vitamin K), Copper Sulfate, Folic Acid, Calcium Iodate, D-Biotin, Sodium Selenite and Vitamin B12 Supplement, Vitamin E Supplement, Ascorbyl Polyphosphate C, Brewer's Yeast, DL Methionine, Astaxanthin and Ethoxyquin, a preservative.

Background

- Dietary fish oil and exposure to sunlight are key factors in a disease known as steatitis

- Steatitis had been reported at different hatcheries.



- Steatitis is defined as inflammation of fatty tissue



Steatitis

- Caused by lipid oxidation
- External signs include skin lesions and fin erosion
- Occurs in animals that consume large amounts of fish or fish oil such as crocodiles, cats, mink and fishes

Steatitis

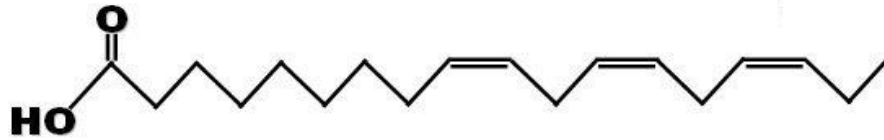
- Marine fish oil contains long chain-polyunsaturated fatty acids (LC-PUFA) such as EPA and DHA
- LC-PUFA are susceptible to peroxidation
- Peroxidation *in vivo* results in biomembrane damage
- Most lipids are devoid of LC-PUFA

Fatty Acids in Lipids

Fatty acid	Canola Oil	Fish Oil
% of Fatty Acids		
EPA	0	14.6
DHA	0	9.3

Susceptibility of fatty acids to oxidation increases as the number of double bonds increases

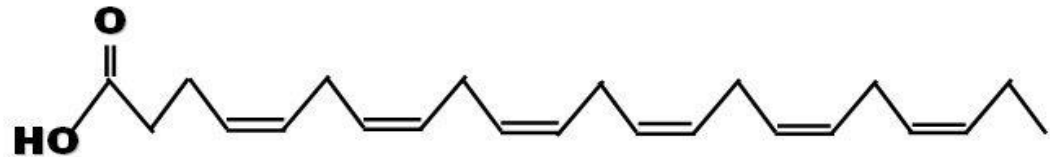
ALA



EPA



DHA



Background

- Antioxidants are added to feed to control rancidity.

COMPLETE FEED FOR SALMON & TROUT

GUARANTEED ANALYSIS

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Complete Feed for Salmonids

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Study Objective

Examine the effects of dietary lipid source and light source on growth, tissue composition and steatitis in steelhead.

Study Design

- Three dietary lipids: canola oil, control fish oil, oxidized fish oil
- Two light sources: fluorescent or ultraviolet (UV)
- Each treatment was assigned to three tanks of fish in a completely randomized design

Study Design

- Ultraviolet radiation supplied by two light fixtures with 26 watt UVB bulbs.



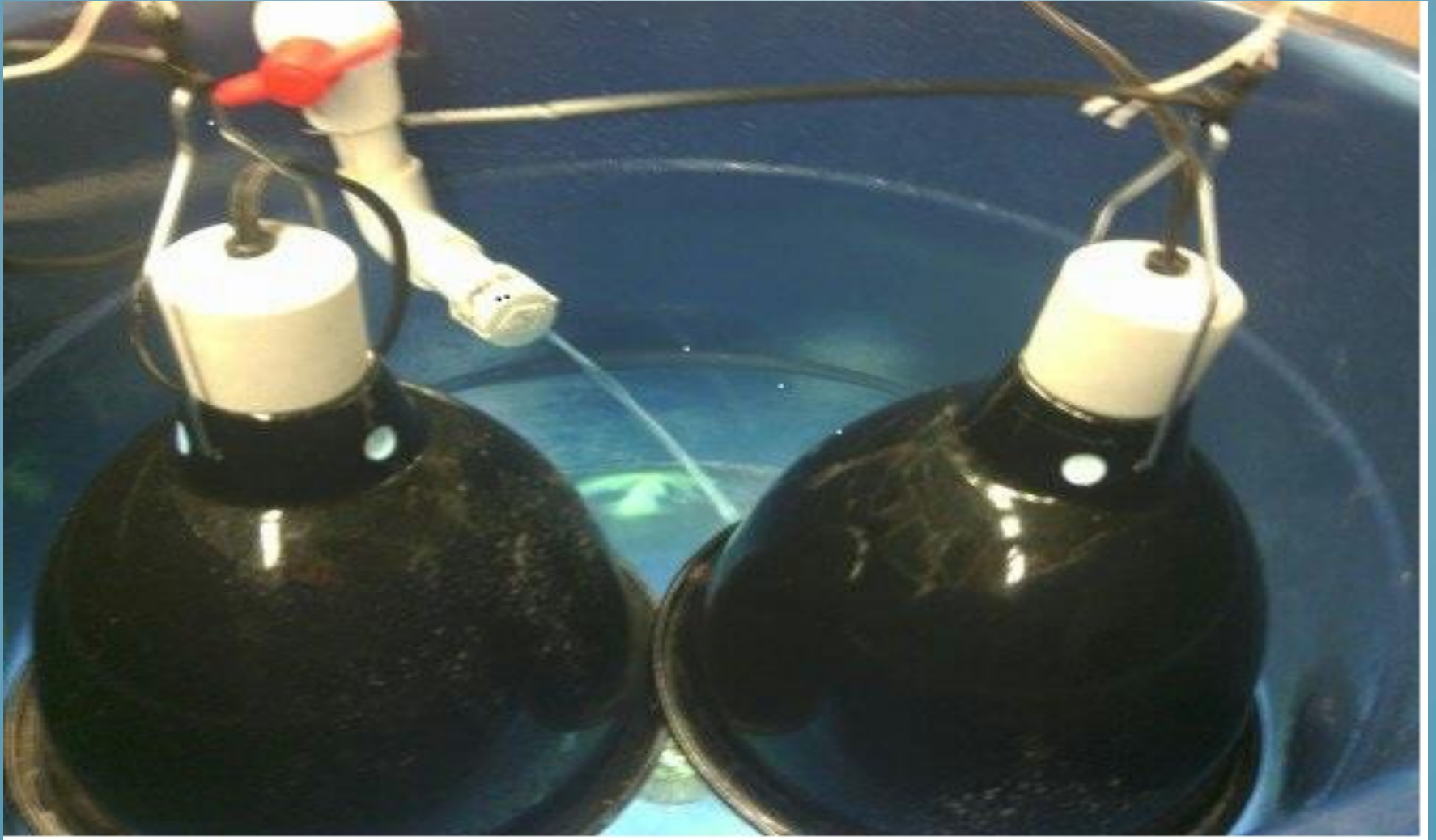
Study Design

- The UV lights were on a 12h:12h light:dark diurnal cycle in the nine tanks.
- Mean UV intensity was 4.2 mW/cm²
- Mean UV intensity outdoors was 12.9 mW/cm² (6/23/15, Longview, WA)

Experimental System



Ultraviolet Lights



Ultraviolet Lights



Feed Composition

Ingredient

Fish meal

Wheat flour

Corn gluten meal

Feather meal

Porcine blood meal

Poultry meal

Vitamin premix

Mineral premix

Choline chloride

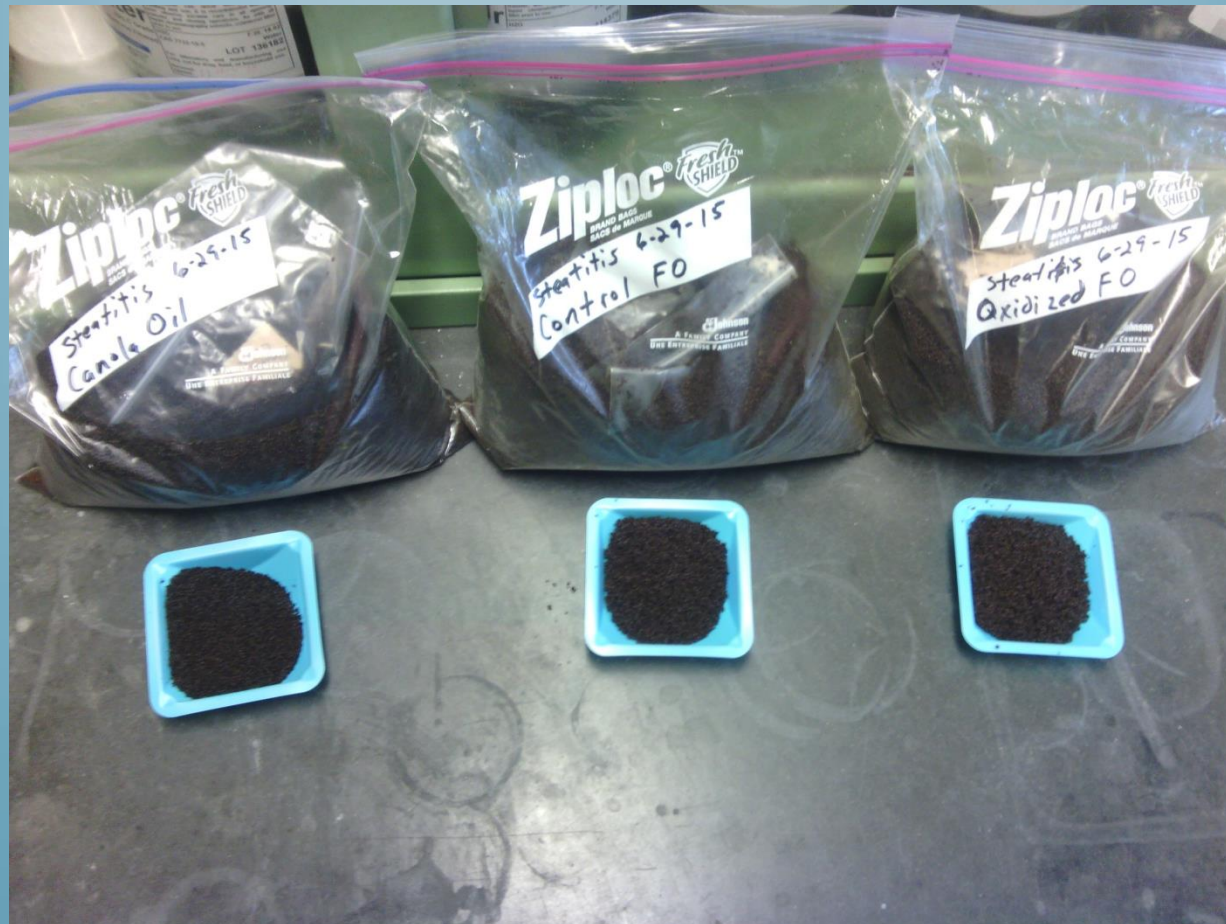
Guar gum

Astaxanthin

Ethoxyquin

Diets

- Each lipid was added to a low lipid commercial diet to produce three dietary treatments



Study Design

- The oxidized fish oil was produced by aerating the control fish oil at room temperature for 14 days using an aquarium air pump.

Lipid Oxidation

	Dietary Lipid Source		
	Canola Oil	Control Fish Oil	Oxidized Fish Oil
Peroxides (meq/kg)	5.8	5.3	21.0

Select Diet Fatty Acids

	Dietary Lipid Source		
	Canola Oil	Control Fish Oil	Oxidized Fish Oil
	% of fatty acids		
20:5n-3 (EPA)	2.8	12.0	12.2
22:6n-3 (DHA)	2.7	8.6	8.7
Total n-3 PUFAs	12.2	27.3	27.5
Total n-6 PUFAs	18.7	8.7	8.8

Dietary Lipid Concentration

	Dietary Lipid Source		
	Canola Oil	Control Fish Oil	Oxidized Fish Oil
Lipid (%)	18.0	18.2	18.4

Fish Husbandry

- 50 steelhead (1.6 g/fish) stocked into each of 18 tanks
- Rearing volume was 28.6 liters
- Water temperature was 12°C
- Fish were fed twice daily, seven days per week for 10 weeks

Response Variables

- Growth responses
- Whole body proximate composition
- Whole body fatty acid composition
- Whole body histology for signs of steatitis
- Plasma enzyme activity

Histology

- Two fish per tank were examined histologically for steatitis.
- Histology assessed using a 0-5 grading system (0=no steatitis and 5=severe steatitis).
- Pathologists had no knowledge of experimental treatments.

Statistical Analyses

- With the exception of histology results, data were subjected to two-way ANOVA.
- Histology scores were subjected to regression analysis for ordinal data.
- Accepted level of significance was 0.05.

Results

- No external lesions observed on any fish
- Growth, body composition and histology were affected by treatments

Weight Gain

Probability Values

Lipid

Light

Lipid x Light

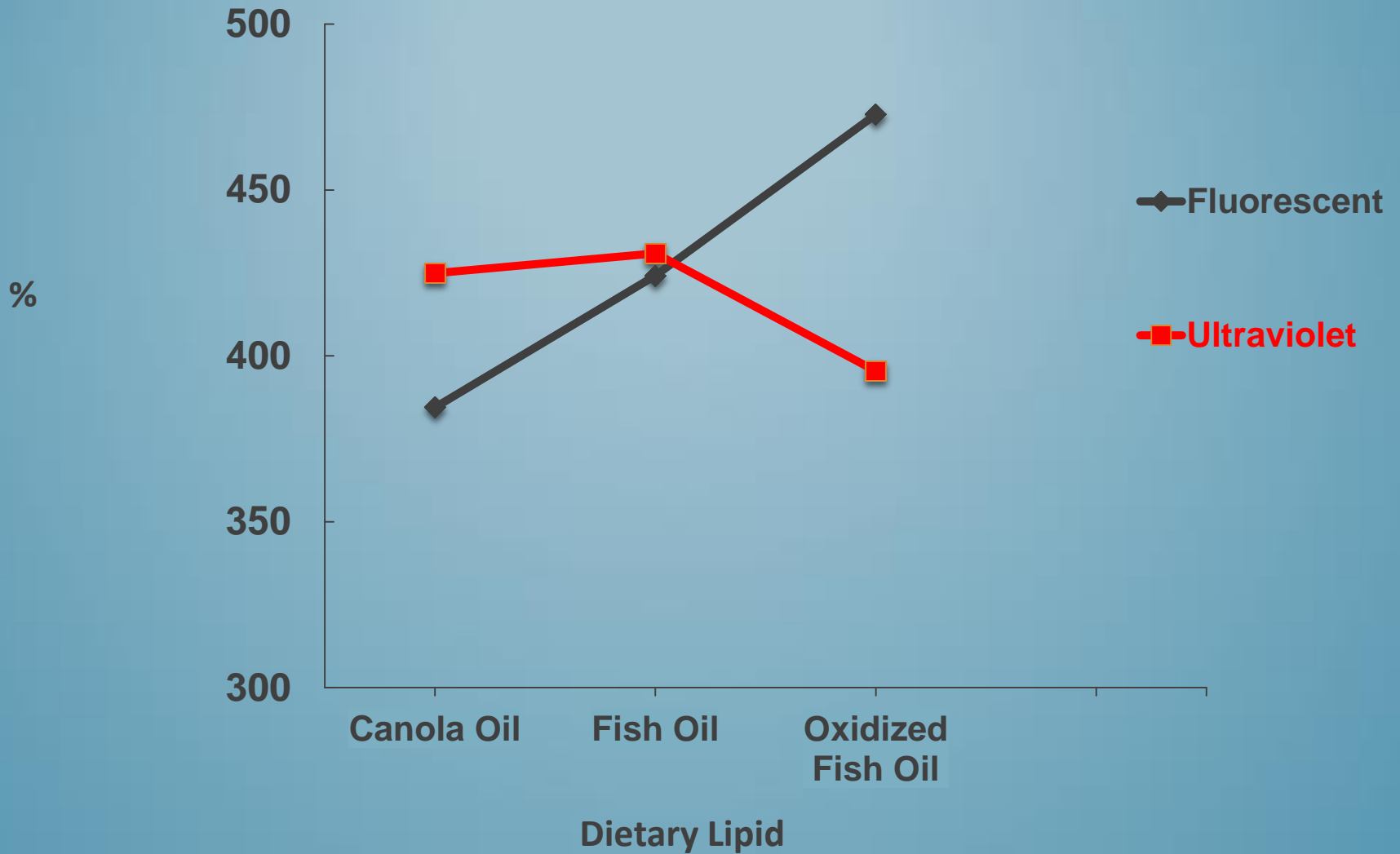
Weight Gain (%)

0.378

0.570

0.044

Weight Gain

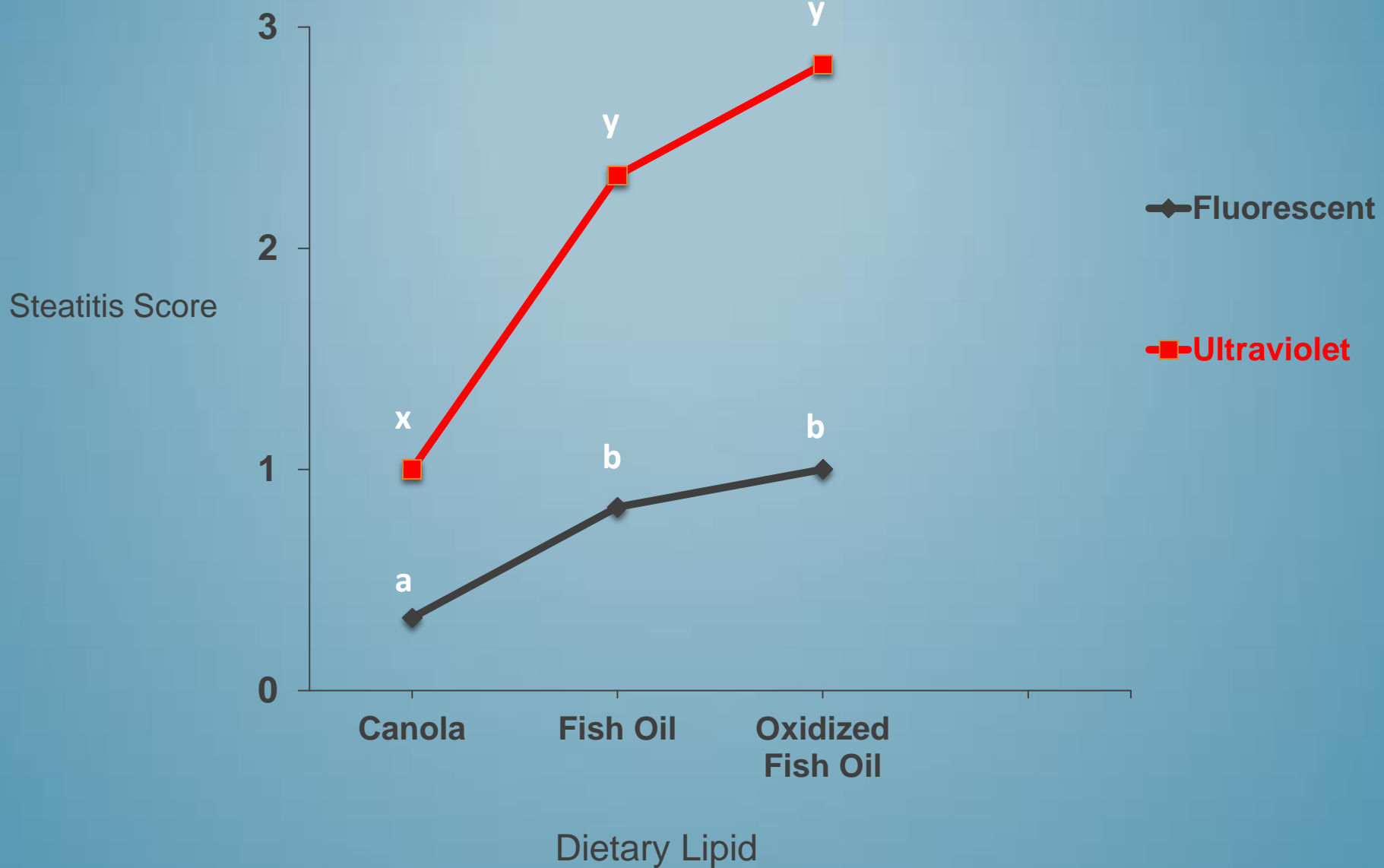


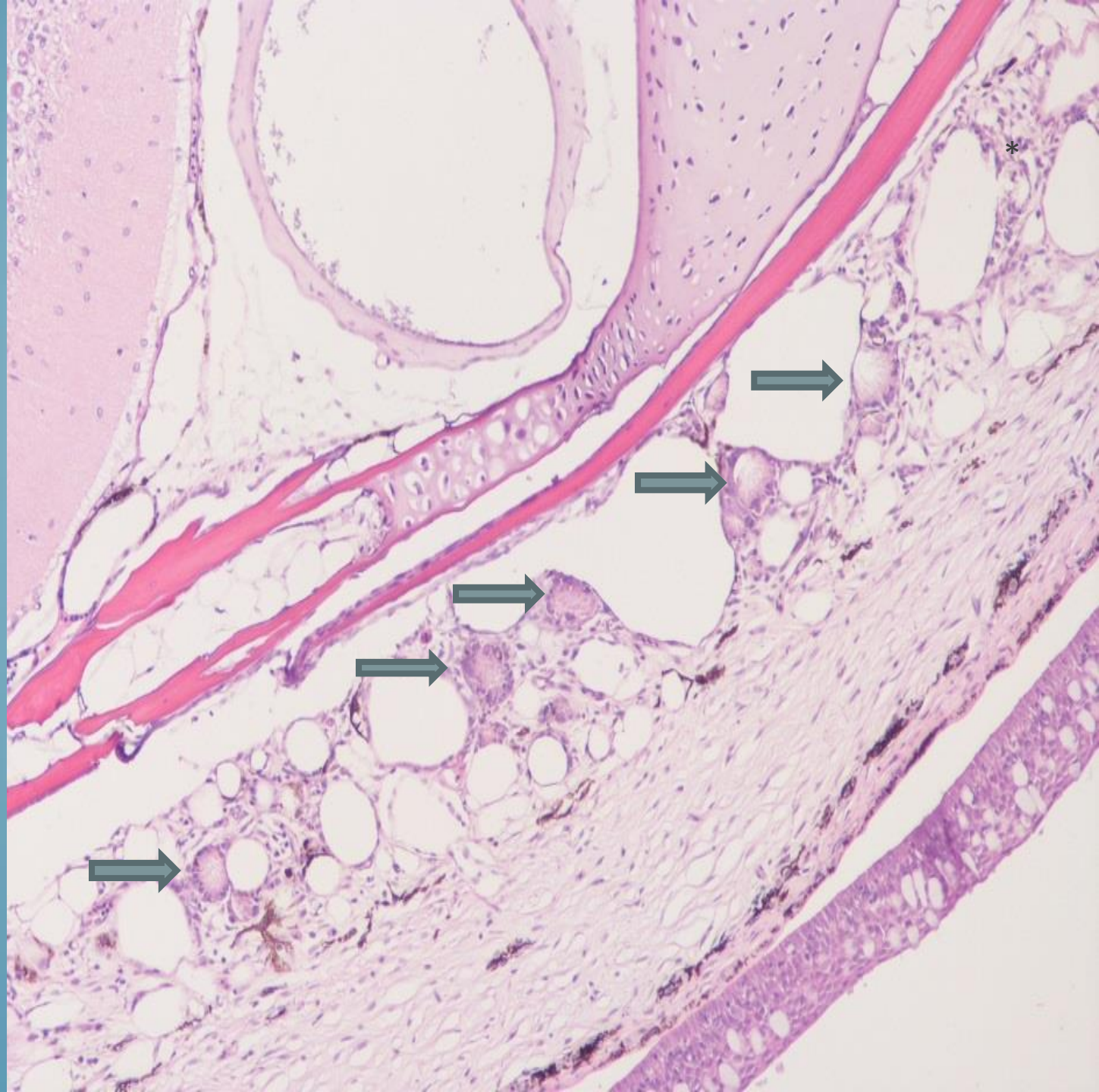
Histology

Probability Values

	Lipid	Light	Lipid x Light
Steatitis Score	0.010	0.001	0.437

Steatitis Score





Survival

Probability Values

Lipid

Light

Lipid x Light

Survival (%)

0.393

0.425

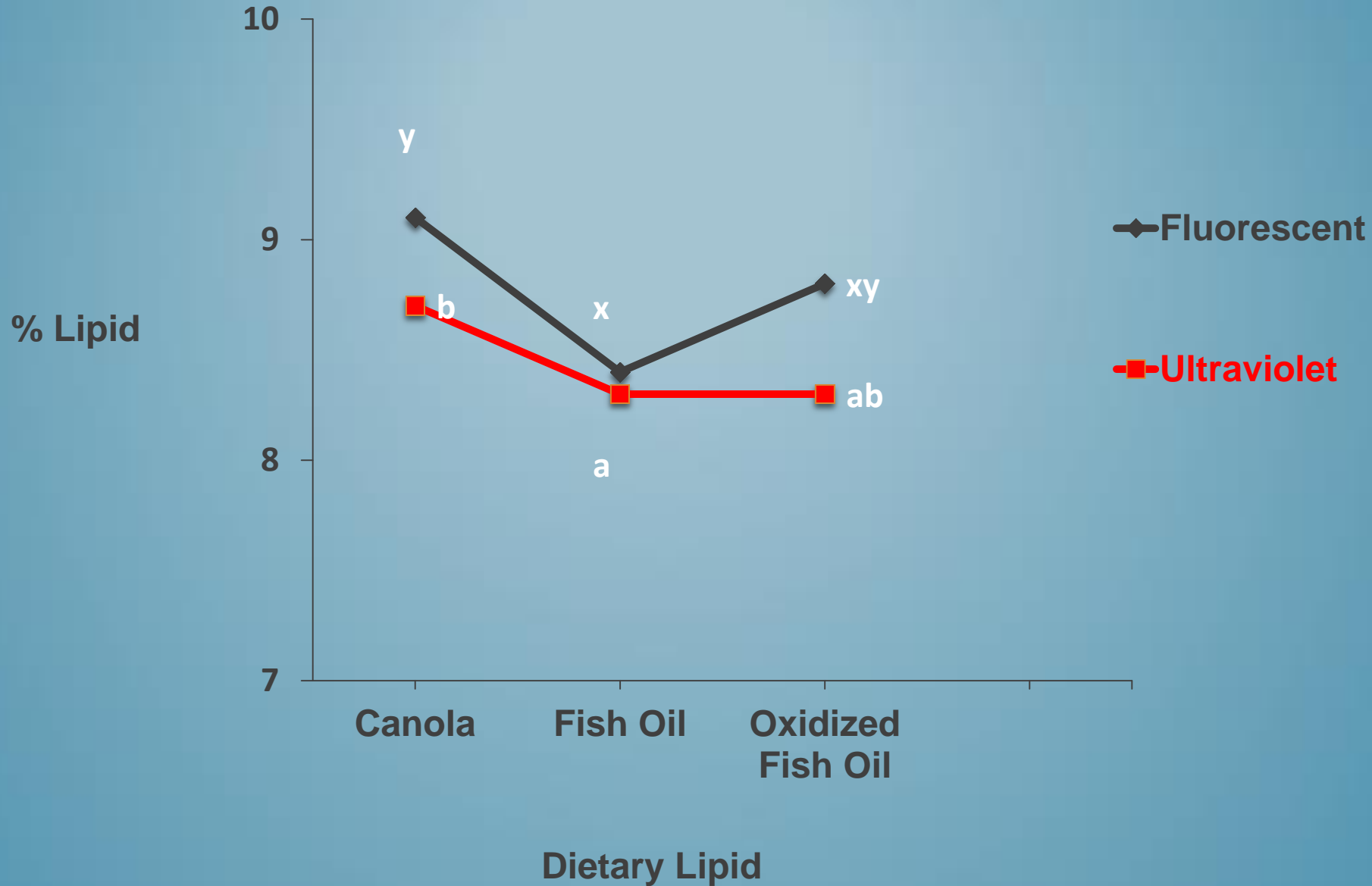
0.172

Whole Body Lipid Level

Probability Values

	Lipid	Light	Lipid x Light
Lipid (%)	0.004	0.006	0.326

Whole Body Lipid

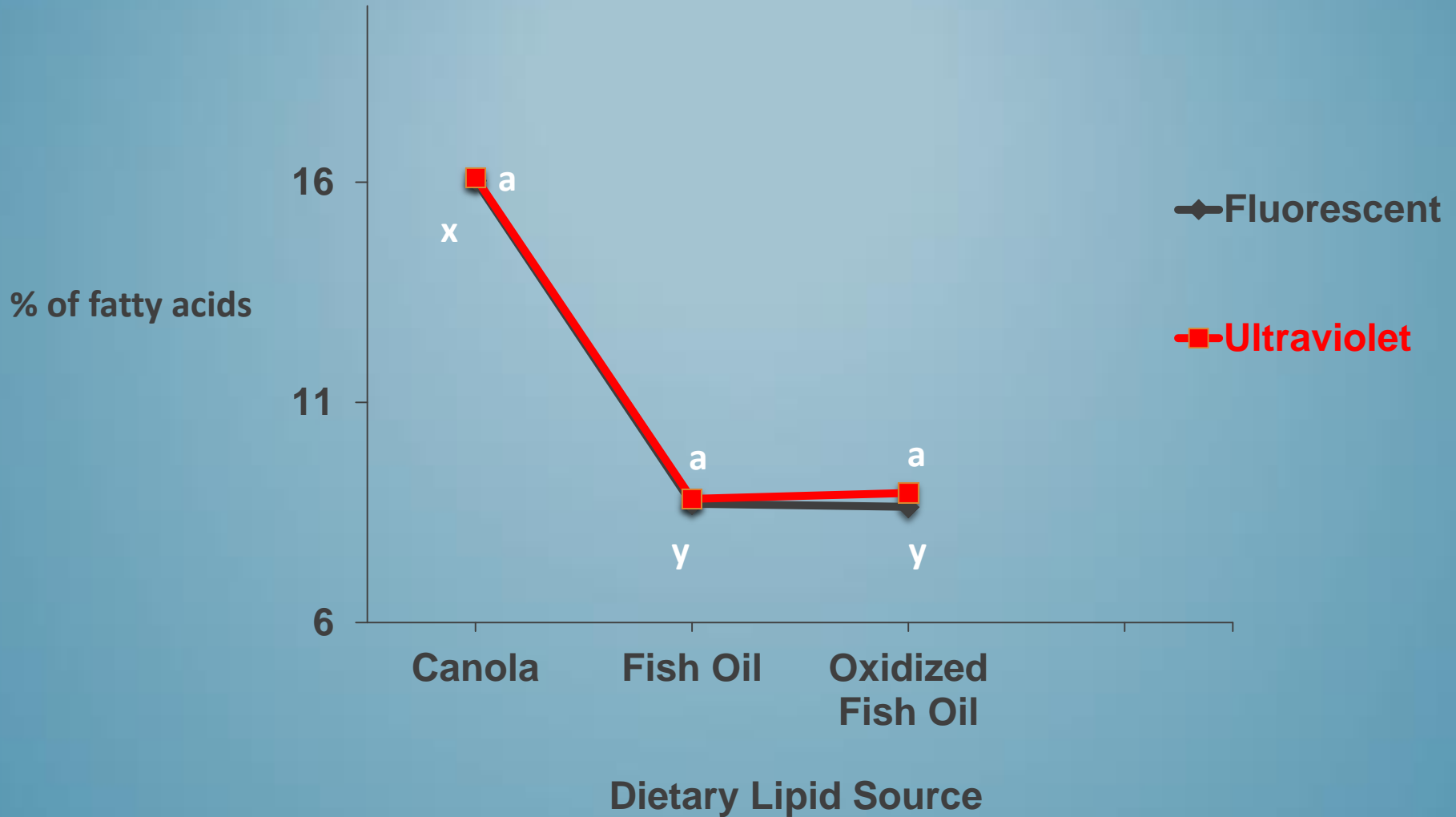


Whole Body n-6 Polyunsaturated Fatty Acids (n-6 PUFAs)

Probability Values

	Lipid	Light	Lipid x Light
n-6 PUFAs	0.001	0.036	0.283

Whole Body n-6 PUFA

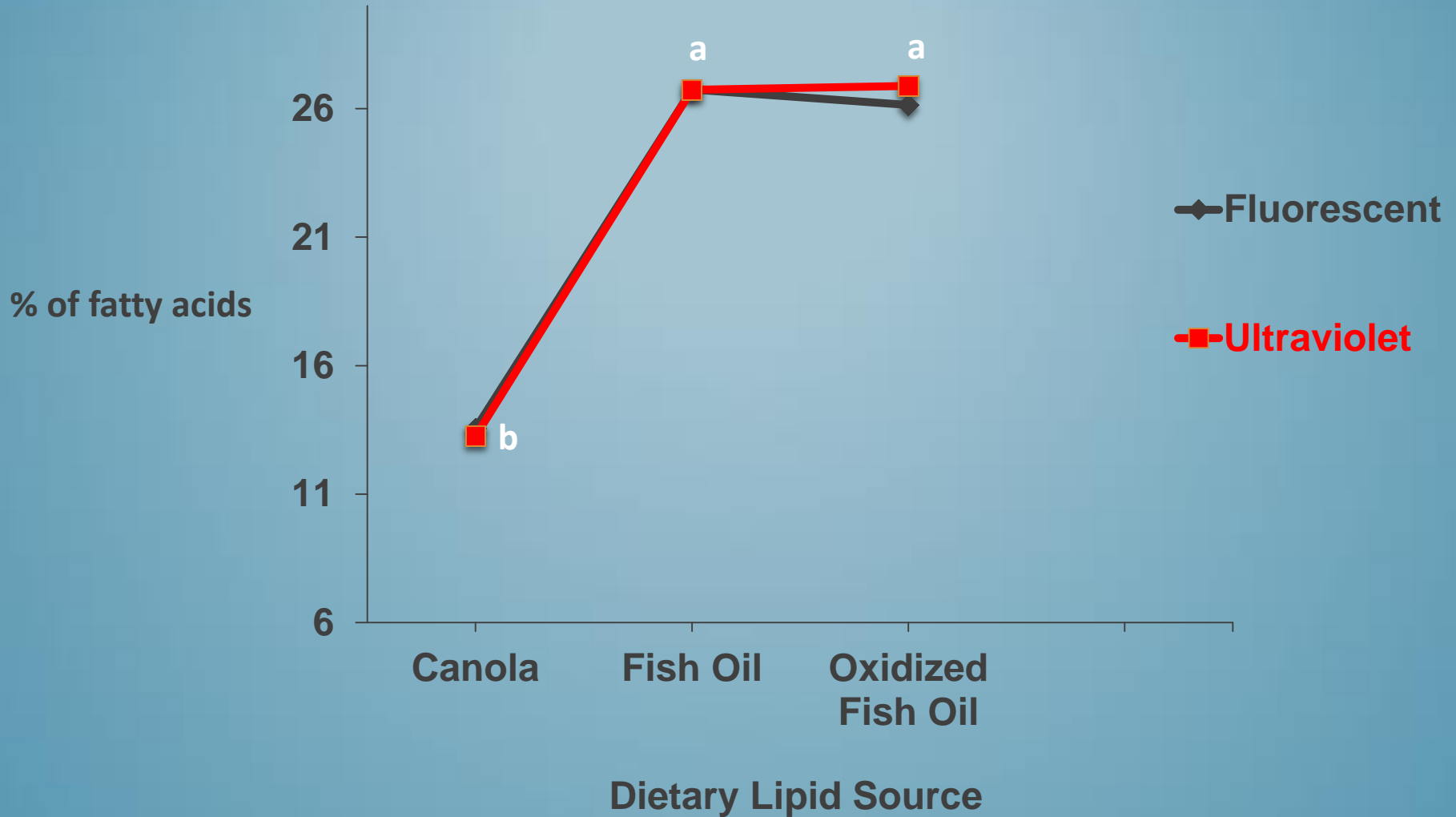


Whole Body n-3 Polyunsaturated Fatty Acids (n-3 PUFAs)

Probability Values

	Lipid	Light	Lipid x Light
n-3 PUFAs	0.001	0.660	0.213

Whole Body n-3 PUFA



Summary

- Steatitis observed in fish with no obvious external lesions.
- UV light and dietary fish oil significantly increased the histological signs of steatitis.
- Low fish oil feed and raceway covers may reduce steatitis.
- Feeding steelhead old feed that may be rancid is not recommended.

THANK YOU.

