Aquaculture Nutrition and Product Quality

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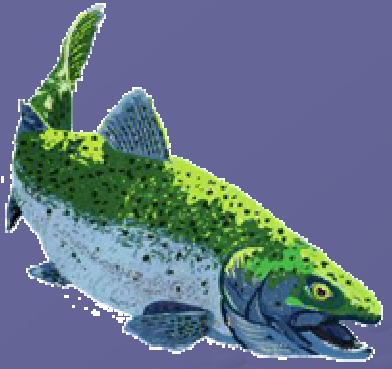


NUTRITION

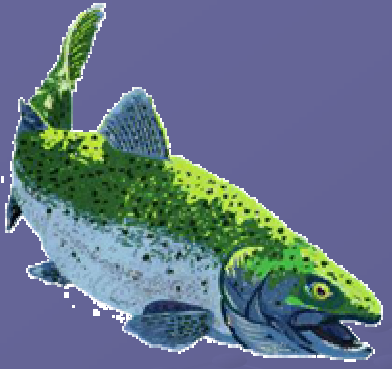
- **Nutrition** - Concerns a series of studies dealing with assimilation, synthesis, digestion, and absorption of food stuffs.

- **Nutrient** – An element or compound of dietary origin which is necessary to support the life processes of an animal.

FISH NUTRTION IS A VERY IMPORTANT AREA OF RESEARCH…

…40-70% of operational costs are related to feed costs.

$$$$$$$$$$$$



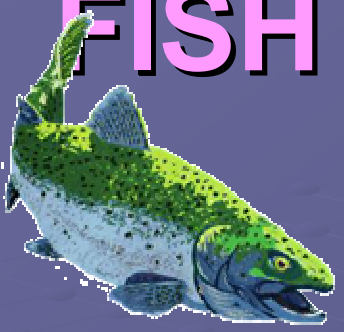
WHY FEED FISH?

- Intensification reduces natural food organisms in a pond.
- Some culture methods have little chance of natural food use (cages, raceways, net-pens).

WHY FEED FISH?

- Reduce reliance upon natural foods (especially for larval fish).
- Have control over what is being eaten by the fish.

FISH NUTRITION COMPONENTS



- **PROTEINS**
  - These provide amino acids and energy to the fish.

TEN ESSENTIAL AMINO ACIDS

PVT	TIM	HALL
Phenylalanine	Tryptophan	Histidine
Valine	Isoleucine	Arginine
Threonine	Methionine	Leucine
		Lysine

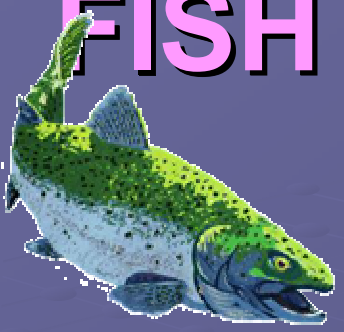
PROTEIN SOURCES

- **Single-cell proteins:** bacteria, yeast, algae
- **Plant-protein concentrates:** Any protein derived from a plant
- **Animal-protein sources:** MBM, blood meal, and FM

PROTEIN QUALITY IS VERY IMPORTANT

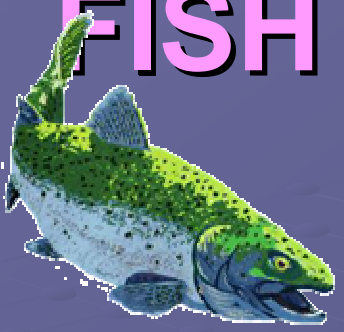
- **Fish meal –** 67% protein
  - expensive
- **Feather meal –** 60-70% protein
  - less expensive

FISH NUTRITION COMPONENTS



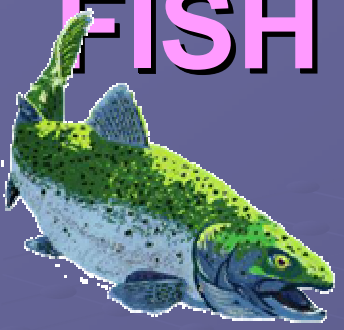
- Protein
- **ENERGY**
  - **Proteins** – expensive
  - **Fats** – fairly expensive; excellent source; essential fatty acids
  - **Carbohydrates** – very inexpensive; not as much research

FISH NUTRITION COMPONENTS



- Protein
- Energy
- **VITAMINS: used in enzyme systems; bone formation; antioxidants**
  - **Water soluble** – B-vitamins, vitamin C, choline chloride
  - **Fat soluble** – A, D, E, and K

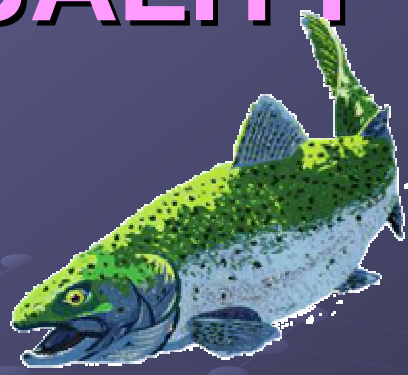
FISH NUTRITION COMPONENTS



- Protein
- Energy
- Vitamins
- **MINERALS: Co-enzymes; iron is a part of the blood**
  - **Major** – Ca, P, Na, K, and Cl
  - **Minor** – I, Fe, Mn, and Se

EFFECT OF NUTRITION ON PRODUCT QUALITY

PROTEIN EFFECTS ON QUALITY



- Little effect on product quality
- Tidwell et al. (1992)
  - KSU research on hybrid bluegill in aquaria

HBG fed →	26% protein	37% protein
% wt. gain	226 b	300 a
% whole-body protein (wet weight)	17.0 a	17.1 a
% lipid	6.6 ab	6.8 a

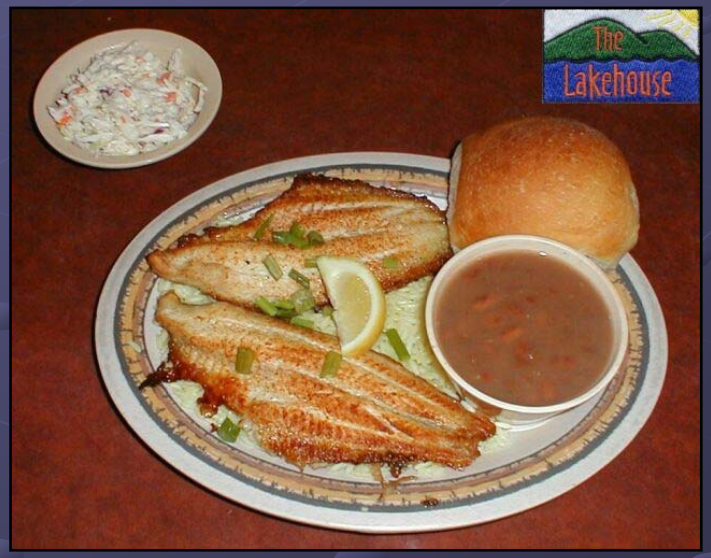
PROTEIN EFFECTS ON QUALITY

- **Tidwell et al. (1996)**
  - **KSU research on largemouth bass in ponds**

LMB fed →	42% protein	47% protein
Harvest weight (g)	374 b	436 a
% protein (whole body)	ND	ND (avg = 18.9% wet wt.)
% protein (fillet)	ND	ND (avg = 20.6% wet wt.)

PROTEIN EFFECTS ON QUALITY

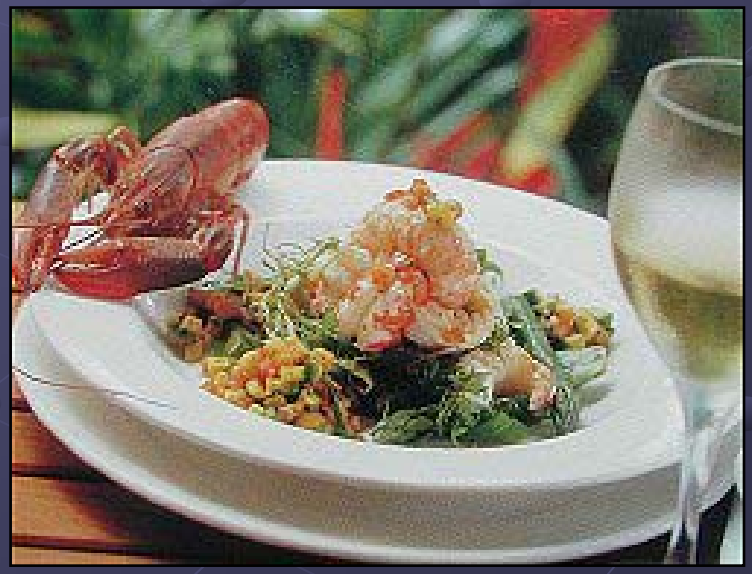
- Protein level didn’t affect % protein in channel catfish fillets when fish were fed either 34% or 38% protein diets.



- Protein level (44% or 53%) didn’t affect % protein in fillet of walleye in ponds.

PROTEIN EFFECTS ON QUALITY

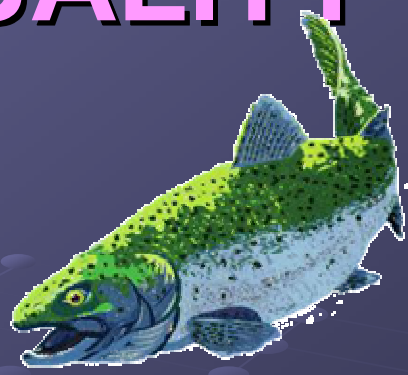
- Thompson et al. (2004) reported that Australian red claw crayfish fed diets containing 22,32, and 42% protein did not have any effect on tail muscle composition



PROTEIN EFFECTS ON QUALITY

- Xiong et al. (1996) reported that protein levels has minimal effect on flesh quality of frozen stored sunshine bass (0,1, 2, 3, 4, 5, and 6 months)

PROTEIN EFFECTS ON QUALITY



- TBARS (oxidative rancidity)
  - Sunshine bass were fed diets containing 29, 36, 42, and 45% protein.
  - Fillets stored at -20°C for up to 6 months had no differences in TBARS (Thiobarbituric Acid Reactive Substances)

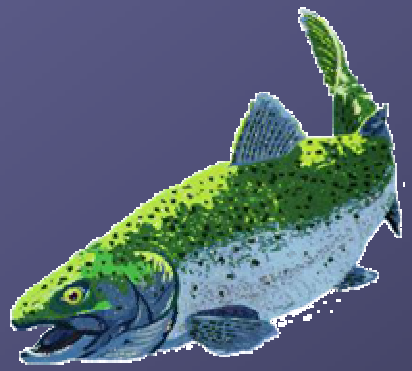
PROTEIN EFFECTS ON QUALITY

- Tensile stress (kN/m^2) of sunshine bass fillets stored at -20°C for up to 6 months indicated no statistical differences ($P > 0.05$) among treatments
- Shear stress (kN/m^2) of sunshine bass fillets stored at -20°C for up to 6 months indicated no statistical differences ($P > 0.05$) among treatments

PROTEIN EFFECTS ON QUALITY

- Shenouda (1980) reported that in gadoid fish, fillets were tough or spongy due to protein-protein interactions via formaldehyde derived from trimethylamine oxide.
  - But, this doesn’t seem to be the case in sunshine bass (non-gadoid fish)

LIPIDS



- An increase in dietary lipid (beyond a certain level) generally leads to an increase in lipid levels in whole-body and fillet of cultured fish. Not true with crustaceans, which generally have a very low lipid level in the muscle.

LIPIDS

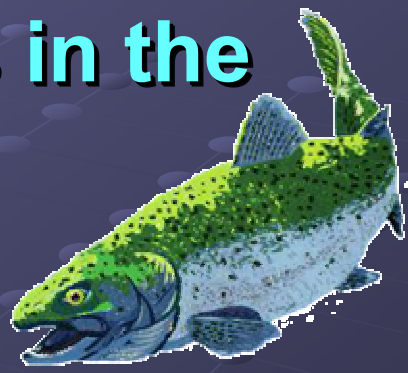
- Lipid levels vary by species:
  - Salmon: 20-30%
  - Catfish: 3-5%
  - Shrimp: 6-10%

LIPIDS

- If energy (lipid) levels are too high, fish will be “fatty” – may be undesirable.
- If lipid levels are extremely high, fish will eat to satisfy energy demand, “get fat,” and not consume enough essential amino acids for optimal growth.

FATTY ACIDS

- Fatty acid composition of fish lipids usually reflect those of the lipids in the diet



- Some dietary fatty acids are modified before being metabolized and stored in tissue lipids, while others are directly metabolized

FATTY ACIDS

- For example, rainbow trout can elongate and desaturate linolenic acid (18:3n-3) into the highly unsaturated fatty acids EPA (20:5n-3) and DHA (22:6n-3).
- But striped bass require a dietary source of EPA and/or DHA; they cannot bioconvert linolenic acid into n-3 HUFAs.

FATTY ACIDS

- Fatty acid profiles of non-polar neutral lipids (NL) generally resemble the dietary fatty acid composition, while the polar (structural) phospholipids (PL) generally comprise the fatty acids that are essential to the organism.

FATTY ACIDS

- Water temperature can also influence fatty acid compositions of fish, but this varies widely by species, age, tissue, and lipid type. Generally:

  ↓ temperature : ↑ in HUFAs

FATTY ACIDS

- Fatty acid manipulation in aquaculture products is easily achieved; however, care must be taken to avoid negative consumer reaction.

Salmon - ↑ HUFA; desirable

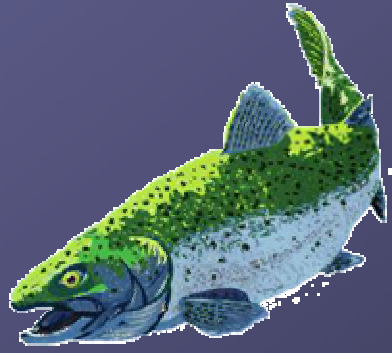
Channel catfish - ↑ HUFA; undesirable

REGIONAL DIFFERENCES

CAROTENOIDS

- Carotenoids comprise a group of over 300 lipid-class pigments found in various animals and plants.
- Carotenoids and xanthophylls are the two most important classes of carotenoid pigments that add color to fish and shrimp.
- Generally, xanthophylls are found in plants (corn) and carotenoid pigments are found in fish and crustaceans.

CAROTENOIDS



- Some fish can convert certain xanthophyll pigments to carotenoid pigments:

Goldfish Common carp	Zeaxanthin (yellow xanthophyll)	→	Astaxanthin (red carotenoid)
P. japonicus (shrimp)	β-carotene Zeaxanthin	→	Astaxanthin

CAROTENOIDS

- Salmon, trout, and red sea bream normally have higher pigmented flesh and skin cannot convert xanthophylls to carotenoids.
- In nature, they get the carotenoids from their diet (algae synthesize carotenoids and these are bio-concentrated through the food chain).

CAROTENOIDS

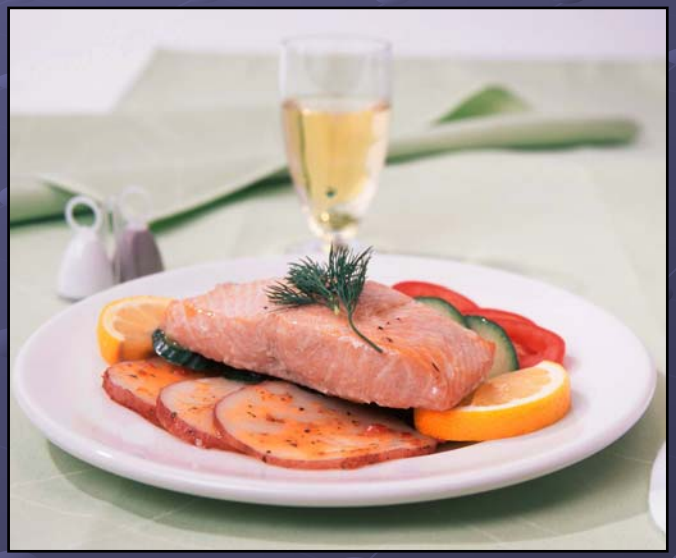
- Fish that are cultured have to have the carotenoids added to the diet (natural products or chemically-synthesized products).

CAROTENOIDS

- Natural carotenoids include:
  - Salmon eggs
  - Paprika
  - Krill
  - Zooplankton
  - *Haematococcus* algae (astaxanthin)
  - Shrimp, crayfish, crab, lobster processing wastes (20% inclusion level in diet)
  - *Phyaffia* yeast (astaxanthin)

CAROTENOIDS

- Synthetic canthaxanthan
  - Carophyll – red (Hoffman-LaRoche)
  - Lucanthin – red (BASF)



can be added at 0.05% of the diet to give a dietary canthaxanthin level of 50 mg/kg of diet.

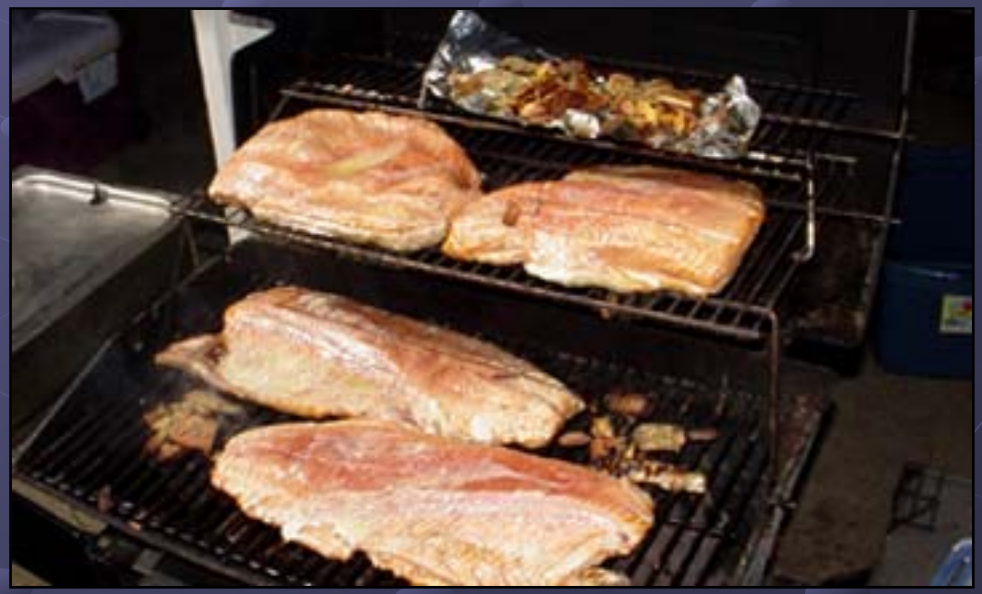
CAROTENOIDS

- Synthetic astaxanthin
  - Carophyll – pink (Hoffman-LaRoche)
  - Lucanthin – pink (BASF)

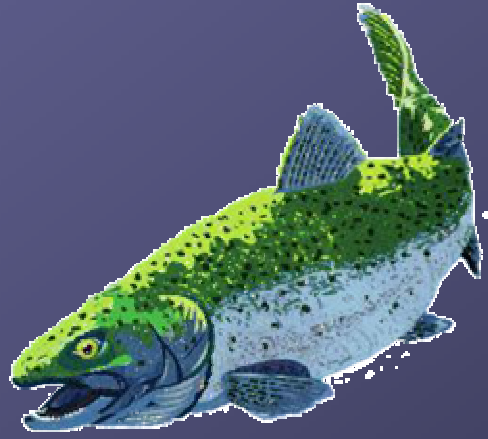
are the most-widely used, manufactured pigment. Add at 0.05% of the diet to give 45 mg/kg of diet of astaxanthin.

CAROTENOIDS

- Natural sources of carotenoids are desirable in salmon production for markets demanding a natural food product.



INGREDIENTS



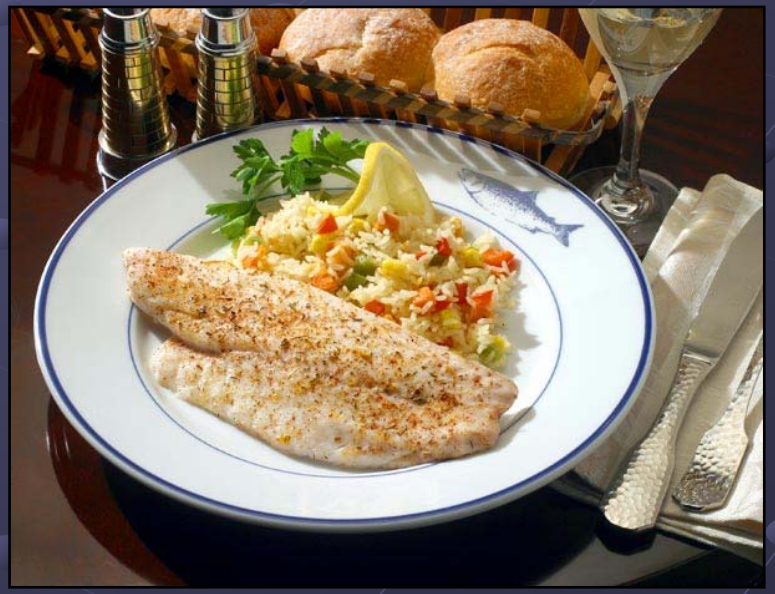
- Poultry by-product meal
- Hempseed meal
- Canola meal
- DDGS
- BGY
- Fish meal
- SBM
- Wheat
- Corn
- Milo

INGREDIENTS

- Generally have little effect on quality, but can influence consumer preference
  - Corn gluten meal with catfish fillets (yellow)
  - DGS does not affect organoleptic in catfish
  - Red claw with BGY (no effect)
  - FM can affect flavor (catfish)

INGREDIENTS

- Bett et al. (1998) reported that level of FM affected organoleptic evaluation in sunshine bass. Fish fed diets with higher levels of FM had fillets that had a higher "fishy" flavor.
  - No other flavors were affected.



INGREDIENTS

- Tidwell et al. (1993) used DDGS in freshwater prawn diets. 0, 20, and 40% DDGS inclusion in isonitrogenous prawn diets did not affect growth or tail composition (% protein and % lipid) after 101-day culture in ponds. No differences in organoleptic evaluation among treatments.

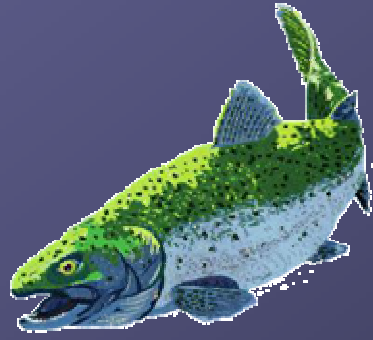
INGREDIENTS

- Muzinic et al. (2004) reported no differences in % protein or % lipid of whole-body Australian red claw fed diets containing various percentages of BGY and SBM, partially or totally replacing FM.
  - Further, they reported that only minimal differences in amino acid composition of tail-muscle of red claw fed the various diets.

MEDICINAL FOODS

- Some researchers have examined adding lipids (HUFAs) or compounds (gossypol) into aquaculture diets so that they could be incorporated into fish muscle. When consumed, these compounds could positively affect human health.

MEDICINAL FOODS



1. Gossypol – potential anti-cancer compound
2. HUFAs – could possibly alleviate clinical depression

Uncertain if this is best use of fish products; may be better to “make a pill.”

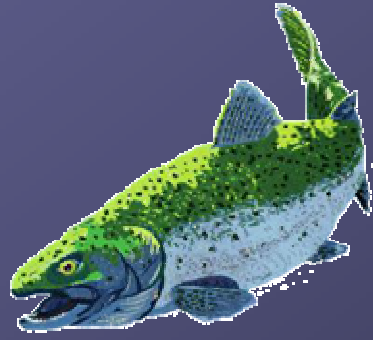
FOOD SAFETY

- FM is biggest culprit for contaminants. Some regions of the world are more polluted than others. So, you can get different contaminant levels in ingredients based on the origin of the ingredient.

FOOD SAFETY

- Diet ingredients can add contaminants (PCBs, dioxins, etc.) to the organism. Ideally, ingredients free from contaminants should be used to make aquaculture diets. Remove FM and you will have less contaminants in the end-product.

FOOD SAFETY

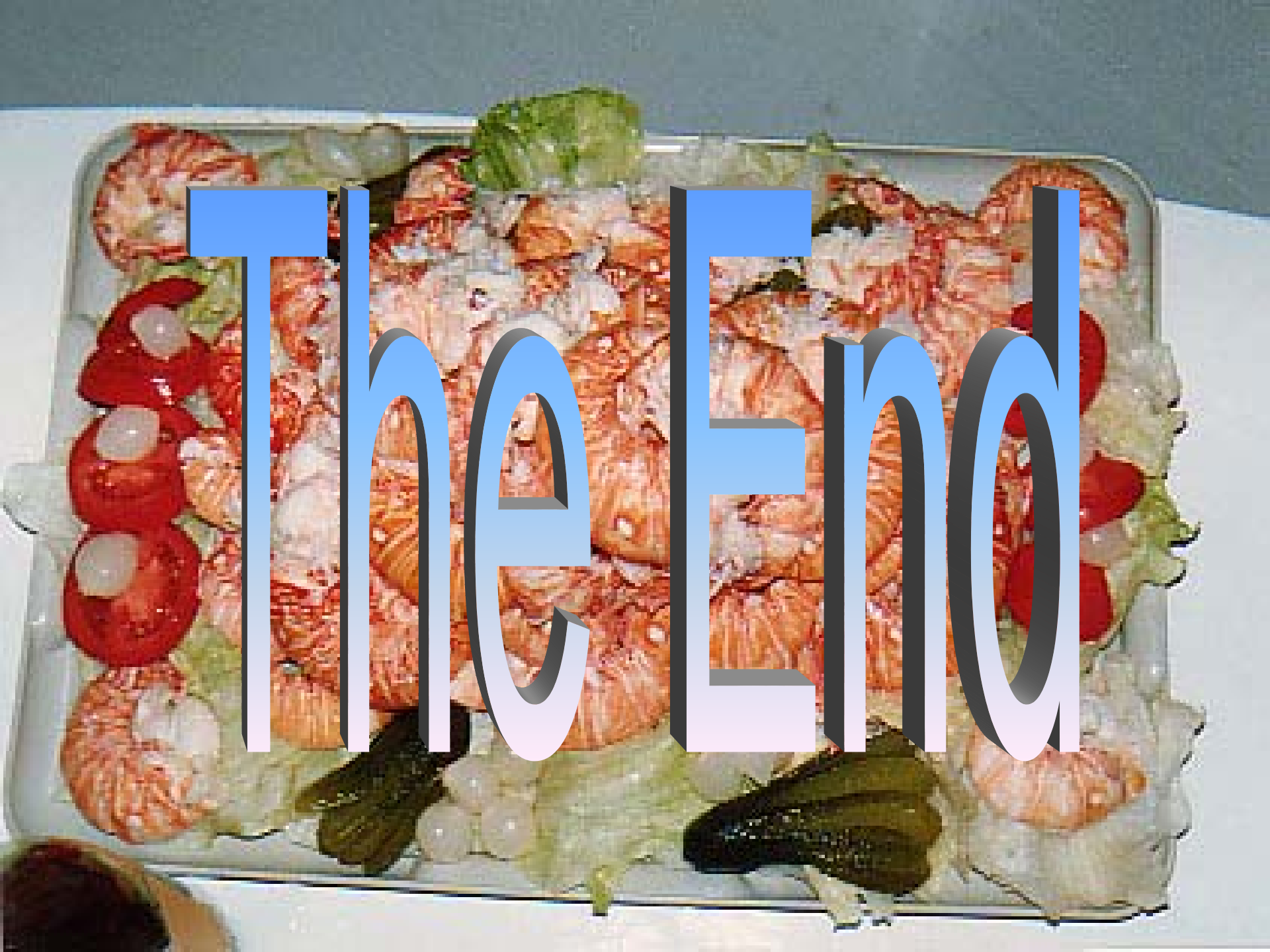


- **PCB (polychlorinated biphenyls) levels in food**

Food	PCB level (ppb)
Fried chicken	9
Beef	22
Salmon fillet	26
Tuna (in oil)	45
Butter	70

FOOD SAFETY

- NOTE: However, all cultured products from the US – no matter the source or level of FM – are extremely healthy and are virtually free of contaminants.
  - PCB level is still 80X less than harmful levels set by the FDA.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