Some Common Myths Associated with Food Debunked

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Key messages

- Seafood from aquaculture (fish farming) is neither more dangerous than wild-caught species nor less ecologically sustainable.
- Pasteurization does not make milk and dairy products less nutritious, nor does it make them dangerous to consume, causing lactose intolerance and allergic reactions.
- Consumption of wheat and wheat products is not dangerous and does not lead to a multitude of illnesses in many consumers.
- Processed foods in general are not less nutritious than non-processed foods, and the vast majority of food-borne illnesses are not caused by/found in processed foods.

Evolving food myths and evolving science

Food myths are common and sometimes entertaining. It was probably your mother who told you not to believe everything you read. Food myths are often as ridiculous as "urban myths" – sometimes partially true, and sometimes even dangerous! The following are four common myths that have been popular in recent years and which we here attempt to debunk with solid scientific evidence taken from current literature.

Having said this with tongue in cheek, we all know of food-related truisms that have changed because the science has taken a closer look in search of the unadulterated truth. For example, we once believed that animal fats (butter, lard, tallow, etc.) were less healthy than vegetable fats (oils manufactured from canola, soy, corn, sunflower, etc.). We now know that for heart health, the total amount of fat in the diet is far more important than the type of fat – but for at least one exception: fish oil.

The following examples are provided in the light of the most recent scientific knowledge available, but that isn't to say that things won't change with time!

Four common food myths

1. *Seafood from aquaculture (fish farming) is more dangerous than wild-caught species and less ecologically sustainable; farmed fish in particular contain dangerously high levels of aquaculture drugs, heavy metals, polychlorinated biphenyls (PCBs), and dioxins – all of which are hazardous to health. Farmed salmon is also to be avoided because it is colored with an artificial dye, making it different from the wild species.*

With a growing world population, the demand for protein is rapidly increasing. In developing coastal countries, this often translates into demand for seafood, and this demand cannot be met with traditional wild catch fishery. The sustainable world landings of wild fish have reached their maximum levels,[1] and therefore the growth in aquaculture has increased exponentially to meet the requirement for high-quality seafood protein at a reasonable price. In 2012, approximately 50% of the world seafood requirement was met by aquaculture; this proportion is expected to grow to 62% by the year 2030.[1] Nevertheless, aquaculture has been criticized for a variety of reasons, many of which are grounded in myth.

> "The major health hazards related to seafood consumption in general lie with the ingestion of *raw* fish or shellfish"

The major health hazards related to seafood consumption in general lie with the ingestion of raw fish or shellfish; the predominant hazards are biological in nature (bacteria, viruses and parasites),[2] although marine biotoxins most commonly associated with molluscan shellfish are considered to be chemical hazards and are generated in the food chain by marine algae. The problem of raw fish consumption can be overcome by cooking insofar as bacterial and viral contamination are concerned, although aseptic handling of landed fish and subsequent refrigeration can be valuable tools for lowering the microbial load. The advantages of aquaculture fish in this regard include the following:

- The proximity of the processing facility to the fish farm, enabling the fish to be harvested and processed within one day and permitting the continuous maintenance of the "cold chain" from farm to fork. This is difficult to accomplish aboard a fishing vessel which is often at sea for days or weeks. Moreover, commercial harvesting of wild stocks is often damaging to the catch (trawling with nets, long lining, gill netting) or to the environment (dragging the ocean floor for shellfish).
- Parasites are found sporadically in wild-caught seafood, but are rare in aquaculture species, since these fish are grown in a water column, confined by the walls of the net cages and unable to access parasites from mammalian hosts found in fecal material only on the ocean floor.[2,3] Consumption of raw fish in sushi, ceviche or marinated finfish is considered hazardous unless aquaculture fish is used in the preparation or if wild fish are frozen prior to consumption. Salting or marination in vinegar or lemon juice have been shown to be an ineffective or unreliable means of destroying fish parasites.[2]
- Marine biotoxins are rarely found in cultured finfish, although cultured mussels have on occasion been contaminated with marine biotoxins such as paralytic shellfish toxins, amnesic shellfish toxin, etc.[4] The risks associated with the potentially deadly foodborne intoxications in both wild and cultured shellfish are principally mitigated through surveillance programs (gathering samples and testing for the presence of toxins by regulatory personnel). The geographic distribution of toxic algal blooms may be widespread, thereby making it difficult to collect representative samples of contaminated shellfish or seawater. Sampling aquaculture shellfish farms on a regular basis is common, particularly in regions with a history of contamination, thus permitting regulatory agencies to quarantine harvests should the need arise.

The question of the ecological sustainability of fish farming is perhaps best addressed by examining the feed conversion ratios for common farmed agricultural and aquaculture species. The current feed conversion ratios are much higher in farmed salmon than in wild salmon, swine, poultry or beef. Globally, aquaculture uses about half a metric ton of wild whole fish as feed to produce one metric ton of farmed seafood, meaning that aquaculture is a more efficient means of converting plant protein into animal protein.[5] As research progresses, plant-based proteins and fats are gradually being substituted for the fish meal and oils traditionally found in aquaculture feeds, making farmed fish more affordable and even more efficient to produce.

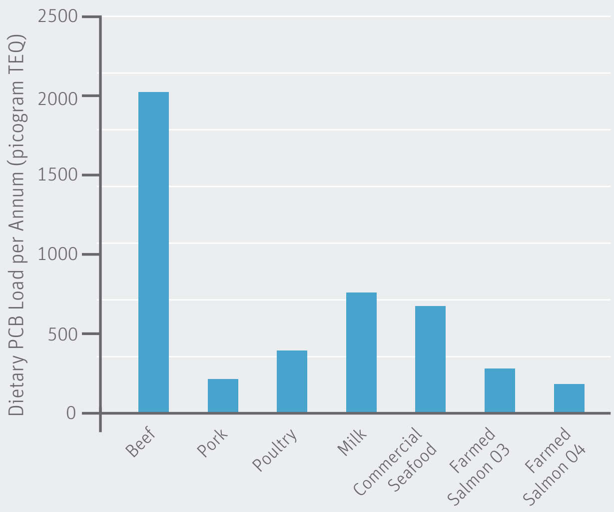
In recent years, it has been suggested that farmed salmon contains high levels of polychlorinated biphenyls (PCBs), dioxins, and heavy metals such as mercury,[6] and furthermore, it has been suggested that farmed salmon flesh is tainted with artificial dyes to give a more desirable pink hue.

PCBs and dioxins are man-made environmental pollutants now banned in many jurisdictions, as they are potential carcinogens; mercury found naturally in the environment is known to cause neurological damage.

Although it is true that some fish contain high levels of heavy metals such as mercury, cadmium and lead, there are no farmed fish on the US FDA list of "species to avoid."[7] Since heavy metals are subject to the phenomenon of "biological magnification," only the largest specimens of carnivorous species are listed as foods to avoid or consume infrequently. These include for example, large tuna, swordfish, marlin and shark,[8] but do not include most canned tuna; much of the canned tuna products are prepared from smaller species such as yellowfin and skipjack. Smaller species such as salmon (canned or other), groundfish species such as cod, haddock, or flatfish species such as sole tend to have very low heavy metal contents.

Farmed Atlantic salmon is particularly high in fat (as compared to wild salmon), rich in omega-3 fatty acids that have been proven to maintain healthy heart function, and is recommended for pregnant women, since omega-3s play an important role in fetal brain and eye development.[9] The health benefits of dietary omega-3 fatty acids are proportional to the amount of fish fat consumed (see below). Therefore, consumption of farmed salmon is more "heart-healthy" than consumption of wild salmon; and herring and mackerel are more "heart-healthy" than demersal (groundfish) species that contain only negligible levels of fat.[9]

FIGURE 1: Annual *per capita* load of dietary PCBs



Data taken from Environmental Working Group Report, 2003[5]

In all but a few cases, the research found that the health benefits of consuming seafood far outweighed the relatively small risks associated with mercury consumption.[9,10,11] Figure 1 illustrates the dietary load of PCBs derived from various types of food with data re-plotted from a 2003 US Environmental Working Group study[6] claiming that levels of PCBs ingested via the consumption of aquaculture salmon could be up to 40 times as high as other foods, making farmed salmon dangerous to consumer health. However, when the levels are adjusted for the relative levels of consumption of the individual foods, the picture becomes clearer (Figure 1). In fact, based on the 2003 consumption data,[6] the PCB load derived from beef, poultry and milk was far greater than that derived from aquaculture salmon.

> "The research found that the health benefits of consuming seafood far outweighed the relatively small risks associated with mercury consumption"

In addition to the health benefits associated with farmed salmon as a rich source of omega-3 fatty acids, recent research evidence also suggests that there may be anti-diabetic benefits associated with Atlantic salmon proteins.[12] This is significant insofar as type 2 diabetes is the fastest-growing chronic disease in North America. Other recent work has shown that farmed Atlantic salmon peptides are also antihypertensive[13] as well as having antioxidative properties.[14]

The issue of artificial pigments in aquaculture salmon has also become a concern in recent years. Wild salmon, trout and char (*salmonids*) derive their natural pink color from the food they eat (crustaceans, which in turn derive their pigment from aquatic vegetation). The principal natural pigment astaxanthin[15] is the same pigment used in aquaculture feeds to achieve the same natural color found in wild salmon (Figure 2). The only difference is that commercial astaxanthin is manufactured rather than being extracted from shrimp shells or marine algae. The so-called bogus colorant (astaxanthin) is chemically identical to the pigment found in nature. Thus, the use of "artificial" pigment in salmon feed is no more dangerous or unethical than taking vitamin C tablets purchased at the local pharmacy, rather than eating oranges.

Finally, there has been a recent concern over the indiscriminant use of antibiotics and parasiticides in farmed fish husbandry. The concern over antibiotics is the same made for the use of antibiotics in agricultural livestock, such as the use of β-lactam antibiotics including penicillin as a growth promoter in poultry and swine. Antimicrobials are also sometimes used in aquaculture, but not for growth promotion.[16] The food safety issue is the possible development of antibiotic resistance in human bacterial pathogens due to trace levels of these drugs perhaps contaminating the food supply.[16] A second concern is that many individuals are allergic to antibiotics and can experience adverse reactions to contaminated foods.[17]

FIGURE 2: Measurement of redness in farmed Atlantic salmon using a reflectance colorimeter to monitor astaxanthin content in the flesh. Astaxanthin is added to aquaculture feeds and is the same pigment found in wild salmon species.

TABLE 1: Classes of chemical compounds used in Atlantic salmon aquaculture (Burridge et al, 2007).[17]

Country	Salmon production (tonnes)	Therapeutic type	kg used*	kg used | tonne
Norway	821,997	Antibiotics	649	0.0008
		Anti-louse	132	0.00016
Chile	300,791	Antibiotics	385,600	1.17
		Anti-louse	600.1	0.0018
UK	132,528	Antibiotics	1553	0.0117
		Anti-louse	194.8	0.0015
Canada	121,370	Antibiotics	21,330	0.175
		Anti-louse	19.8	0.00016

*Data represent kg used per kg finished product.

Table 1 shows the relatively small amounts of antibiotics and parasiticides currently being used in the aquaculture industry in relation to the volume of finished seafood produced.[17] The therapeutic amounts used in aquaculture are far less than the levels used in agriculture, the latter sometimes used non-therapeutically. It has been estimated that approximately 80% of all antibiotic use in the US is directed to therapeutic and non-therapeutic (growth promotion) uses in farm animals. There are currently no known advantages in the inclusion of antibiotics at sub-therapeutic levels in fish feed.

The sporadic presence of "sea lice" on farmed salmon continues to be a problem.[17] Sea lice are members of the copepod family and are ectoparasites, attacking the external surfaces of farmed salmon. Because sea lice become immune if the same type of chemical is repeatedly used at the same sites, avoidance of overcrowding, fallowing, removal of dead and sick fish, and prevention of net fouling are examples of good husbandry and effective in reducing parasite levels without the use of chemicals. Although most of the parasiticides present an ecological risk, they are not considered to be of immediate concern to human health. Antibiotics have largely been replaced by vaccines to treat microbial diseases in farmed fish, and are considered to be more efficacious in the treatment of disease.

2. *Some believe that pasteurization changes the chemistry of the milk and dairy products in some way, making them dangerous to consume, causing lactose intolerance and allergic reactions, destroying their nutritional value and therefore making them less wholesome and healthy than raw milk and products.*

The process of food pasteurization dates back to Louis Pasteur (1822–1895), the founder of modern microbiology, who was responsible for the "germ theory of disease" and discovered that the spoilage of beverages such as wine, beer and milk was caused by tiny microorganisms. The process he discovered bears his name, i.e., pasteurization.

However, the first planned heat treatment of foods for the purpose of preservation is credited to Nicholas Appert (1749–1841), a French confectioner who began working on an idea to preserve containerized food by heating in 1795. By 1810, Appert had perfected a process for a number of foods using heat, and won a prize of 12,000 francs for his invention from the Emperor Napoleon.

Today a number of foods and beverages are heat-processed to ensure the destruction of foodborne microorganisms. Pasteurization of milk is based on heating for specific time-temperature combinations to destroy *Coxiella burnetii*, the most heat-resistant bacterium associated with raw milk and the causative organism of Q fever. Pasteurization also destroys a wide variety of pathogenic organisms including enterotoxigenic *Staphylococcus aureus*, *Campylobacter jejuni, Salmonella species, E. coli, Listeria monocytogenes, Mycobacterium tuberculosis, Mycobacterium bovis, Brucella species* and *Yersinia enterocolitica.*

"Pasteurization does *not* alter the nutritional value of raw milk, nor does it change the proteins in any way to make them more allergenic"

The shelf life of pasteurized milk is far greater than that of raw milk, although not nearly as long as commercially sterilized (canned) food. The latter process is designed to destroy the much more heat-resistant spore-forming bacteria that are only able to grow in the absence of air and in low-acid foods such as canned meats, fish and most vegetables. Pasteurization kills harmful organisms responsible for such foodborne diseases as listeriosis, typhoid fever, tuberculosis, diphtheria, and brucellosis.[20,21] Pasteurization does *not* alter the nutritional value of raw milk, nor does it change the proteins in any way to make them more allergenic.[20] The phenomenon of lactose intolerance is related to the milk sugar lactose that is present at the same levels in both raw and pasteurized milk. Thus pasteurized milk is neither more nor less likely to cause lactose intolerance than raw, unheated milk.

North American consumers are 160 times more likely to contract listeriosis from cheeses made with unpasteurized milk as compared to its pasteurized counterpart, as shown in a recent quantitative risk assessment study published jointly by Health Canada and the US Food & Drug Administration.[20] In Canada, although cheese production is permitted with unpasteurized milk, such cheeses must be aged for a period of ≥ 60 days. The sale of unpasteurized raw milk for human consumption is illegal in many jurisdictions, including all Canadian provinces. Health Canada and the US Food & Drug Administration discourage consumption of soft cheeses produced from unpasteurized milk, particularly in pregnant women, the very old, the very young, and individuals with compromised immune systems. As an added note, unpasteurized raw "organic" milk is as dangerous to consume as non-organic dairy products.

3. *Consumption of wheat and wheat products is dangerous and can lead to a multitude of illnesses in many consumers because wheat contains a toxic substance called gluten.*

Gluten is a protein that occurs naturally and is actually composed of two individual proteins, glutenin and gliadin, which form a complex during the bread-making process. It is gluten that gives bread its three-dimensional structure, providing elasticity to the loaf of leavened bread. During the leavening process, the baker's yeast produces carbon dioxide that becomes trapped in the dough upon rising, and it is gluten that forms the structure around the "air pockets." Gluten is found in a number of grains besides wheat, including triticale, barley, rye and oats.[22] Publications about gluten intolerance and gluten sensitivity are often contradictory, but the fact that gluten can cause two independent foodborne maladies is now well accepted.[23]

- Celiac disease: affects an estimated 0.5 to 2% of population.[24]
- Wheat allergy: affects an estimated 0.2 to 0.5% of population.[25]

In addition to gluten, other wheat components have been associated with non-celiac wheat sensitivity, fructose malabsorption and irritable bowel syndrome. Unfortunately, many of the gluten-related illnesses are either undiagnosed or mis-diagnosed.[26]

It should be noted, however, that only a very small proportion of the human population is subject to these wheat-related disorders and that gluten is not always the causative agent; the exact role of other wheat components in the latter three disorders is also unclear.[23] For example, in a double blind study of non-celiac wheat sensitivity, Carroccio et al[26] showed in a placebo-wheat challenge study, approximately 70% of the 900 patients identifying as wheat-sensitive were actually not affected by dietary wheat. Thus, for the vast majority of the population, wheat-related illness is not an issue. It has been suggested that the apparent increase in wheat-related illnesses is due to selective wheat breeding to increase yields. Davis[27] suggested that ancient or heritage varieties have fewer allergens, but the scientific literature does not support this claim. Patients suffering from gluten-related illnesses are advised to avoid all wheat varieties, both heritage and modern.[24] Some researchers have suggested that the apparent increase in wheat-related sensitivities is due to better tools for diagnosis.[24] Still others have suggested that modern wheat-processing technologies tend to expose more immune-reactive epitopes on constituent proteins, making them more likely to stimulate adverse reactions within the digestive tract.[23]

"Only a very small proportion of the human population is subject to these wheat-related disorders, and gluten is not always the causative agent"

4. *Processed foods in general are less nutritious than non-processed foods, often containing ingredients that are either unnecessary or harmful. The vast majority of foodborne illnesses are caused by/found in processed foods.*

We are currently living in the age of the "empowered global consumer". Never before has the consumer been faced with as many choices. Modern, large-scale food production and processing has enabled the consumer to select foods from around the world at reasonable prices. However, the fact that foods are now transported from across the globe has implications for food safety. As a "rule of thumb," the further the distance from the food source, the greater the risk and challenge in keeping the food safe for human consumption.[28]

Food processing has a long history and has been used for thousands of years. The ancient Greeks had three major foods including bread, olive oil and wine. All three involved complicated processing steps to convert the perishable raw materials (wheat, olives and grapes) into shelf-stable finished products that were safe, nutritious and flavorful.[29] The principal aims of food processing are shown in Table 2, along with some examples of the benefits of processing and the technologies that have been developed to provide tangible benefits to the consumer. Processed foods are not necessarily less nutritious than foods prepared in the home. For example, frozen vegetables can be more nutrient-rich than fresh ones because they are picked, blanched and frozen immediately upon picking, when they are at the height of their nutritional value. Many processed foods, such as processed milk products, are fortified with vitamins D and A as required by law in North America, although they are not present in raw, unprocessed milk – the latter being illegal for sale in Canada and several other jurisdictions. The question of the nutritional value of commercially processed foods is complicated because, like foods prepared in the home, processed foods range from being highly nutritious to those with high calorie densities (e.g., pastries and candy) and relatively low nutritional value.

To a certain extent, the adage that "necessity is the mother of invention" is true, and many of the important discoveries in food processing were developed as a result of some impending need. For example, the development of thermal processing as a form of preservation (canned food) came about in the 18th century, when the French Emperor Napoleon needed a means of sustaining his troops on their military campaigns in Europe. The idea that heat could preserve food by destroying bacteria was not known until much later; Appert had no idea why his invention worked.

The development of HACCP (hazard analysis and critical control points) strategies to improve the safety of processed foods world-wide, stemmed from the US Apollo space program and its requirement for the safety of the foods consumed in space travel. Food safety remains an integral component of space travel today, and it was Pillsbury Corporation that landed the contract with NASA to ensure the safety of the foods processed for the Gemini and Apollo programs.[30] The HACCP strategy now widely used worldwide in commercial food production is a proactive process in which foodborne hazards to health are divided into three broad categories: biological hazards (pathogenic microorganisms, parasites and viruses); chemical hazards (pollutants, pesticide residues, heavy metals, drug residues, naturally occurring biotoxins); and physical hazards (metal fragments, glass, small bones). All HACCP-based food protection strategies also require the construction of a plan in which all hazards are identified and preventive measures recorded in a plan for each food product and process for production. In many cases, these strategies involve pre-determined limits for heating/cooling temperatures, holding times, pH values, water activities and redox potentials. In addition, HACCP-certified plants in North America and the EU must comply with sanitary standards for food processing facilities and equipment design.

The food safety issue was developed by a NASA initiative so as to be certain that there was a "zero" probability of foodborne illness on any of the manned space missions. Prior to that time, food processing quality control involved extensive end-product testing, most of which is destructive by nature, and the only way to ensure "zero" tolerance on safety was to test every package of food for hazards before lift-off. A group of researchers consisting of a team from the US Army Laboratories in Natick MA, NASA and Pillsbury Corporation decided to use a proactive approach, strictly controlling the "unit operations" involved in each of the food manufacturing processes, rather than testing final products for safety – the hypothesis being that if all processes are in control, the final products should be safe to eat. This strategy is now an integral part of the food safety strategy world-wide, and is endorsed by the Codex Alimentarius.[31] The Codex Alimentarius or "food code" was established by the United Nations (FAO and the World Health Organization) in 1963 to develop harmonized international food standards which protect consumer health and promote fair practices in food trade. This is not to say that all commercially processed food is safe. However, the HACCP concept is now a global phenomenon used by all countries importing or exporting foods. If systematically applied, the HACCP foods have a remarkable success record for food safety, considering the size of the global food processing industry. In many cases, commercially processed foods offer several advantages over home-processed foods. Convenience and safety are two important features of commercial products.

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Table 2 illustrates some other examples of significant advances in food processing technologies that have contributed to at least one of the five objectives listed by Floros et al.[29]

The myth that foods prepared in the home are generally safer than commercially processed foods is unjustified. According to the US Centers for Disease Control, home-canned vegetables are the most common cause of botulism outbreaks, with 48 out-

TABLE 2: Objectives, nature, specific examples and technologies used in typical food processing operations.

Objectives[29]	Nature of objective	Examples	Technologies
Preservation	Shelf-life extension, reduce waste (spoilage)	Canned food, frozen food, acidified or fermented foods, dried shelf-stable foods, powdered milk or soups	Continuous sterilizers for canned canned foods,[32] vacuum-microwave drying,[33] sous-vide technology,[34] active packaging[35]
Improved quality	Flavor, odor, appearance, nutritional value, etc.	Flash freezing, vitamin fortification, freeze-drying	Quick frozen foods,[36] micro/nano-encapsulation[37]
Safety	Eliminate /control pathogens or other biological, chemical or physical hazards	Pasteurized milk, cured meats, hurdle technologies, freezing to eliminate parasites, metal detectors	Ultra-high temperature (UHT) technology,[38] high pressure processing (HPP),[39] modified atmosphere packaging[40]
Availability	Permit consumers to access foods that are not always available	Not from concentrate orange juice, controlled atmosphere (CA) apples, live shipping of seafood (shrimp, lobster, fish)	CA storage permits year round access to fresh apples,[41] aseptic year-round bulk storage of tomatoes[42]
Sustainability	Processes that permit continued supply of foods with minimum wastage of raw materials or energy inputs	Re-usable or re-cyclable packaging such as glass, plastic, aluminum beverage containers	Active and intelligent packaging[43]
Convenience	User-friendly products that require minimal or no preparation time/effort	Microwaveable products: soups in plastic cans, popcorn; frozen pizza, UHT milk/juice (drink in a box)	Microwave cooking,[44] blanching, thawing etc.
Improved health & wellness	Processes that provide "functional foods" that have health-related benefits other than traditional values	Fortification of everyday foods with vitamins, minerals, enriched fish oils; probiotics, "healthy" bacteria in yogurt	Micro-encapsulation,[45] delivery of nutrients or nutraceuticals.

breaks reported over a 12-year period. Botulism outbreaks are far less common with commercially processed foods, despite the relatively large volume of commercially processed products. These outbreaks often occur because home canners did not follow canning instructions, did not use pressure canners, ignored signs of food spoilage, and were unaware of the risk of botulism from improperly preserving vegetables.[46]

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