FISH FOR HEALTH

Fish for health: improving the nutritional value of fish & shrimp for health & human consumption

Albert G.J. Tacon [1], Daniel Lemos [2] & Rodrigo Carvalho [3]

[1] Aquahana LLC, Kailua, Hawaii 96734, USA

[2] Laboratório de Aquicultura, Departamento de Oceanografia Biológica, Instituto Oceanográfico, Universidade de São Paulo, São Paulo, Brasil

[3] Tecnologia do Pescado e Nutrição, Unidade Acadêmica Esp. Ciências Agrárias, Universidade Federal do Rio Grande do Norte, Natal, Rio Grande do Norte, Brazil.

MALNUTRITION

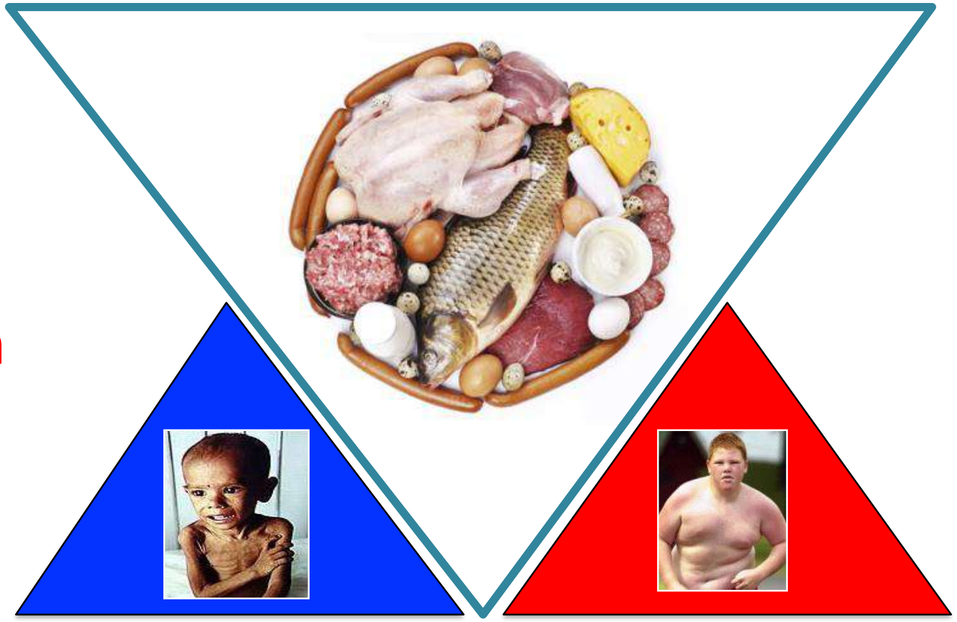
represents

The World's Greatest *Preventable* Health Challenge

The double-burden of Malnutrition

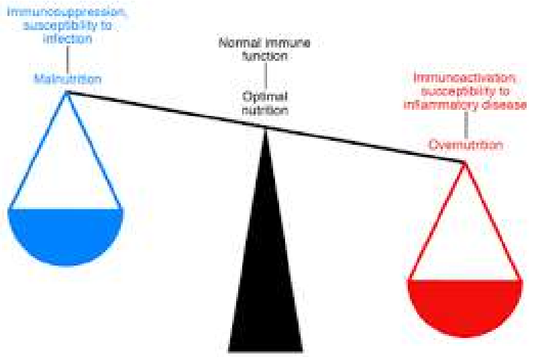
Under-nutrition

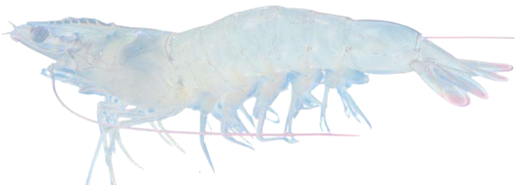
- Wasting
- Stunting
- Underweight
- Vitamin & mineral deficiency



Over-nutrition

- Obesity
- Heart disease
- Hypertension
- Stroke
- Diabetes





Global scale of Malnutrition

CHILDREN

- Stunted - 149.2 million children or 22% of all children
- Wasted - 45.5 million children or 6.7% of all children
- Low birth weight - 20.5 million or 14.6% of all live births

➢ Overweight - 38.9 million children or 5.7% of all children

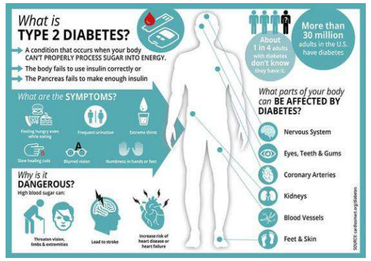
ADULTS

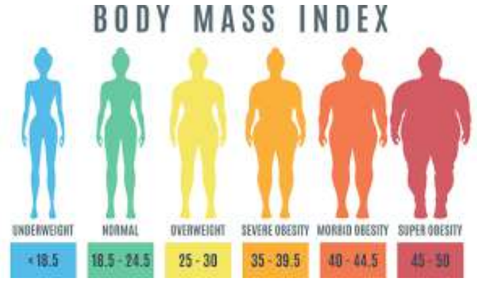
- Underweight – 451.8 million people
- Anemia - 571 million girls and women

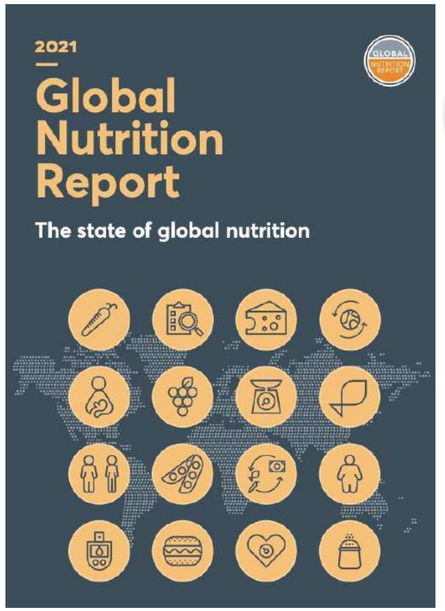
➢ Overweight - 2.2 billion with 772 million affected by obesity

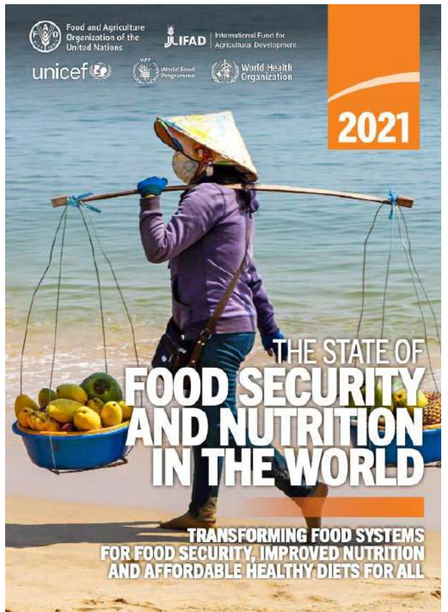
➢ Raised blood pressure – 1.2 billion people

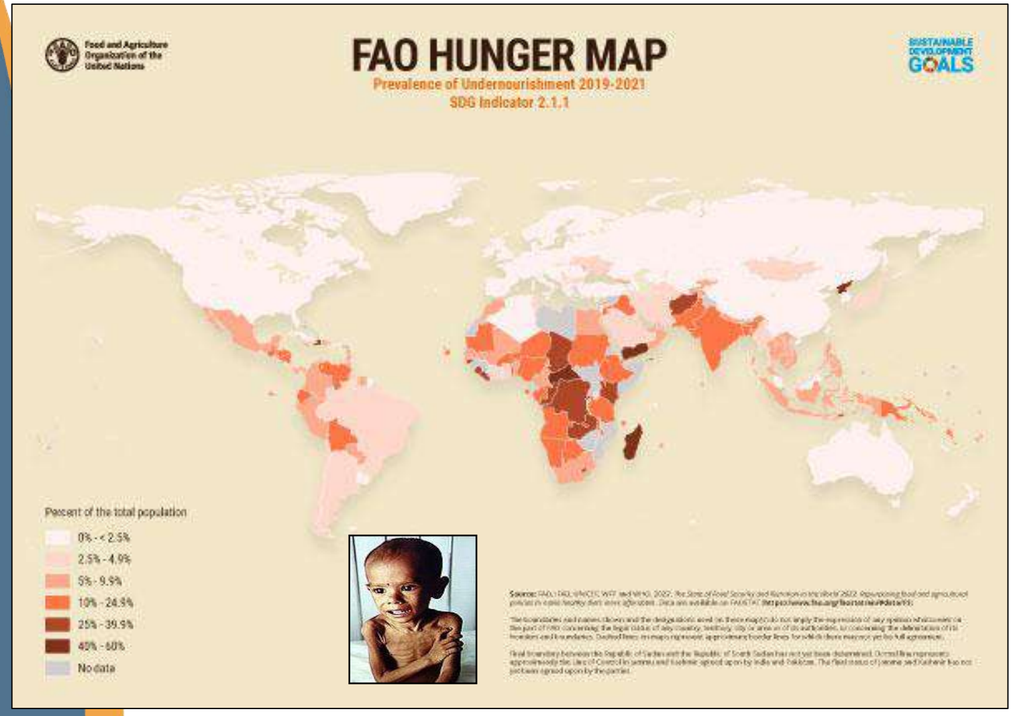
➢ Diabetes – 538.7 million people

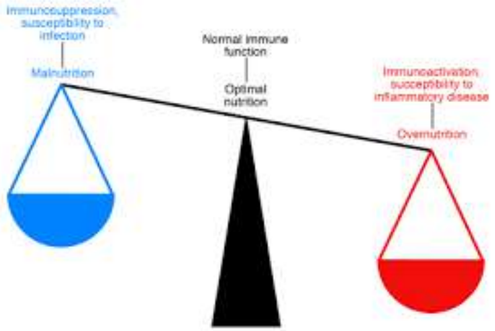


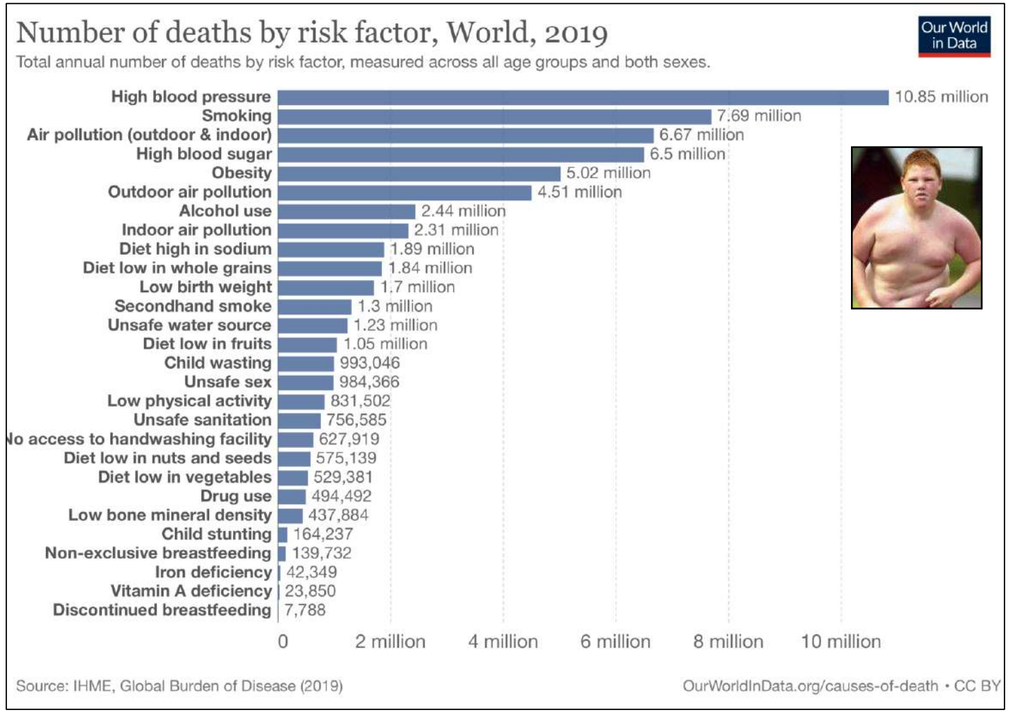


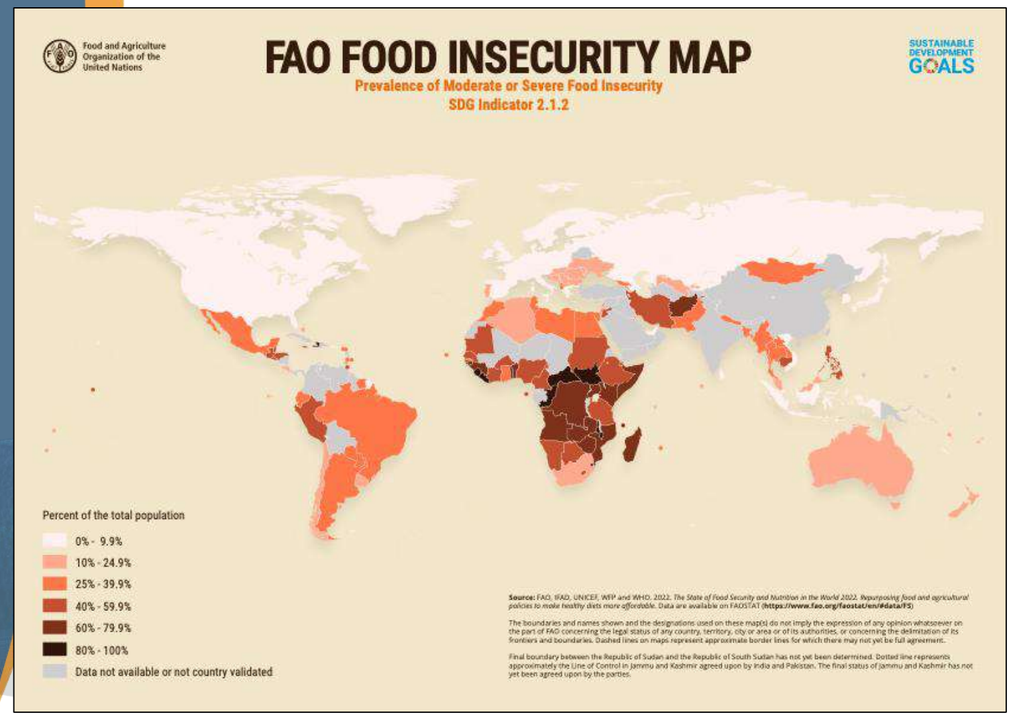


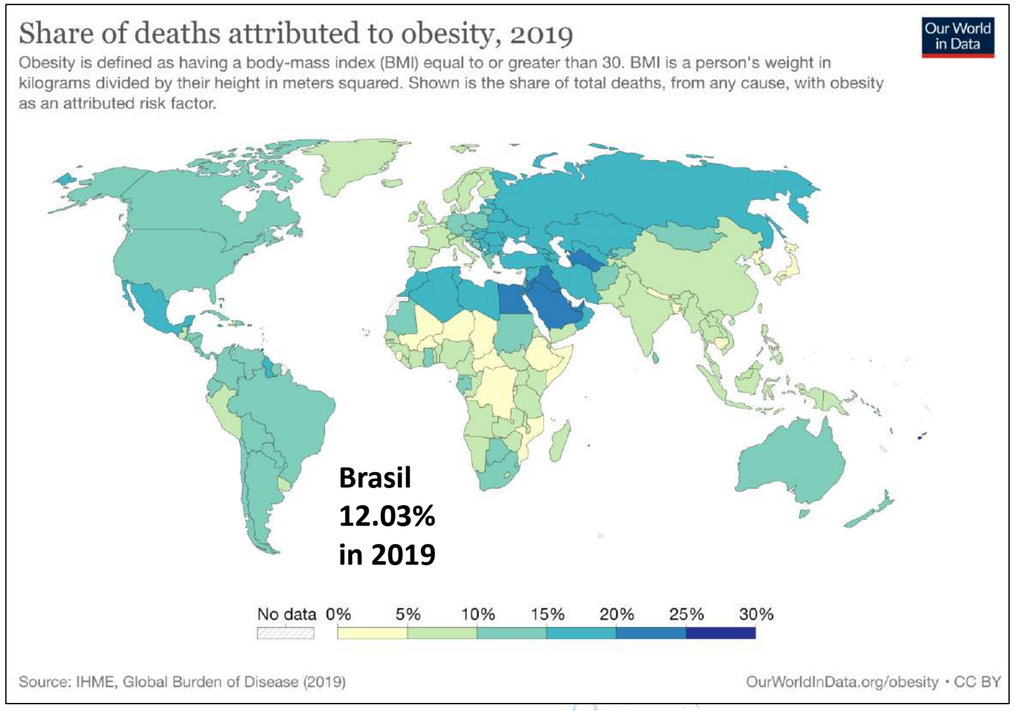


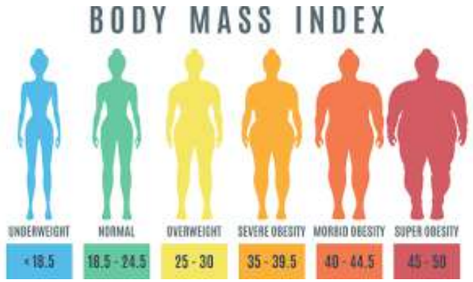

Food and Agriculture Organization of the United Nations
FAO HUNGER MAP
Prevalence of Undernourishment 2019-2021
SDG Indicator 2.1.1
SUSTAINABLE DEVELOPMENT GOALS
Percent of the total population
0% - < 2.5%
2.5% - 4.9%
5% - 9.9%
10% - 24.9%
25% - 39.9%
40% - 60%
No data

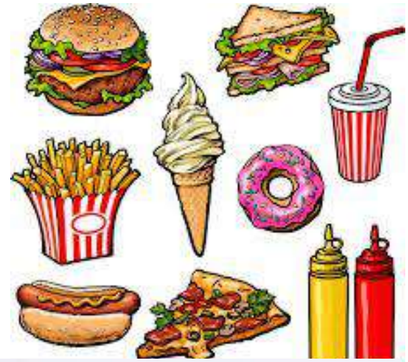

Immunosuppression, susceptibility to infection
Malnutrition
Normal immune function
Optimal nutrition
Immunoactivation, susceptibility to inflammatory disease
Overnutrition


Number of deaths by risk factor, World, 2019
Total annual number of deaths by risk factor, measured across all age groups and both sexes.
Our World in Data
High blood pressure 10.85 million
Smoking 7.69 million
Air pollution (outdoor & indoor) 6.67 million
High blood sugar 6.5 million
Obesity 5.02 million
Outdoor air pollution 4.51 million
Alcohol use 2.44 million
Indoor air pollution 2.31 million
Diet high in sodium 1.89 million
Diet low in whole grains 1.84 million
Low birth weight 1.7 million
Secondhand smoke 1.3 million
Unsafe water source 1.23 million
Diet low in fruits 1.05 million
Child wasting 993,046
Unsafe sex 984,366
Low physical activity 831,502
Unsafe sanitation 756,585
No access to handwashing facility 627,919
Diet low in nuts and seeds 575,139
Diet low in vegetables 529,381
Drug use 494,492
Low bone mineral density 437,884
Child stunting 164,237
Non-exclusive breastfeeding 139,732
Iron deficiency 42,349
Vitamin A deficiency 23,850
Discontinued breastfeeding 7,788
0
2 million
4 million
6 million
8 million
10 million
Source: IHME, Global Burden of Disease (2019)
OurWorldInData.org/causes-of-death • CC BY


Food and Agriculture Organization of the United Nations
FAO FOOD INSECURITY MAP
Prevalence of Moderate or Severe Food Insecurity
SDG Indicator 2.1.2
SUSTAINABLE DEVELOPMENT GOALS
Percent of the total population
0% - 9.9%
10% - 24.9%
25% - 39.9%
40% - 59.9%
60% - 79.9%
80% - 100%
Data not available or not country validated


Share of deaths attributed to obesity, 2019
Obesity is defined as having a body-mass index (BMI) equal to or greater than 30. BMI is a person's weight in kilograms divided by their height in meters squared. Shown is the share of total deaths, from any cause, with obesity as an attributed risk factor.
Our World in Data
Brasil
12.03%
in 2019
No data
0%
5%
10%
15%
20%
25%
30%
Source: IHME, Global Burden of Disease (2019)
OurWorldInData.org/obesity • CC BY





Overnutrition & Obesity

Over past 50 years there has been a rapid increase in over-nutrition and associated ailments;

Including obesity, coronary heart disease, diabetes and hypertension;

Due primarily to the increased consumption of lower cost fast-foods, red meats & dairy produce, together with a less active & sedentary lifestyle

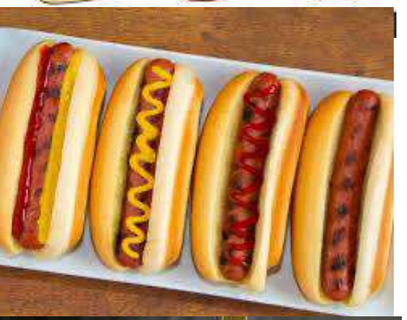
Fast Foods

Include food items that can be prepared & served quickly

- processed red meat products: hot dogs, hamburgers, sausages, bacon, ham, spam, corned beef;
- processed & refined carbohydrates: biscuits, cookies, donuts, pancakes, muffins, crackers, bread, pizza, pasta;
- fried foods: french fries, hash browns, fried chicken, chicken nuggets;
- sugary drinks, sweets, cheeses & ice cream:

The Rise of Fast Foods

- lower cost and affordability
- bigger portion sizes
- taste and accessibility
- increased convenience & ability to purchase on-line

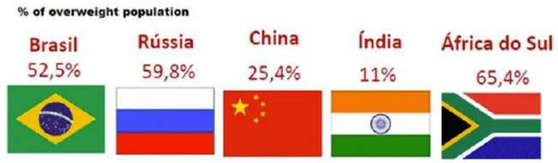


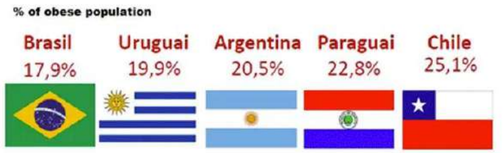
Obesity rates

As % of total adult population (aged 15 years and over), 2015 or nearest year

Note: * means that self-reported height and weight data are used in these countries, while measured data in other countries.
Source: OECD (2017), OECD Health Statistics 2017 (Forthcoming in June 2017).
www.oecd.org/health/obesity-update.htm

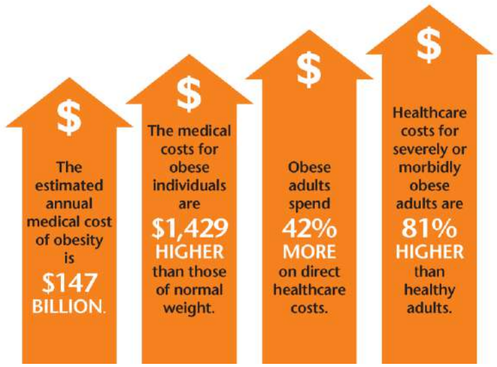
OECD

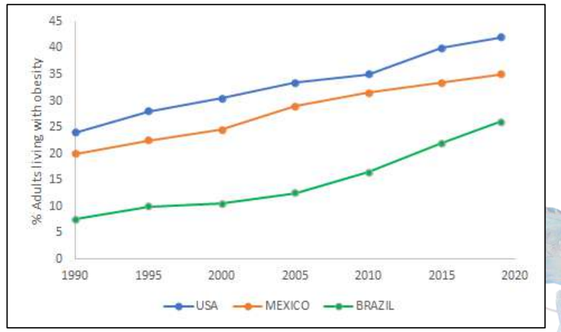




Source: Ministry of Heath Brazil

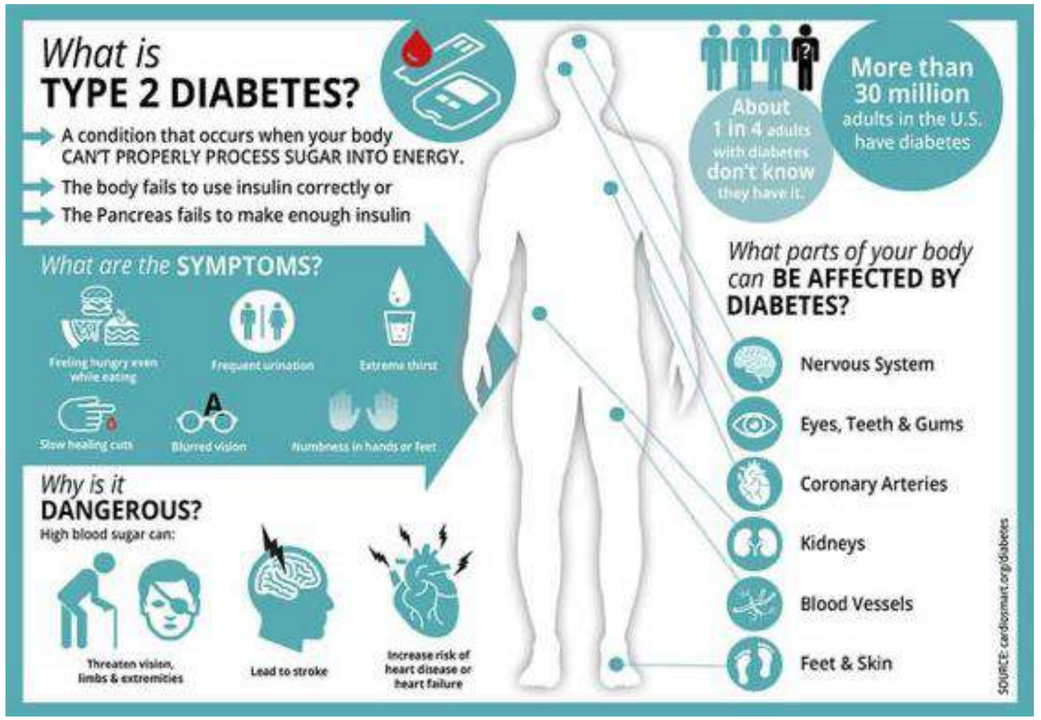
Soaring medical costs associated with treating obesity & associated ailments





Americas – contribution of sugars & sweeteners to total energy supply in 2019

Colombia	601 (20.1%), 2,992 calories
Guatemala	459 (18.0%), 2,556 calories
Costa Rica	500 (16.7%), 2,996calories
Honduras	443 (16.5%), 2,678 calories
Nicaragua	413 (15.8%), 2,620 calories
El Salvador	423 (15.4%), 2,739 calories
USA	591 (15.3%), 3,862 calories
Suriname	423 (15.3%), 2,758 calories
Cuba	505 (15.0%), 3,375 calories
Uruguay	477 (15.0%), 3,209 calories
Chile	442 (14.3%), 3,078 calories
Mexico	426 (13.5%), 3,163 calories
Argentina	433 (13.1%), 3,304 calories
Bolivia	276 (11.2%), 2,464 calories
Canada	407 (11.5%), 3,539 calories
Brazil	405 (12.5%), 3,246 calories
Ecuador	269 (10.5%), 2,563 calories
Peru	217 (7.7%), 2,786 calories



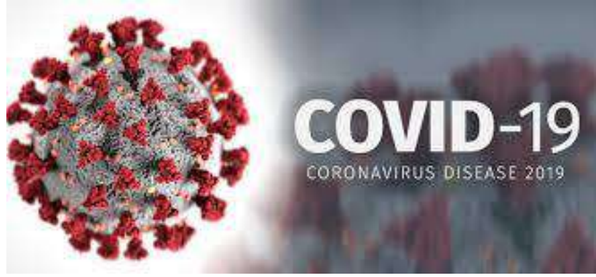
WORLD OBESITY

COVID-19 and Obesity: The 2021 Atlas

The cost of not addressing the global obesity crisis

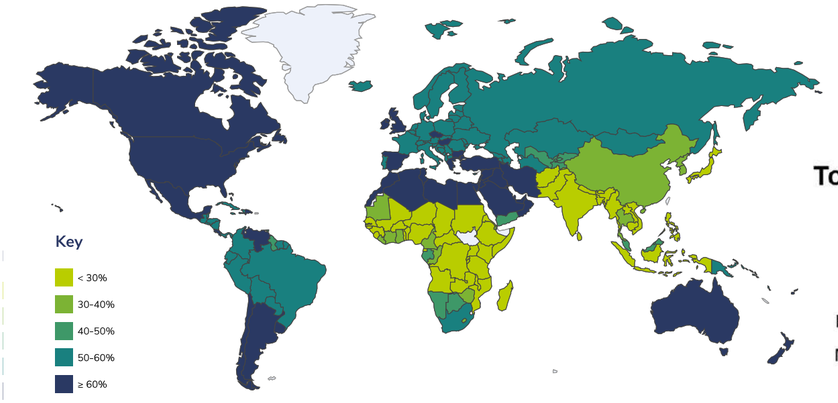
March 2021

www.worldobesity.org

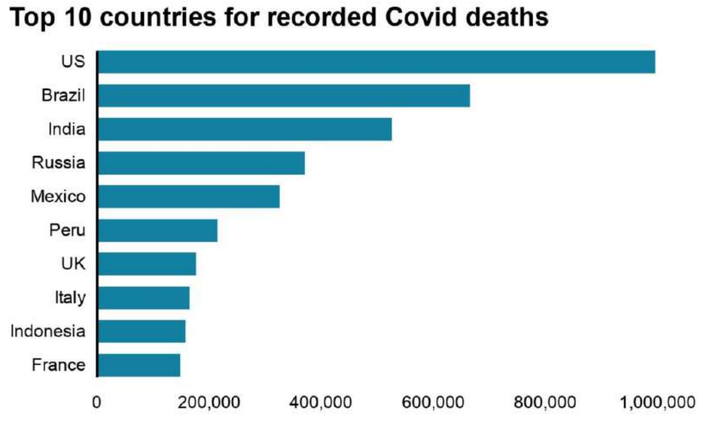


2. Prevalence of overweight in adults

Adult overweight BMI > 25kg/m²



Source: World Health Organization, Global Health Observatory.

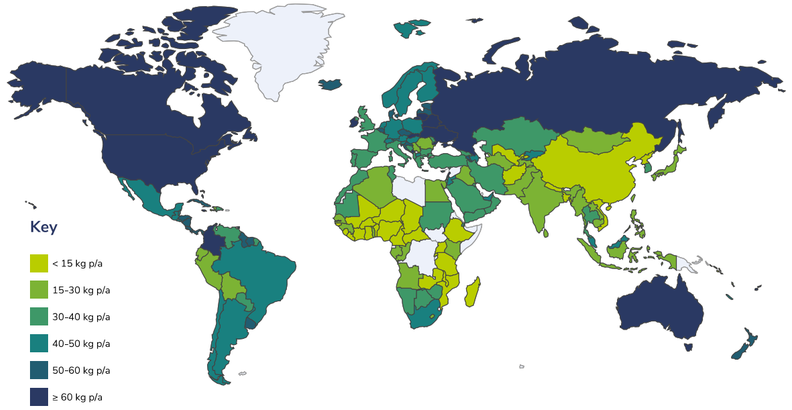


Source: Johns Hopkins University, data as of 4 May

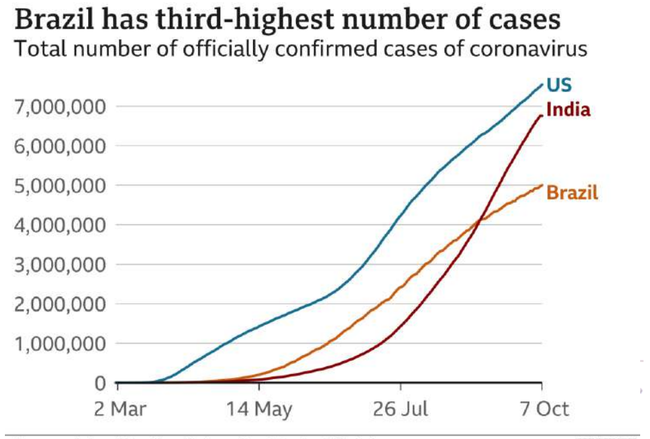
BBC

11. Consumption of sugars

Kilograms per person per year



Source: UN Food and Agriculture Organization, Food Balance Sheets.

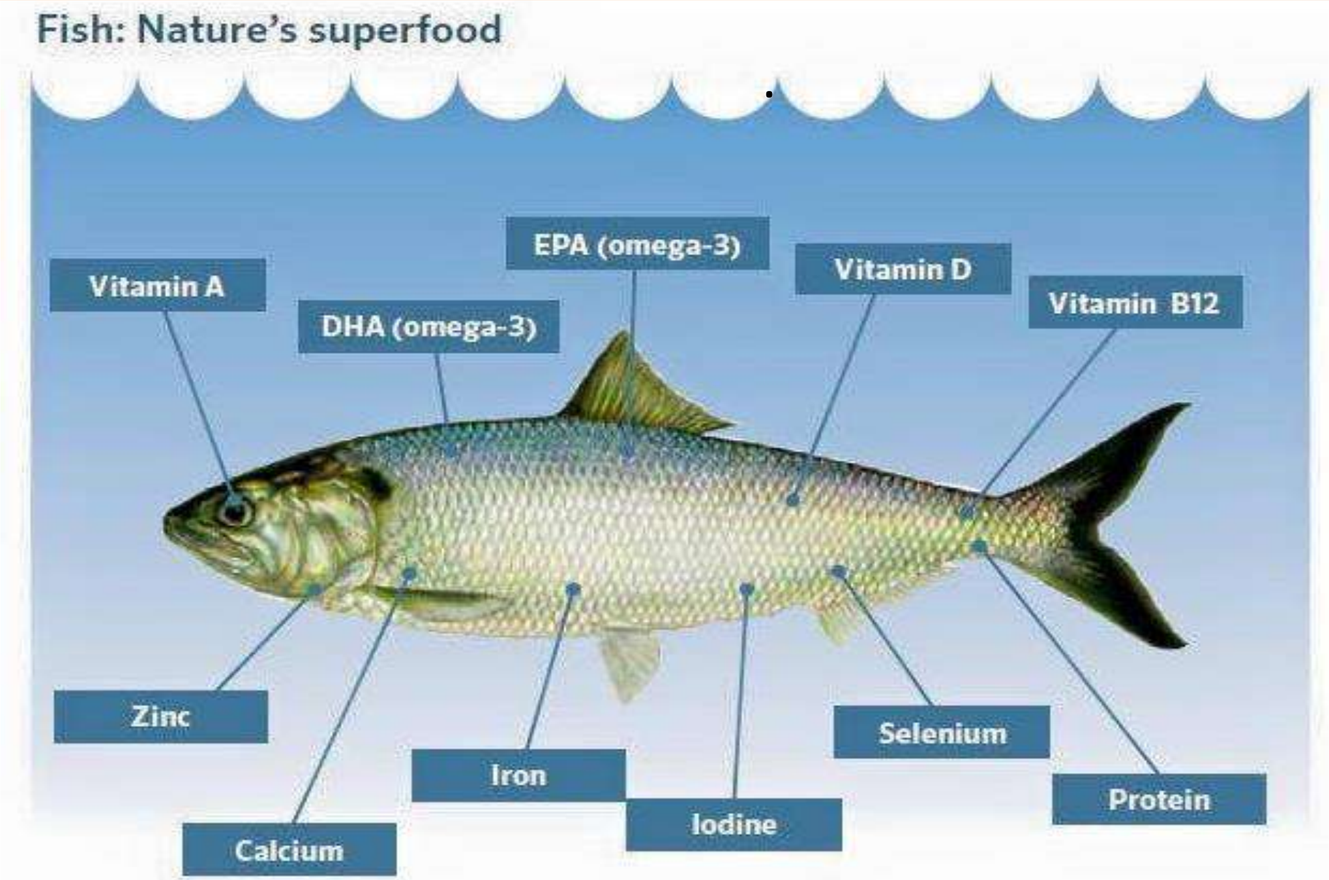


Source: Johns Hopkins University, data to 7 October

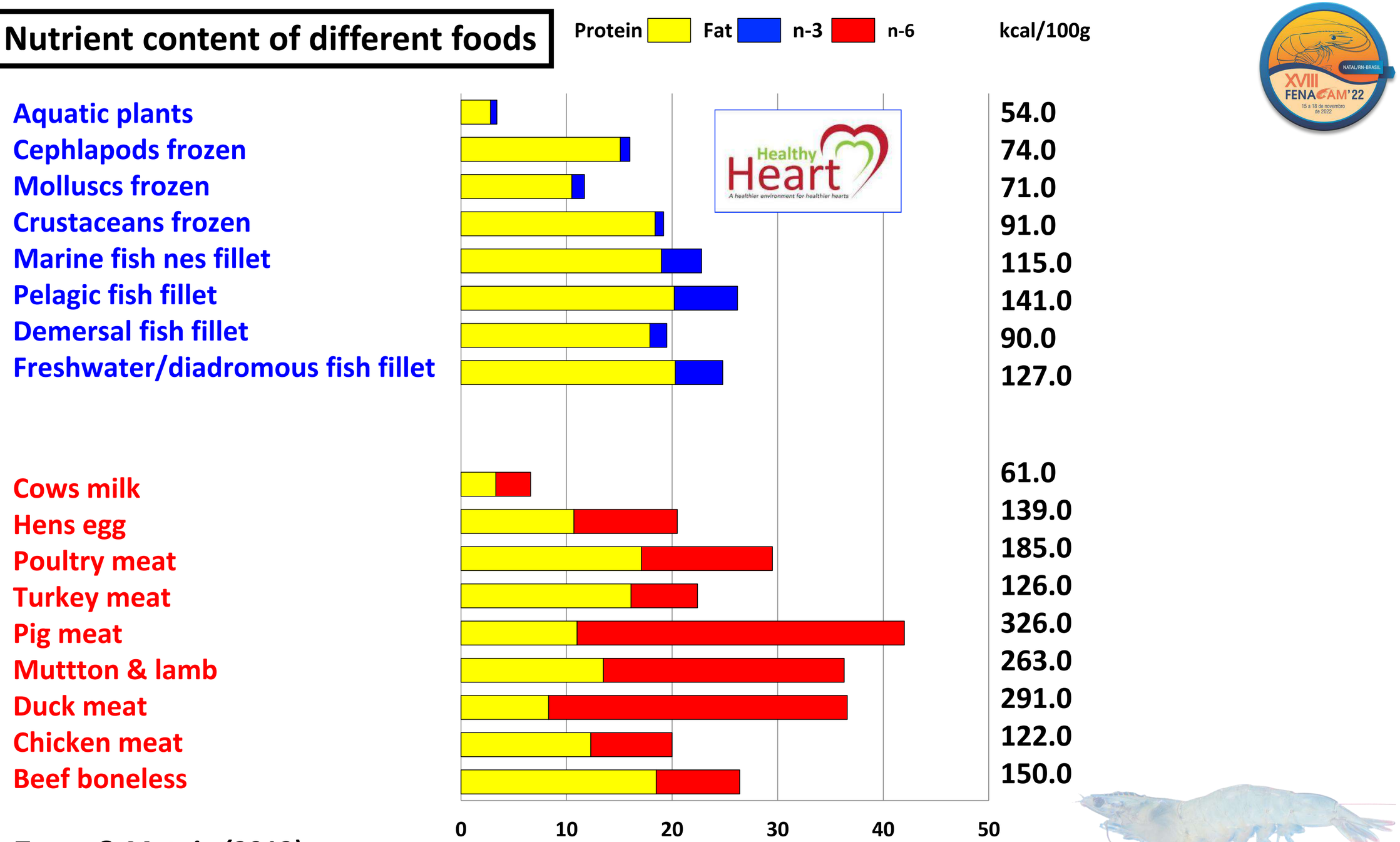
BBC

Global importance of aquatic foods in human nutrition as a much needed healthy food source

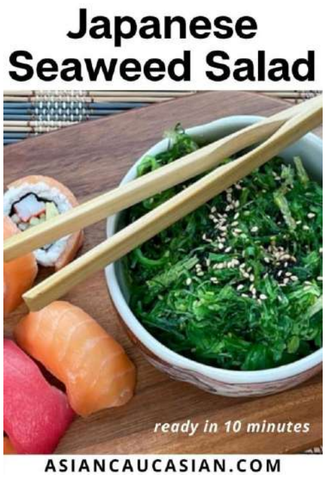
Global importance of aquatic foods in human nutrition as a much needed healthy food source



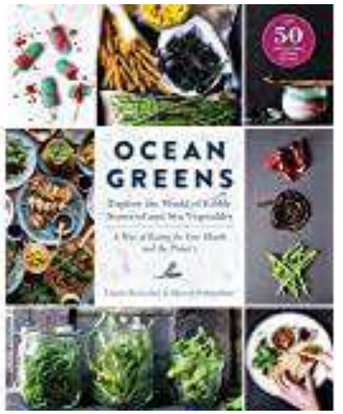
Nutrient content of different foods



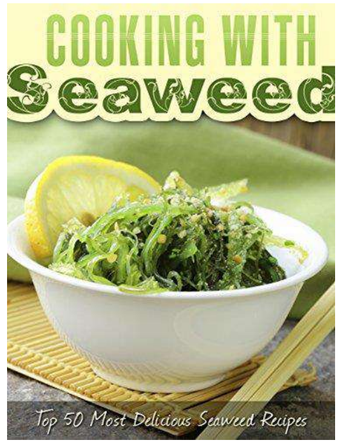
Tacon & Metain (2013)

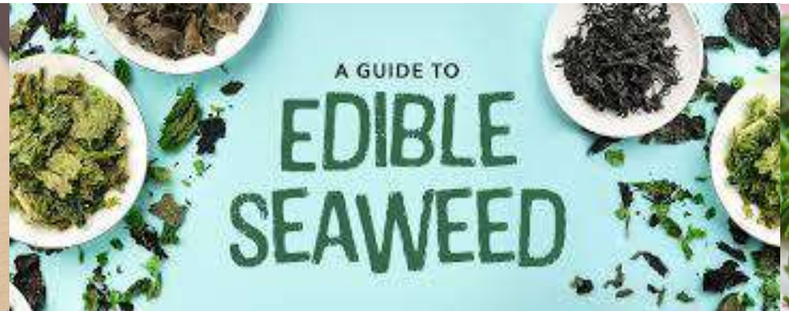


EDIBLE AQUATIC PLANTS OR SEA VEGETABLES



- **Essential amino acids:** red seaweeds > green seaweeds > brown seaweeds; taurine, glutamic acid;
- **Essential fatty acids:** omega-3 PUFA, EPA;
- **Dietary** soluble & insoluble fiber;
- **Essential minerals**: iodine, iron, zinc, copper, magnesium, potassium, calcium);
- **Essential vitamins:** vitamin C, vitamin E, vitamin B_{12}, thiamin, riboflavin, niacin, pyridoxine, inositol & folic acid (MacArtain et al. 2007; Pereira, 2011)





HEALTH ATTRIBUTES OF FISH & SEAFOOD

Reported health benefits of consuming fish & fishery products, including:

- Reduced risk of death from coronary heart disease & stroke (FAO/ WHO, 2011; Forouhi et al. 2018; He 2009; Hellberg et al. 2012; Verbeke et al. 2005; Wallin et al. 2012),
- Reduced risk of diabetes (Wallin et al. 2012),
- Increased duration of gestation & improved visual & cognitive development (Hellberg et al. 2012),
- Improved neurodevelopment in infants & children when fish is consumed before & during pregnancy (FAO/ WHO, 2011), and
- Reduced risk of thyroid cancer in women through seaweed consumption (Michikawa et al. 2012).

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FISH FOR HEALTH

Global importance of aquatic foods in human nutrition as a much needed healthy food source

Reviews in Fisheries Science, 21(1):22-38, 2013
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ISSN: 1064-1262 print / 1547-6553 online
DOI: 10.1080/10641262.2012.753405

Taylor & Francis

Fish Matters: Importance of Aquatic Foods in Human Nutrition and Global Food Supply

ALBERT G. J. TACON[1] and MARC METIAN[2]
[1]Laboratório de Aquicultura (LAM), Instituto Oceanográfico, Universidade de São Paulo, São Paulo, Brasil
[2]Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden

In a world where nearly 30% of humanity is suffering from malnutrition and over 70% of the planet is covered with water, aquatic foods represent an essential component of the global food basket to improve the nutrition, health, and well being of all peoples.

REVIEWS IN FISHERIES SCIENCE & AQUACULTURE
https://doi.org/10.1080/23308249.2022.2124364

Routledge
Taylor & Francis Group

Check for updates

REVIEW

Contribution of Fish and Seafood to Global Food and Feed Supply: An Analysis of the FAO Food Balance Sheet for 2019

Albert G. J. Tacon

Aquahana LLC, Kailua, Hawaii, USA

Fish for Health: Improved Nutritional Quality of Cultured Fish for Human Consumption

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In most Asian & African countries fish represents the cheapest source of animal protein

Table 4. Top aquaculture country producers and capture fisheries landings in 2020 (values given in metric tonnes; FAO 2022c).

Top aquaculture producers	2020	Top capture fisheries landings	2020
China	70,483,538	China	13,445,983
Indonesia	14,845,014	Indonesia	6,989,382
India	8,641,286	Peru	5,675,209
Viet Nam	4,614,692	India	5,522,714
Bangladesh	2,583,866	Russian Federation	5,081,017
Korea Rep	2,327,903	USA	4,253,236
Philippines	2,322,831	Viet Nam	3,421,880
Egypt	1,591,896	Japan	3,215,130
Chile	1,505,486	Norway	2,603,574
Norway	1,490,412	Chile	2,182,768
Total aquaculture production	122,580,187	Total capture fisheries landings	91,420,562

Source: FAO, 2022

Brasil 16th **630,200**

Brasil 27th **709,391 E**

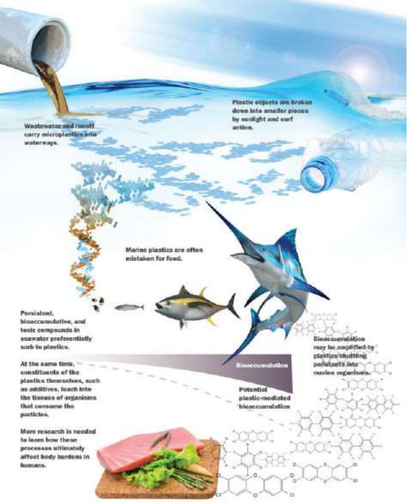


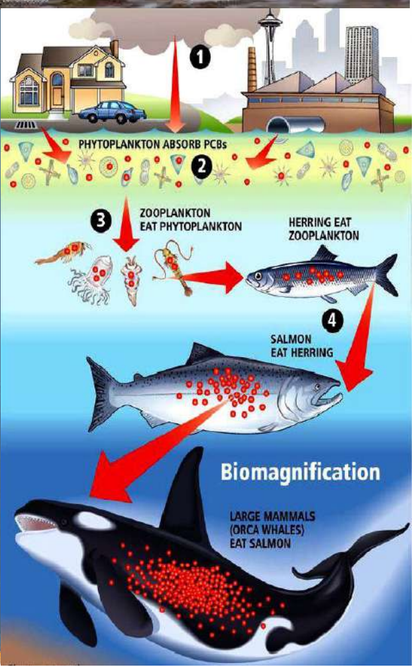



Not all fish are created equal

Nutritional composition & potential health value depends upon:

- Species & part consumed: fillet, whole, head, offal
- Source: wild, farmed, recreational fishery, marine, freshwater
- Country of origin & method of production
- Cooking method prior to consumption
- Nutrient composition of the feed used if farmed

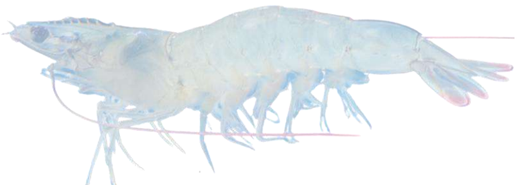




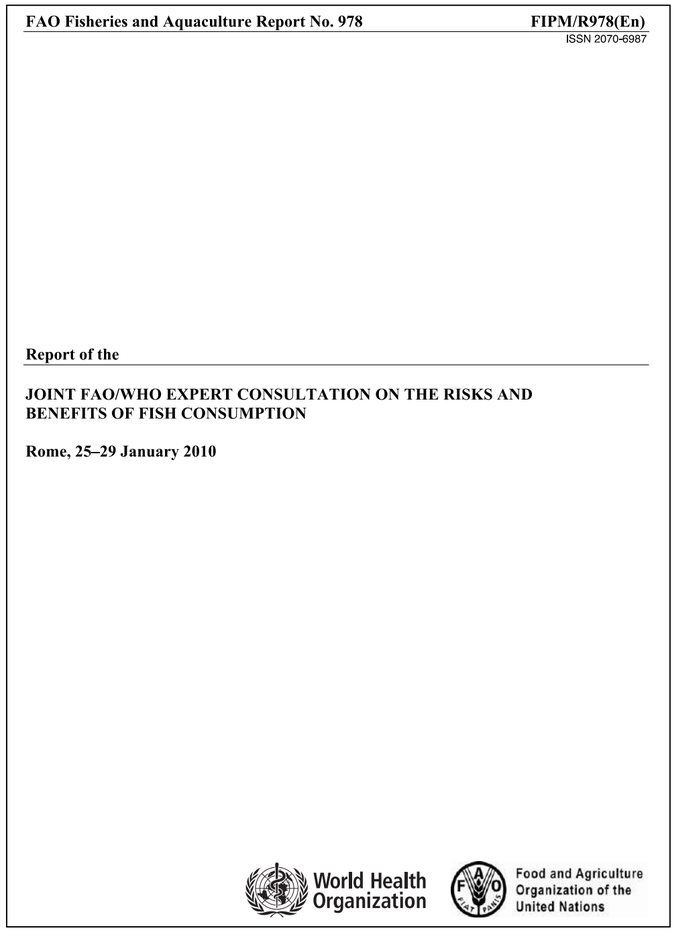
Potential Health risks of fish & seafood consumption

- Risk from the consumption of raw and/or unprocessed fish & seafood contaminated with viable pathogenic organisms, including parasites, nematodes, cestodes, trematodes, bacteria, and toxins (depending on species), these risks can be eliminated through proper cooking & handling (FAO/WHO, 2003; Hellberg et al. 2012).

- Risk from the presence of environmental contaminants (depending upon species & origin), including heavy metals (Hg, Cd, As), persistent organic pollutants (POPs - PCBs, dioxins), veterinary drug residues, and micro-plastics (Berntssen et al. 2010; Domingo et al. 2007; FAO/WHO, 2011; Hellberg et al.., 2012; Tacon & Metian 2008; Verbeke et al. 2005; VKM, 2014).



FISH FOR HEALTH


FAO Fisheries and Aquaculture Report No. 978 FIPM/R978(En)
ISSN 2070-6987

Report of the

JOINT FAO/WHO EXPERT CONSULTATION ON THE RISKS AND BENEFITS OF FISH CONSUMPTION

Rome, 25–29 January 2010

World Health Organization

Food and Agriculture Organization of the United Nations

Notwithstanding the above mentioned risks, it is generally believed that the higher nutritional value and potential health benefits derived from increased fish consumption far out-way the potential negative risks to human health (FAO/WHO, 2003, 2011; VKM, 2014).

BAD NEWS

FISH FOR HEALTH

Contribution of fish to animal protein supply in the Americas - 2019

Bolivia:	2.1%	El Salvador:	7.9%
Argentina:	3.0%	Nicaragua:	8.4%
Honduras:	3.5%	Canada:	9.1%
Brazil:	4.4%	Mexico:	9.5%
Cuba:	4.5%	Panama:	10.4%
Guatemala:	4.5%	Costa Riva:	12.3%
Paraguay:	4.6%	Venezuela:	13.4%
Colomobia:	5.3%	Suriname:	14.6%
Uruguay:	5.5%	Peru:	16.5%
Chile:	7.1%	Guyana:	18.4%
Ecuador:	7.1%		
USA:	7.1%	World	16.5%

FAO, 2022

Contribution of fish & seafood to animal protein supply - 2019

South America	5.6% (Brazil 4.4%)
Northern America	7.2% (USA 7.1%)
Central America	9.1% (Mexico 9.5%)
Oceania	10.5% (Australia 8.7%)
Europe	11.1% (Norway 22.6%)
World	**16.5%**
Africa	20.3% (Egypt 27.3%)
Asia	21.9% (China 21.7%)

FAO, 2022

Cambodia:	69.6%	Gambia	44.0%	Angola:	35.5%
Kiribati	65.5%	Côte d'Ivoire:	44.3%	Senegal:	34.5%
Sierra Leone	61.3%	Congo DPR:	43.6%	Myanmar:	34.0%
Bangladesh:	60.1%	Cameroon:	41.0%	Japan:	33.9%
Solomon Islands	58.8%	Lao DPR:	40.0%	Togo:	33.4%
Maldives:	56.2%	Thailand:	38.4%	Uganda:	31.0%
Indonesia:	55.6%	Malaysia	37.5%	Korea Rep:	30.3%
Ghana:	53.8%	Nigeria:	35.9%	Rwanda:	28.8%
Sri Lanka:	49.4%	Seychelles	35.7%	Philippines:	28.0%

Per capita food supply in Japan, USA & Brasil in 2019

(FAO Food Balance Sheets, 2022)

	JAPAN	WORLD	BRASIL	USA
Calories (kcal/day)	2,691	2,963	3,246 +	3,862 ++
Fish & seafood (kg/year)	46.06 ++	19.91	8.95	22.13
Fish & seafood (g protein/day)	16.68	5.47	2.43	5.40
Fish & seafood (g fat/day)	5.76 ++	1.22	0.46	1.29
Fish % animal protein supply	33.9 ++	16.5	4.4	7.1
Animal protein (g/day)	49.17	33.16	54.86 +	75.93 ++
Animal fats (g/day)	35.74	38.89	62.76 +	81.11 ++
Terrestrial meat (kg/year)	51.11	43.16	99.53 +	128.44 +
Sugar & sweeteners (kg/year)	26.39	26.07	42.14 +	66.11 ++
Sugar & sweeteners (% total cal)	9.2	7.8	12.5 +	15.3 +

FAPESP
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FISH FOR HEALTH

FISH FOR HEALTH

Universidade de São Paulo

Instituto de PESCA

UMC UNIVERSIDADE

UFRN UNIVERSIDADE FEDERAL DO RIO GRANDE DO NORTE

FAPESP SÃO PAULO RESEARCH FOUNDATION

The aim of the project is to promote the increased use of farmed fish & seafood products as a more healthy alternative to the consumption of processed red meat products & fast-foods in the fight against obesity, coronary heart disease & diabetes

FISH FOR HEALTH

2022-2027

Início 1/10/2022

Nucleus Research Tasks

FISH FOR HEALTH

FAPESP
SÃO PAULO RESEARCH FOUNDATION

1. Market survey of fish consumption in the State

1 - 6

2. Nutrient content & contribution to diet

4 - 16

3. Variability in nutrient content of fish & feed

12 - 30

4. Dietary nutrient enrichment of fish

24 - 48

5. Improved fish/fishery processing methods

24 - 48

6. Genetic markers nutrient profile

12 - 48

7. Results, education & increased consumption

36 - 60

Nucleus Research Tasks

FISH FOR HEALTH

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Instituto de PESCA
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AQUAHANA

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AQUAHANA

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UMC UNIVERSIDADE
NEOGEN
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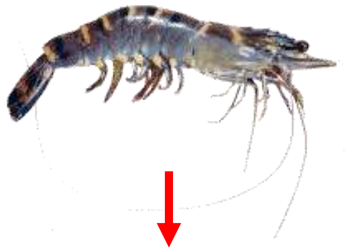
Polinutri Juntos vamos mais longe
Phileo by Lesaffre
BioMar

PESCADO PARA SAÚDE

Realization that the nutritional profile of the cultured fed fish or shrimp can be augmented & tailored to meet the needs of the consumer through the use of supplemental omega-3 fatty acids level (EPA/DHA), trace minerals (iron, zinc, selenium, iodine, chromium), vitamins (A, D, E), and/or fillet protein/lipid/calorific energy content;

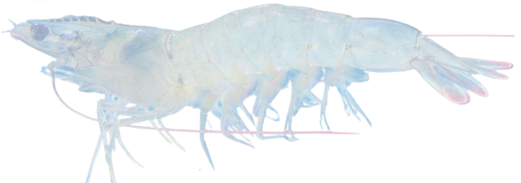
Nutrients



Contaminants

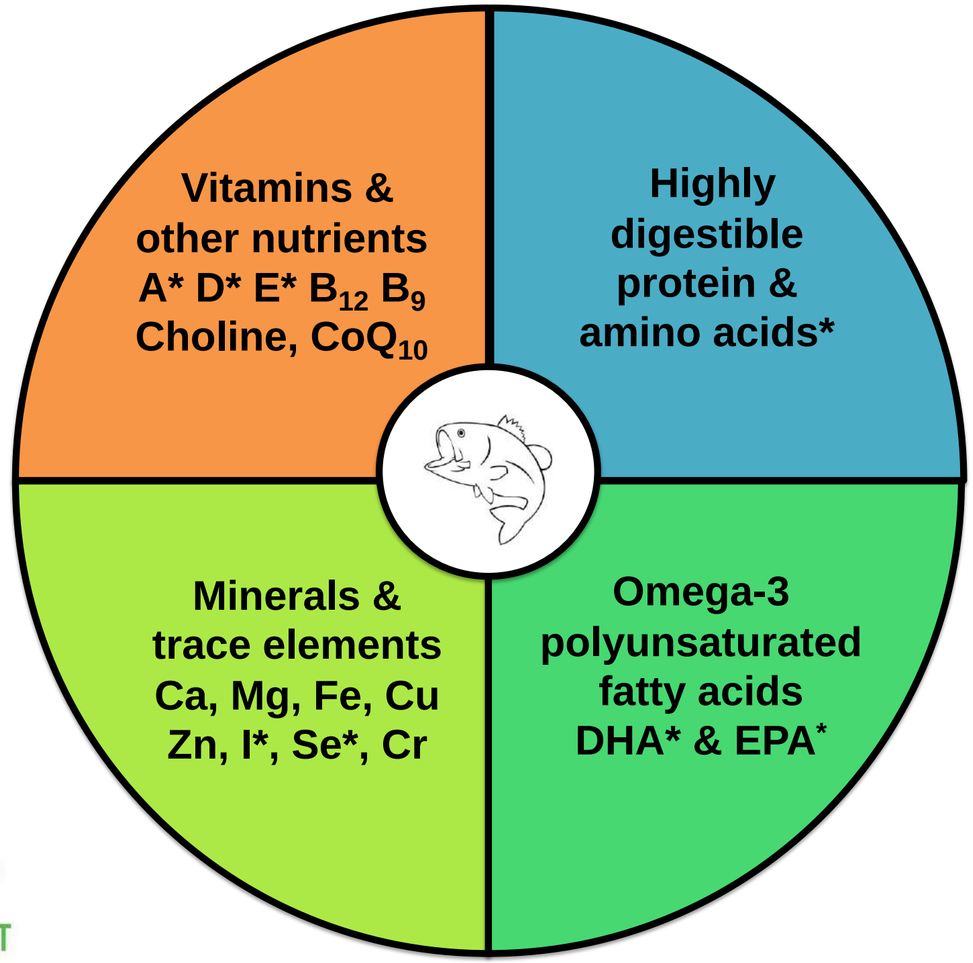
Optimum nutrient & health benefits

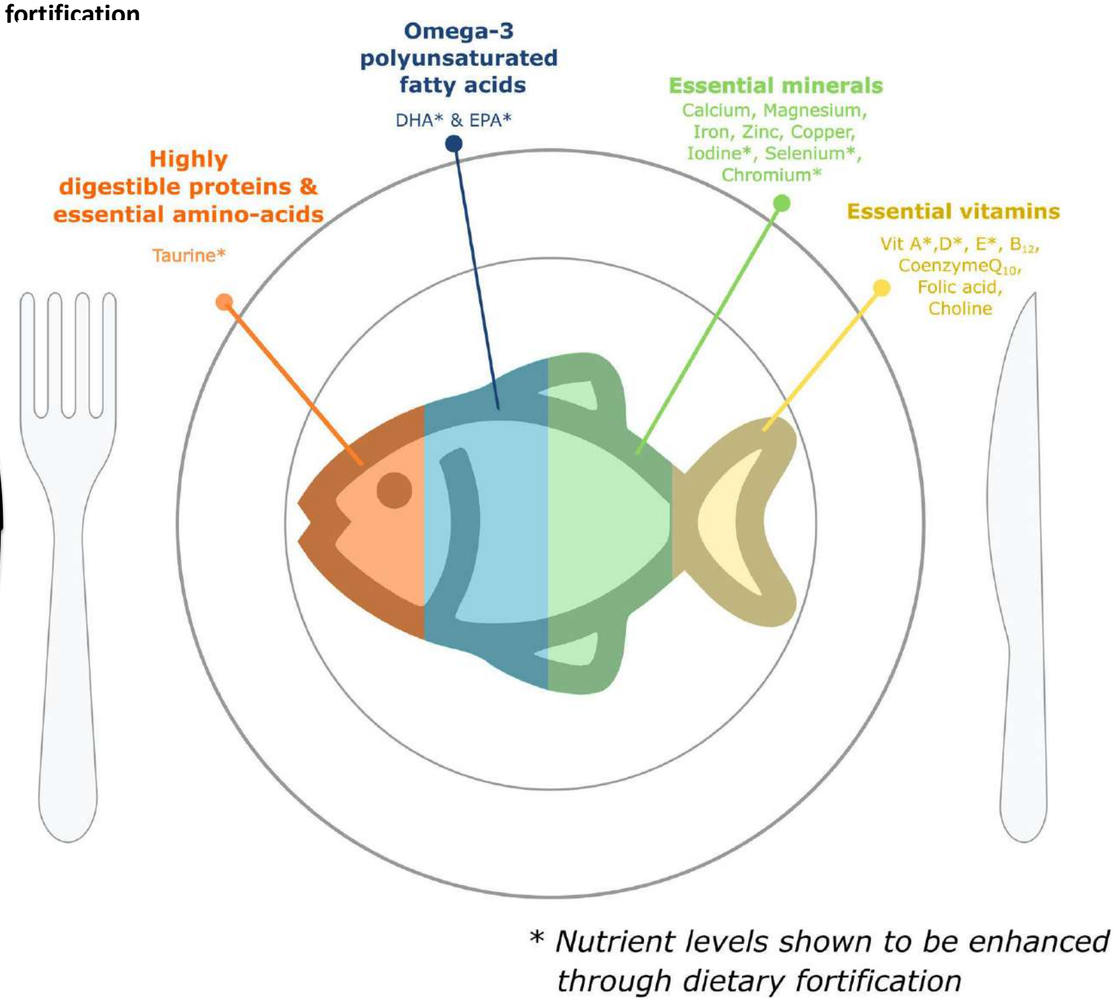
Healthy Heart
A healthier environment for healthier hearts



Farm Fish: A Superfood with many health attributes

[1] Tissue levels in farmed fish which have been shown to be able to be manipulated through dietary fortification





HEALTHY DIET

Figure 2. Farmed fish: a superfood with multiple health attributes.

NUTRITIONAL FACTS

Serving Size (per 100 grams)

	Value	Daily Value %
Calories	100	
Fats	1.7 g	9%
Saturated fats	0.6 g	2%
Trans fat	0 g	
Cholesterol	50mg	
Sodium	50mg	2%
Carbohydrate	0 g	0%
Fiber	0 g	0%
Sugar	0 g	0%
Protein	20 g	
Vitamin A		0%
Vitamin C		2%
Calcium		2%
Iron		0%

Nutrition Facts

Serving Size 4 oz (113g)
Servings Per Container Varies

Amount Per Serving

Calories 110 Calories from Fat 15

	% Daily Value*
Total Fat 2g	**3%**
Saturated Fat 0.5g	**3%**
Trans Fat --g	
Cholesterol 55mg	**18%**
Sodium 60mg	**3%**
Total Carbohydrate 0g	**0%**
Dietary Fiber 0g	**0%**
Sugars 0g	
Protein 23g	

Vitamin A 0% • Vitamin C 0%

Calcium 2% • Iron 4%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Production of lower-priced fish products

FISH FOR HEALTH

Increased Public Awareness

Urgent need to increase public awareness and understanding concerning the nutritional merits & health-benefits of increased consumption of fish and seafood products, including the inclusion of fish and aquatic foods as an essential component of a healthy diet and national dietary nutrient requirement guidelines, as well as the dangers of high intakes of processed foods and fast-foods on overweight, obesity, coronary heart disease, diabetes & associated ailments.

Fider
PESCADOS

DIA NACIONAL DA SAÚDE E NUTRIÇÃO

SUMACUA
Suministros Acuícolas

Come fresco
come saludable

Pescado é Saúde

aproveitamento integral do pescado

PESCADO PARA SAÚDE

O projeto tem como objetivo a promoção e o aumento do consumo de peixes e alimentos de origem aquática (Pescado) como uma alternativa mais saudável para as carnes vermelhas processadas e as ‘fast-foods’ no combate à obesidade, doenças do coração e males associados no Estado de São Paulo;

PESCADO PARA SAÚDE

2022-2027

Início 1/10/2022

FISH FOR HEALTH

Host Institution: University of São Paulo (USP)
***Partner Institution*:** Fisheries Institute, São Paulo State Secretary of Agriculture (SAA)
***Supporting companies and institutions*:** Polinutri Alimentos S.A. (Brasil), Neogen Ltda. (Brasil), Phileo by Lesaffre (France), Veramaris (The Netherlands), BioMar A/S (Norway), Aquahana LLC (USA)

***Coordinator*:** Prof. Dr. Daniel Eduardo Lavanholi de Lemos (USP, Oceanographic Institute, São Paulo)
***Vice-Coordinator*:** M.Sc. Thaís Moron Machado (Fisheries Institute, Santos)
***Communication Coordinator*:** Dr. Cristiane Rodrigues Pinheiro Neiva (Fisheries Institute, Santos)
***Partnership Coordinator*:** Dr. Vander Bruno dos Santos (Fisheries Institute, São Paulo)
***Executive Manager*:** Dr Rafael Tsuyoshi Coelho (USP, Oceanographic Institute, São Paulo)

***Principal Investigator*:** Prof. Dr. Daniel Eduardo Lavanholi de Lemos (University of São Paulo, USP)

***Associated Researchers*:**
Prof. Dr. Alexandre Wagner Silva Hilsdorf (Universidade de Mogi das Cruzes)
M.Sc. Thaís Moron Machado (Fisheries Institute, Santos)
Prof. Dr. Renata Guimarães Moreira Whitton (USP, Biosciences Institute, São Paulo)
Prof. Dr. José Roberto Machado Cunha da Silva (USP, Biomedical Sciences Institute, São Paulo)
Dr. Eduardo Gianini Abimorad (Fisheries Institute, São José do Rio Preto)
Dr. Fernando Stopato da Fonseca (Fisheries Institute, São José do Rio Preto)
Prof. Dr. Rodrigo Carvalho (Federal University of Rio Grande do Norte, Natal)

Post Doctorate Researcher:
Dr. Jéssica Levy, Pos Doc (Fisheries Institute/USP, Santos)

***Visiting Researcher*:** Dr. Albert G J Tacon (Aquahana LLC, USA

FISH FOR HEALTH

FISH FOR HEALTH

The mission of the research nucleus on ***Fish for Health*** is to promote and increase fish consumption, including nutritionally fortified farmed fish, as a more healthy alternative to the consumption of processed meats and `fast-food' products, in the fight against the epidemic of obesity, coronary heart disease, and associated ailments within the State of São Paulo and Brazil.

The **research nucleus** on **Fish for Health** is composed of an alliance between universities (led by the University of Sao Paulo), government institutions (led by the Fisheries Institute) and national and international private sector companies engaged in aquatic feed nutrition research, fish technology and the fish production sector; the active participation of the private sector in this research nucleus facilitating and ensuring the fast-track application of the results of the envisioned research tasks to the needs of society and the consumer within the State.

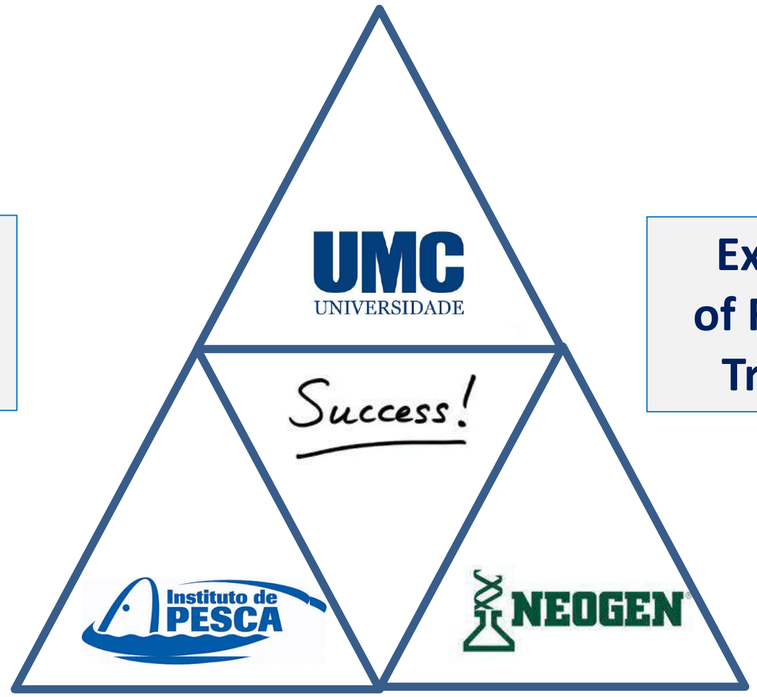
***Activity focus*:** The project research objectives are directly linked to the focus themes of the State Secretary of Agriculture (SAA) and to the topics listed by the State Secretary of Health (SES), that require a multi-disciplinary research approach to problem solving and addressing the key agricultural and health issues within the State.

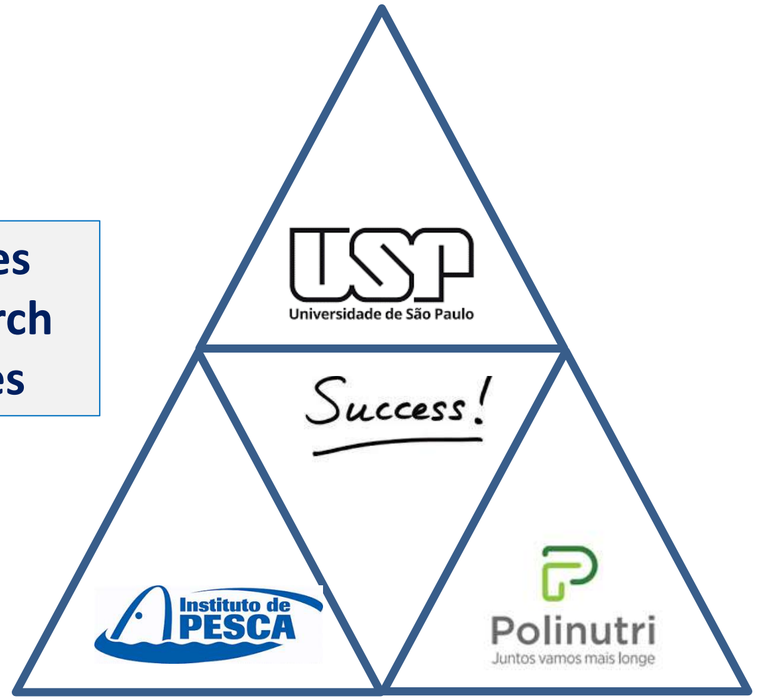
FISH FOR HEALTH

Justification & approach: The main justification & approach of the **Fish for Health** research nucleus is that university (USP) and government research institutions (IP) must work together as a research team, and partner with industry (as a research triangle), if they are to achieve the mission and goal of the project; namely increased fish consumption and consumer awareness and understanding concerning the health benefits of fish and seafood in a healthy diet.

Nucleus Research Partners

Examples of Research Triangles





FISH FOR HEALTH

***Partnership and communication*:** The research nucleus intends to work closely with all relevant government bodies within the State, including SAA and SES, engaged in policy decisions relating to promoting the increased consumption and health benefits of fish and fishery products.

In addition, the research nucleus will seek formal collaboration with renowned institutions engaged in research activities related to increasing fish consumption and awareness concerning the health benefits of increased fish and seafood consumption, such as EMBRAPA, the USP School of Public Health, the National Institute of Nutrition and Seafood Research (NIFES, Norway), and the Food and Agriculture Organization of the United Nations (FAO, Rome, Italy & Santiago, Chile).

The formal relationship and resource sharing with current and future sponsors of the Nucleus will be also managed by the Coordination of Partnerships, who will also be charged with prospecting and facilitating the development of new innovative research-based startup companies related to fish and health, including support for entrepreneurs in the submission of proposals to funding opportunities and calls as the FAPESP small business program (PIPE).

FISH FOR HEALTH

The problem: Despite having one of the longest coastlines in the world (8,500 km), abundant freshwater resources (12% of the world's surface waters), Brazil still trails the rest of the world in terms of fish & seafood consumption; per capita fish & seafood consumption being only 8.95 kg/year (world average 19.91 kg/year) and per capita meat consumption of 99.53 kg/year (pork 14.35 kg/year, beef 37.12 kg/year & poultry 46.94 kg/year; FAO, 2022).

Not surprisingly, there has been an increasing epidemic of obesity and heart related diseases in Brazil due to excessive meat consumption and reduced intake of polyunsaturated fatty acids, and the consequent urgent need to promote awareness concerning the nutritional value and health merits of the increased consumption of fish and seafood.

Most of the aquatic food consumed by Brazilian citizens in 2019 were freshwater fish (942,580 tonnes of which 211,820 tonnes was imported), demersal fish (529,910 tonnes of which 317,800 tonnes was imported), pelagic fish (197,760 tonnes of which 147,060 tonnes was imported), other marine fish (59,080 tonnes of which 39,740 tonnes was imported), crustaceans (113,350 tonnes of which 1,240 tonnes was imported), cephalopods (12,300 tonnes of which 9,280 tonnes was imported) and other mollusks (33,980 tonnes of which 4,720 tonnes was imported); total food fish supply in Brazil in 1999 reported as being 1,889,180 tonnes, of which 731,670 tonnes or 38.7% was imported (FAO FishStat, 2022).

FISH FOR HEALTH

The problem:

The majority of freshwater fish consumption is currently derived from local fish farms and freshwater fisheries, while marine fish almost exclusively sourced from marine capture fisheries, of which more than half was imported (FAO, 2022). Aquaculture has been a significant food production sector in São Paulo and the state is the second largest farmed fish producer in the Federation, producing about 10% of total farmed fish production in Brasil in 2019 (PEIXE BR, 2020).

According to the dietary guidelines for the Brazilian population it is believed that the low fish consumption in Brasil is due the higher fish prices compared to red meats and poultry (Ministry of Health of Brasil, 2015). To date information concerning the major food items consumed in Brasil is published in the Food Composition Tables of NEPA/UNICAMP (TACO, 2011) and USP (TBCA, 2019), although information concerning fish is relatively poor (Martins & Oetterer, 2010).

Nucleus Research Tasks

FISH FOR HEALTH

FAPESP
SÃO PAULO RESEARCH FOUNDATION

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Polinutri Juntos vamos mais longe
Phileo by Lesaffre
BioMar

FISH FOR HEALTH

1. Market survey of the main aquatic food products consumed within the State by geographic location and income level, including major cities, rural inland areas & coastal communities

***Methodology*:** Based on in-house methods developed by Fisheries Institute staff (Neiva et al., 2010), using a census methodology employing questionnaires and meetings with both consumers, traders and producers within the State, thereby determining the origin & cost of the fish & seafood consumed within the different markets.

In addition, a detailed review will be performed of existing publications and databases available within the State, including (but not limited to), the Brazilian Institute of Geography and Statistics (IBGE), Municipal Supply Secretary (ABAST), Municipal Planning Secretary (SEMPLA), State System for Data Analysis (SEADE), Ministry of Agriculture (MAPA), Institute of Environment and Renewable Resources (IBAMA), Ministry of Development, Industry and Foreign Trade (MDIC), Fisheries Industry Union (SIPESP), National Restaurant Association (ANR), Brazilian Association of Pubs and Restaurants (ABRASEL), Brazilian Association of Colective Meals (ABERC), São Paulo Union of Colective Meal Companies (SINDERC), São Paulo Association of Supermarkets (APAS), São Paulo Union of Vessel Owners (SAPESP), and Coordination of Agriculture Defense (CDA) of State Secretary of Agriculture (SAA).

Research team: MSc Thaís Moron Machado, Dr Cristiane Neiva, Dr Jéssica Levy, Dr Daniel Lemos & Dr Albert G J Tacon

Timeline: Month 1-6

FISH FOR HEALTH

2. Nutritional analysis of the major aquatic food products consumed within the State & relative contribution to total dietary nutrient supply

Methodology: Nutritional analyses will be performed on the top eight aquatic food products consumed within the State, with representative samples obtained from major distributors over an 8-month period (a minimum of 8 x 4 samples in total).

Representative fish & seafood samples will be analyzed for the following, including: moisture, crude protein, crude lipid, crude fiber, ash, amino acid composition, fatty acid composition, cholesterol, gross energy, minerals and trace element composition (Ca, P, K, Na, Mg, NaCl, Fe, Zn, Cu, Mn, I, Co, Cr, Mo), key vitamins (A, D, E, C & choline), and environmental contaminants (including heavy metals, persistent organic pollutants or POPs & microplastics). The results will be expressed on an as-fed and dry matter basis per 100g of edible product and compared with existing published levels and dietary nutrient requirement guidelines.

Research team: MSc Thaís Moron M., Dr. Cristiane Neiva, Dr Jéssica Levy, Dr Vander Bruno Santos, Dr Rodrigo Carvalho, Dr Daniel Lemos & Dr Albert G J Tacon

Timeline: Month 4 -16

FISH FOR HEALTH

3. Determination of the variability in the nutrient content and potential health value of two of the most consumed farmed fish (Tilapia) and crustaceans (White shrimp) within the State, including the aquaculture feeds used to produce them

Methodology: Two independent fish and shrimp farms (willing to share the results from this survey) will be selected from São Paulo (Tilapia) and Rio Grande do Norte (White shrimp) for this study. Monthly sampling will be performed over a twelve month period, including the commercial compound aquaculture feeds used to produce them.

Samples will be analyzed on an as-fed and dry matter basis per 100g of edible product in case of the aquatic food products and on an as-fed basis (% or mg/kg) in the case of the aquaculture feeds tested; analyses to be performed including moisture, crude protein, crude lipid, crude fiber, ash, amino acid composition, fatty acid composition, cholesterol, gross energy, minerals and trace elements (Ca, P, K, Na, Mg, NaCl, Fe, Zn, Cu, Mn, I, Co, Cr, Mo) and major vitamins (A, D, E, C, choline), and possible contaminants, including heavy metals and mycotoxins.

Research team: MSc Thaís Moron Machado, Dr Cristiane Neiva, Dr Jéssica Levy, Dr Eduardo Abimorad, Dr Vander Bruno Santos, Dr Daniel Lemos, Dr Renata Guimarães Moreira, (USP, São Paulo), Dr Rodrigo Carvalho & Dr Albert G J Tacon

Timeline: Month 12-30.

FISH FOR HEALTH

4. Enhancing the nutrient profile & potential health value of farmed Tilapia & White shrimp through dietary manipulation and use of improved fish processing techniques

***Methodology*:** Dietary nutrient enhancement studies will be performed on Tilapia and Shrimp in close collaboration with the relevant industry partners, namely Polinutri Alimentos S.A. (Brasil), Veramaris (The Netherlands), Phileo by Lesaffre (France) and BioMar A/S (Norway).

All fish and shrimp feeding trials will be conducted under controlled indoor laboratory conditions over a 8 to 16 week culture period to market size so as to demonstrate the following 1) tissue nutrient enhancement of dietary omega-3 polyunsaturated fatty acids, and in particular EPA and DHA through the use of more non-fish oil dietary sources such as microbial/algal biomass (Vermaris, and possibly Alltech/Brasil), 2) tissue nutrient enhancement with essential trace elements and vitamins (including organic Iodine, Selenium and trivalent Chromium, and vitamin E (Phileo, and possibly DSM/Brasil for vitamin E), and 3) tissue reduction of cholesterol levels in shrimp through the use of dietary phytosterols.

Research team: Dr Eduardo Abimorad, Dr Vander Bruno Santos, Dr Daniel Lemos, Dr Rafael Tsuyoshi Coelho, Dr Renata Guimarães Moreira, Dr José Roberto Machado Cunha da Silva & Dr Albert G J Tacon

***Timeline*:** Month 24-48

FISH FOR HEALTH

5. Development & use of innovative fish processing techniques for the production of new fish products, extending shelf life & reducing fish waste & losses in industrialization

Methodology: Studies will be conducted for 1) extending the shelf-life, market value and acceptability of Tilapia fillets through smoking and/or dietary supplementation (vitamin E & Selenium), 2) use of mince processing technology for the production of low-cost ready-to-eat fish products from Tilapia filleting wastes, and 3) development and use of aquaculture production strategies for the production of smaller-sized fish and shrimp for the production of lower-cost aquaculture-based fast-food products

Research team: MSc Thaís Moron Machado, Dr Cristiane Neiva, Dr Jéssica Levy, Dr Vander Bruno Santos, Dr Daniel Lemos, Dr Rafael Tsuyoshi Coelho & Dr Albert G J Tacon

***Timeline*:** Month 24-48.

FISH FOR HEALTH

6. Use of genetic markers to improve the nutritional quality & cost-effectiveness of Tilapia production within the State using Genome Wide Association Studies

Methodology: The phenotypic database, with information on body characteristics, as well as biological material for genomic analyses, will be obtained from ten commercial hatcheries of Nile tilapia. The broodstock belonging to the base population will be tagged by electronic PIT-Tags to generate F1 progeny, which in turn will produce generation F2. All progeny will remain in separate hapas until they reach a weight above 10 grams for chip-tagging. Tagged fingerlings from F_1 and F_2 generations will be placed into the same environment in a earth pond for growing testing until they reach the market size of 800 g. The following phenotypes will be measured: body weight at harvest, growth rate; feed conversion; fillet ventral thickness (by ultrasonography); fillet yield, and fillet composition like long-chain omega-3 polyunsaturated fatty acids, essentials amino acids, taurine, creatine, vitamin D and selenium.

Research team: Dr Alexandre Wagner Silva Hilsdorf, Dr Vander Bruno Santos, Dr Fernando Stopato, MSc Thaís Moron Machado, Dr Cristiane Neiva, Dr Daniel Lemos & Dr Albert G J Tacon

Timeline: Month 12-48.

FISH FOR HEALTH

7. Communication of project results & increasing public awareness & understanding concerning the health benefits of aquatic fish products in human nutrition & well-fare

***Methodology*:** 1) Establishment of a project web page and database concerning the nutrient composition of aquatic food products available in the State and Brasil; 2) Publication of project findings within relevant leading international and national journals dealing with public health, nutrition, aquaculture, and fisheries; 3) Presentation of project findings at relevant major State and national conferences, and expert working groups dealing with public health, nutrition, aquaculture, and fisheries; 4) Creation of public exhibits, posters, and leaflets for schools, public health offices, public aquariums, and museums, which will inform the public about the health benefits of aquatic food products (including farmed aquatic products) and the need to increase sustainable fish production and consumption in Brazil for reducing the incidence of obesity, diabetes, hypertension, and associated ailments.

***Research team*:** MSc Thaís Moron Machado, Dr Cristiane Neiva, Dr Jéssica Levy, Dr Vander Bruno Santos, Dr Eduardo Abimorad, Dr Alexandre Wagner Silva Hilsdorf, Dr Daniel Lemos, Dr Rafael Tsuyoshi Coelho, Dr Renata Guimarães Moreira, Dr Rodrigo Carvalho & Dr Albert G J Tacon

***Timeline*:** Month 36-60.