
BOLTON
ALL
THE GOODNESS
OF SEAFOOD
Scientific research for people's health
and innovation for the most effective use of resources

Contents

Foreword

We have great pleasure in presenting this report, a document that reflects Bolton Food's deep-seated commitment to protecting people's health and ensuring the sustainable use of fish resources, a fundamental part of our path to sustainability.

Our path embraces all factors involved in achieving development that is completely sustainable on the environmental, social and economic levels, adopting a responsible approach in which, as a major corporate player, we work to generate positive impact and change, leading by example.

In the last few years, as well as implementing a series of practical measures for environmental stewardship, which for us means sustainable fishing and the protection of the oceans, we have decided to take an additional step forward. We have dedicated resources and attention to analysing the impacts our products generate in terms of both people's health and the conservation of the environment and pushed even further ahead to make the optimal use of every resource. It is our distinctive ambition to contribute to global challenges by creating new knowledge through scientific research and by promoting change by means of transformative innovation.

This report highlights the reasons for our commitment and sets out the results achieved and is a significant opportunity for us to demonstrate Bolton Food's determination to be a supportive partner for the world of scientific research and transformative innovation. We are proud of the progress described here, which makes a substantial contribution to enriching knowledge about a healthy, balanced diet and the effective use and reduction of fish waste. The contents of this document reflect our responsible approach, as we aim to set high standards that establish new benchmarks and inspire industrial, scientific and public stakeholders in a more and more informed, efficient reproach to the management of resources. Implementing this determination, we have also opened out to the world of education and training, areas in which we have intensified our efforts.

Here at Bolton Food we are confident that with the right partners, shared ambitions and solid expertise we will continue to develop solutions that safeguard people's health, conserve resources and inspire positive change for future generations.

Our path embraces all factors involved in achieving completely sustainable development.

Luca Alemanno
CEO Bolton Food

Introduction

The transformation of the food system has now become an unavoidable imperative: the brands that will succeed in adapting to this change will be the brands of the future. Worldwide, the consequences of imbalanced lifestyles are putting health systems under unsustainable economical stress, while at the same time there is an impelling need to change models of production to guarantee environmental sustainability and access to food.

European policy has provided major transformative, systemic and operational input through the Green Deal and the Farm to Fork strategy, which focuses on the urgent need for food systems to embrace change towards sustainable outcomes and function within the planet's ecological limits. The Sustainable Development Goals also support and encourage this action. This has generated a different way of conceiving products and the need to intensify partnerships between industry and the world of research: the only possible approach to this transformation

is a systemic, collegial one. At the root of this change is the fact that fulfilling people's calorie requirements is no longer enough. So far, nutritional sciences have applied a reductionist method, considering the nutrients in food as the fundamental unit of nutrition. Recently, given the clear effects of food as such on health, this concept has been superseded and now food itself is viewed as the fundamental unit of nutrition. Therefore, greater scientific understanding of the interaction between food and health is now required.

Food itself is now considered to be the fundamental unit of nutrition.

Moreover, what we judge to be a healthy diet is a dynamic concept, therefore a scientific definition of what constitutes a healthy diet in different sociocultural groups is also required. To an ever-increasing extent, food products' value is decided in terms of their effects on health. Obviously, the food industry is a stakeholder and a powerful medium for the production and distribution of "healthy" food, and must partner with cooperative research programmes with universities, research centres and government bodies to explore innovative approaches and thus benefit from the consequences of this change.

Finally, at a higher level, supra governmental bodies are pushing hard to achieve a definition of healthy food as a basis for drawing up the legal and regulatory framework to be applied to the industry. This, in fact, is a central theme of the European strategy just launched.

At the same time, the effects of climate change are threatening food security and diet quality, putting populations at risk of multiple forms of malnutrition. As a matter of facts, **a poor diet is one of the main causes of mortality and morbidity**.

Last but by no means least, people are finding it hard and harder to make ends meet. Data collected by the United Nations paint a clear and very concerning picture. 3 billion people worldwide live in socioeconomic conditions which do not permit them to follow a healthy diet, and 1 and a half billion are unable even to feed themselves in a way which provides minimum levels of essential nutrients. These statistics are driven partially by **social inequality** but above all by **unsustainable food systems**, which are unable to meet the food needs and nutritional requirements of all.

The effects of climate change are threatening food security and diet quality, putting populations at risk of multiple forms of malnutrition.

Therefore, climate change and food systems reciprocally interact, with direct, currently negative, consequences for food and nutritional security.

More sustainable diets, which meet nutritional needs while safeguarding the environment and spending power, would make a major contribution to reducing food supply problems and the environmental footprint.

The fish industry, the role of which is still under-appreciated, can play a key role in creating a sustainable future.

In this report, subdivided into two chapters, we will explore how the inclusion of fish products in diets can improve the health of the global population and combat malnutrition. We will also see how the innovative reuse of fish resources can reduce waste and help to safeguard the environment.

Our partnerships

Bolton Food, the Bolton Business Unit which is a fish food industry leader and a global player, managing the entire tuna supply chain, tackles this major challenge through **partnerships with centres of excellence in scientific research and international innovation**.

As this document reveals, the company encourages synergy across multidisciplinary **areas of expertise to create a new, positive form of public-private sector collaboration**, involving businesses, research organisations and universities.

CNR

IMN Istituto di Ricerche Farmacologiche Mario Negri - IRCCS

IPH Italian Institute for Planetary Health

NWU®

ONE EARTH

onfoods

Università degli Studi di Bari Aldo Moro

Università degli Studi di Milano

Università degli Studi di Napoli Federico II

Alma Mater Studiorum Università di Bologna

Università degli Studi di Catania

Università degli Studi di Padova

1

THE HEALTH BENEFITS OF SEAFOOD AND FOOD SECURITY

This chapter discusses the topic of fish resources from the point of view of their use in diets, to ensure that everyone has access to healthy, affordable food. In the last few years, Bolton Food has sponsored a growing number of scientific studies to define the relationship between fish consumption and people's health. Research has focused in particular on the relationship between fish intake and Non-Communicable Diseases (NCDs), chronic conditions caused by a combination of genetic, physiological, environmental and behavioural factors.

They mainly comprise **cardiovascular diseases, cancer, chronic respiratory conditions and metabolic disorders such as diabetes**.

Nowadays, malnutrition is one of the biggest health costs in developed and developing countries, and at the global level it is the most important risk factor for disease and death. Malnutrition occurs when a person fails to consume enough macronutrients (carbohydrates, proteins and fats), required to cover their energy and physiological needs, and micronutrients (such as vitamins and minerals) necessary for their growth, development, metabolism and physiological functions.

A poor diet is one of the main causes of mortality and morbidity. At present, about 690 million people are unable to obtain sufficient food for their needs, and this figure is forecast to exceed 840 million by the end of 2030.

In this scenario, the EAT-Lancet[1] model (a dietary model that combines sustainability and health benefits) recommends fish as a particularly promising, affordable source of macro and micronutrients for both developed and developing countries. In fact, fish products contain important proteins and differing quantities of fats and micronutrients depending on the species.
Oily fish, such as herring, mackerel, trout, salmon or eel, and moderately oily fish, such as halibut, catfish and tuna, are generally the main dietary sources of omega-3 fatty acids, while white fish (cod, haddock, saithe, plaice and pike) contains less. Seafood derives its high nutritional quality not only from its proteins and healthy fats but also from its high content of a series of essential micronutrients including iodine, selenium, calcium, iron, zinc, vitamin D, vitamin A and vitamin B12.

The nutritional qualities of canned fish are also guaranteed by the production process, which ensures that most of the fresh fish's nutritional characteristics are conserved.

These characteristics make fish an appropriate ingredient in programmes that aim to combat malnutrition and suggest that fish-based food strategies can potentially make a substantial contribution to global food and nutritional security.

Given this scenario, Bolton Food has implemented a **wide-ranging plan of partnerships with major Italian and international research organisations**, described below, to investigate **the effects of eating fresh and canned fish on human health.**

1.1 The role of canned fish in a healthy, sustainable diet

Food systems include all the actors involved in the production, transformation, distribution, consumption and disposal of food products derived from farming, forestry, fishing and the food industries, as well as the economic, social and geographical system of which these activities form a part (von Braun et al., 2021). Today, food systems are considered unsustainable due to the large quantity of natural resources they consume (use of land and freshwater, for example) and their environmental impacts (such as greenhouse gas emissions and nitrogen and phosphorus pollution).

Other issues include high levels of food waste and the co-existence of malnutrition with overweight/obesity and their correlated chronic diseases (GBD 2017 Diet Collaborators, 2019; Herforth et al., 2022). In spite of the overall reduction of per capita levels, the environmental impact of food systems

has increased in absolute terms in the last few decades due to the growth in food production generated by population expansion, urbanisation, changes in consumption patterns and globalisation. However, food production will have to increase further, since the world's total population reached 8 billion in 2022 and is forecast to exceed 9 billion by 2050 (Finley et al., 2017, United Nations Department of Economic and Social Affairs).

Therefore, enabling future food systems to feed a growing global population without further jeopardising the state of natural resources is a major challenge that also implies the definition of healthy, sustainable dietary models (FAO and WHO, 2019).

In response, in 2019 the EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems put forward a scientific approach to encourage the adoption of healthier, more sustainable diets (Willett et al., 2019). It calculated a set of

The environmental impact of food systems has increased in absolute terms in the last few decades due to the growth in food production.

assumptions for different food groups (such as the EAT–Lancet healthy reference diet - ELHRD, or Planetary Health Diet) consistent in theory with scientific data on healthy diets. However, this programme's main innovation lies in its guidelines' consistency with the six "scientific targets for food systems" (such as limit of 4.7-5.4 Gt of CO2eq per year to combat climate change). These scientific targets are set within the planetary boundaries and were established by the Commission to enable the achievement

Food production will have to increase further, since the world's total population reached 8 billion in 2022.

of the United Nations Sustainable Development Goals (SDGs) and the objectives of the Paris Agreement (Willett et al., 2019, United Nations, 2021). Basically, the ELHRD is designed to optimise the environmental impact of health and diet and is intended for use at the national level to develop a healthy, sustainable diet.

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debate. On the one hand, ASFs generally have a higher environmental impact than foods of vegetable origin. On the other hand, ASFs are a source of important, bioavailable nutrients which may be crucial, especially in vulnerable population groups. Therefore, when studying the role of ASFs within healthy, sustainable diets it is essential also to consider the nutritional needs of the target population and its vulnerable members (e.g. the elderly).

Amongst foods of animal origin, fish such as tuna is an important source of nutrients such as proteins with high biological value, long-chain omega-3 (W-3) polyunsaturated fatty acids and various vitamins and trace elements. Moreover, canned tuna is relatively inexpensive and convenient and can therefore play a role in healthy, sustainable diets, which should be not only nourishing and environment-friendly but also safe, desirable and affordable.

This research project has a number of aims, but above all it **sets out to assess the nutritional quality and environmental impact of theoretical dietary models** including and not including **canned tuna**.

At present, there is only limited knowledge of the nutritional and environmental impact of healthy, sustainable diets that include canned tuna, or fish products in general, especially in terms of studies conducted in real-life contexts. Further investigation of this commonly used, easily accessible food could allow definition of the role of tuna in healthy, sustainable dietary models.

To enable this, **Bolton Food** has joined forces with the **Universities of Milan and Bologna** within the ONFOODS partnership to undertake a study[2] to analyse canned tuna's positive contribution to healthy, sustainable diets, to allow it to be recommended as a valid alternative to fresh fish in nutritional, economic and environmental terms.

Year of project launch **2024** onfoods

1.2 Health impacts of consuming canned versus fresh fish

As already explained in the introduction, fish products play an important role not only in a healthy diet but also in facilitating the right, accessible nutrient intake.

In 2022, with the support of partners including **Bolton Food**, researchers in the **Human Nutrition Division of the Department of Food, Nutrition and Environmental Sciences at the University of Milan** undertook a scientific study to identify any significant differences between the impact on human health of eating fresh or frozen versus canned fish products.

The study enrolled 148 volunteers[3], representative of the Italian population, who were assigned at random to two different diets for a four-month period.

The first diet included 3 portions of fresh or frozen fish per week, further subdivided into 1 portion of white fish or seafood and 2 portions of oily fish. In the second diet, 2 of the 3 weekly portions of fish consisted of canned fish products (tuna, sardines, mackerel and salmon).

As expected, the findings did not reveal any significant differences between the two diets. It can therefore be stated that canned fish can offer a good alternative to fresh fish and can help to provide the weekly portions of fish recommended in a healthy, varied, balanced diet.

2 different diets for 4 months but the same benefits:

Diet **1**

3 portions of fresh/frozen fish per week, comprising 1 portion of white fish or seafood and 2 portions of oily fish

Diet **2**

3 portions of fish per week, comprising 1 portion of fresh/ frozen fish or seafood and 2 portions of canned fish products (tuna, sardines, mackerel and salmon)

Recommendation of **1 to 4 portions of fish per week** giving a total of **2,5 gr of omega-3 fatty acids** for adults

It can be stated that canned fish can provide a valid alternative to fresh fish

It should also be remembered that this advice is issued by the **European Food Security Authority (EFSA)**. In its current guidelines, it recommends eating fish from 1 to 4 times a week (EFSA, 2015) to provide the adult population with a weekly intake of 2,5 gr of omega-3 fatty acids (EFSA, 2010)[4].

Year of project launch: **2022**

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Collectively, Non-Communicable Diseases (NCD), which include heart disease, stroke, cancer, diabetes and chronic respiratory disease, account for 74% of all deaths worldwide. More than three-quarters of deaths due to non-communicable diseases and 86% of the 17 million people who die prematurely, or before reaching 70 years of age, are in low and medium income countries.

The NCD epidemic has devastating consequences on the health of individuals, families and communities and threatens to overwhelm health systems. Given the socioeconomic costs of NCDs, the prevention and control of these conditions is a major imperative for development in the 21st century.

NCDs share five main risk factors: tobacco use, sedentary lifestyle, alcohol abuse, unhealthy diets and atmospheric pollution. In view of the very wide availability of canned fish products, Bolton Food decided to investigate the extent to which fish and canned fish can reduce the risk of NCDs.

74% percent of deaths worldwide are due to non-communicable diseases (NCDs)

86% of the 17 million deaths before 70 years of age occur in low and middle income countries

The socio-economic costs associated with non-communicable diseases make the prevention and monitoring of these diseases an imperative for development in the 21st century.

1.3 Eating fish regularly can reduce the risk of cardiovascular disease by up to 10%

Epidemiological studies have shown that eating fish significantly reduces the incidence of cardiovascular disease and the associated mortality. However, more up-to-date scientific studies are currently needed to combine the vast amount of scientific findings that have been accumulated. In partnership with researchers from **North-West University (South Africa)**[5], Bolton Food has conducted a study[6] on fish consumption in relation to incidence of and mortality from cardiovascular disease. According to the results of the research, published in a peer-reviewed journal[7], eating fish reduces the risk of heart and blood vessel diseases such as myocardial infarction and stroke by up to 10%.

Eating fish significantly reduces the incidence of cardiovascular disease and the associated mortality.

The researchers estimated that a **high-fish diet provides a reduction of about 8% in cardiovascular risk** compared to low-fish alternatives. Even a small amount of fish (50 g of fish, the average size of a small can of tuna) can produce **a statistically significant reduction of 9% in the risk of fatal and non-fatal CVD** if consumed daily.

Similarly, eating two or three 150 g portions of fish per week can **reduce cardiovascular risk by 8%**. Moreover, eating 100 and 150 g of fish per day **reduces cardiovascular risk by 16% and 28% respectively**. These findings strongly support the hypothesis that constant high consumption of fish products plays a key role in preventing cardiovascular conditions, which, it should be remembered, are particularly disabling and thus important with regard to the protection of public health.

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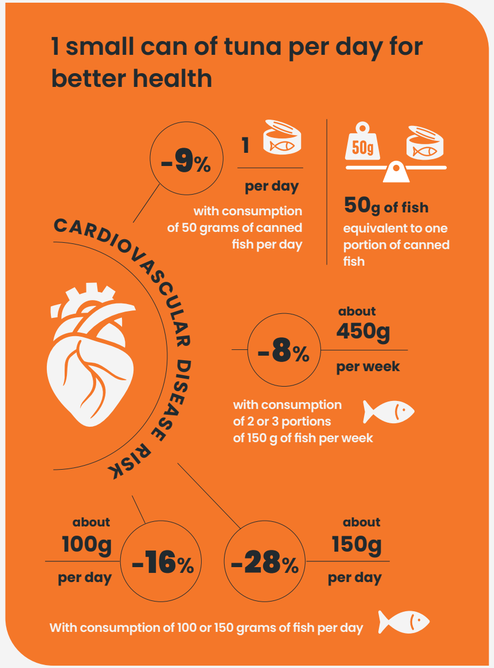

1.4 Canned fish consumption and impact on reducing the risk of cancers of the upper gastrointestinal tract

Stomach cancer is the fifth most common cancer and cause of cancer deaths worldwide, with almost a million cases in 2022. In recent years there has a been a general downward trend in its incidence thanks to better clinical management of one of its main risk factors, Helicobacter Pylori. Amongst modifiable factors, diet plays a fundamental role in its onset. The Mediterranean diet, with high intake of fruit, vegetables, nuts, pulses, whole grains and extra virgin olive oil, moderate intake of poultry, fish and alcohol and low red and processed meat consumption, is usually associated with lower risk of stomach cancer.

Conversely, a diet rich in starches, saturated fats and salted, pickled or smoked foods, such as salted or dried fish and vegetables preserved in brine, and excessive alcohol consumption, have been directly linked to stomach cancer. Fish is part of habitual diets worldwide

higher canned fish consumption =
reduction in oral cavity, pharynx and stomach cancer risk

and is the main source of omega-3 polyunsaturated fatty acids (PUFAs), which have anti-inflammatory and thus anti-carcinogenic characteristics.

A number of epidemiological studies have focused on the link between fish consumption and gastric cancer risk, with inconsistent findings. One subcategory of fish which deserves attention is canned fish, widely consumed for practical reasons especially in Europe and North America, during the pandemic and post-pandemic period in particular. In previous studies, we analysed the data from two large case control studies conducted in Italy and found a reverse correlation between canned fish consumption and colorectal and stomach cancer.

Together with **Bolton Food**, researchers from the **Mario Negri Institute of Pharmacological Research IRCCS of Milan and the University of Milan** used the data from a network of studies conducted in northern Italian hospitals which yielded information about consumption of canned fish as a separate item.

The study involved a total of 946 patients with oral cavity and pharynx cancer, 304 patients with cancer of the oesophagus and 230 patients with gastric cancer.

The findings revealed an effective reduction in cancer risk corresponding to higher canned fish consumption with oral cavity and pharynx cancer, and the correlation was even stronger with stomach cancer. However, no association with cancer of the oesophagus was found.

Year of project launch: **2023**

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1.5 Canned fish consumption and reduction of onset of colorectal cancer

In 2020, colorectal cancer (CRC) accounted for 1.9 million new cases of cancer worldwide, placing it in second place for women and third place for men in terms of incidence, and it was the second biggest cause of cancer mortality, with 935,000 deaths. High-income countries have the largest number of CRC cases, but incidence rates are tending to increase in countries undergoing rapid transition (such as Eastern Europe, South-East and Central South Asia and South America), probably reflecting changes in lifestyle and dietary factors. The modifiable risk factors for CRC are a sedentary lifestyle, which leads to a reduction in exercise and an increase in body weight, excessive alcohol consumption, tobacco smoking and high red or processed meat consu mption. Eating wholegrain cereals, dietary fibre, dairy products and calcium and non-starchy fruit and vegetables has been inversely correlated with CRC risk. It has been shown that fish plays a favourable role in the risk of cancer, especially

In 2020, colorectal cancer (CRC) accounted for 1.9 million new cases of cancer worldwide.

digestive tract cancer, including CRC, although the evidence is still inconsistent. Fish is the main dietary source of long-chain omega-3 polyunsaturated fatty acids (PUFAs), which have anti-inflammatory properties and thus have anti-carcinogenic effects. Environmental studies have provided conflicting evidence regarding intake of omega-3 polyunsaturated fats and the risk of various cancers, triggering a certain amount of debate on the topic.

Here again, fish is one of the foods with favourable effects in preventing disease, in this case specifically colorectal

Fish is the main dietary source of long-chain omega-3 polyunsaturated fatty acids (PUFAs), with anti-inflammatory properties and thus anti-carcinogenic effects

conditions. Hitherto, there had been no investigation of the benefit of fish eaten in canned form within this type of prevention. The first study8 was conducted by **Bolton Food together with researchers from the Mario Negri Institute of Pharmacological Research IRCCS of Milan in 2022, in the context of the activities of the Italian Institute for Planetary Health (IIPH)**[9], in association with the **University of Milan**.

The findings revealed a reduction of about 34% in the risk of this type of cancer in people who ate at least two portions per week of fish canned in oil (of 160 grams each).

The study analysed the data from two previous studies conducted between 1992 and 2010 in different areas of

"The study's findings provide further grounds for maintaining that eating fish canned in oil can be part of a healthy, balanced diet, since the fish undergoes only minimal processing as it is steamed, cleaned, placed in oil and canned without preservatives. The implications for public health may be very significant. In fact, this cancer has high incidence and mortality in both high and low and medium income countries, while canned fish consumption is rising all the time thanks to its convenience and affordability."

Carlotta Franchi
Researcher in the Health Policy Department of the Mario Negri Institute and scientific head of IIPH

"Simply eating canned fish compared to never or only rarely eating fish (canned, fresh or frozen) was associated with a 23% reduction in colorectal cancer risk: this reverse correlation is even higher in people who eat both canned and fresh fish. The favourable effect may be due to the omega-3 fatty acid content or to other nutrients in the fish."

Carlo La Vecchia
Lecturer in Epidemiology, University of Milan

"We confirmed these findings after assessing the confounding factors regarding diet and exercise notoriously associated with the onset of colorectal cancer and we also identified the same dose-response effect in colon and rectal cancers when considered separately. The benefits may be due to the omega-3 fatty acid content or to other nutrients in the fish itself."

Barbara D'Avanzo
Researcher in the Health Policy
Department of the Mario Negri Institute

Italy, covering a total of 2419 confirmed cases and 4723 hospital checks. Canned fish consumption was analysed by weekly frequency (p/w): <1 portion per week, 1 <2 p/w and ≥ 2 p/w. Overall, canned fish consumption was lower in confirmed cases of the disease than in cases where only a check was performed (23.8% compared to 28.6%).

Year of project launch: **2022**

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Italian Institute for Planetary Health

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1.6 Fish consumption, cognitive impairment, dementia and Alzheimer's disease

In the last few decades the lengthening of human life expectancy and the ageing of the population worldwide have changed the epidemiology of diseases and caused a substantial increase in age-related health conditions. It is now well known that mental and cognitive health is an emerging global problem. With regard to cognitive conditions in particular, it is estimated that there are about 60 million cases of Alzheimer's Disease (AD) and other forms of dementia worldwide, and this figure is forecast to increase threefold by 2050. Nowadays it is an accepted fact that diet affects the human brain and mental health. Various dietary components, such as healthy fats, some amino acids and oligopeptides,

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antioxidant vitamins and phytochemicals such as polyphenols, play a role in preserving the neuron stability and function and in combating neuroinflammation. Dietary models in which fish consumption is one of the main sources of protein [such as the Mediterranean diet, the Scandinavian diet and the Dietary Approach to Stop Hypertension (DASH)] have been constantly linked with a lower risk of neurodegenerative conditions. The role of fish in human health has been the subject of lengthy study.

Its omega-3 polyunsaturated fatty acid (PUFA) content is considered to be the cause of its potentially beneficial effects on mental health, while just recently more attention has been focused on its bioactive oligopeptides (bioactive molecules consisting of only a few amino acids) and their direct anti-inflammatory and antioxidant effects on the brain. Although the underlying logic which states that fish consumption has potential beneficial effects in neurodegenerative disease is fairly convincing, it is not yet clear whether eating fish in itself can play a role in the prevention of cognitive decline and dementia. Together with researchers from the **Department of Biomedical and Biotechnological Sciences of the University of Catania and in partnership with analysis institutions including the Laboratory of Pharmacoepidemiology and Human Nutrition, and the Health Policy Department of the Mario Negri Institute of Pharmacological Research IRCCS, Bolton Food** conducted a study (also published in "Aging Clinical and Experimental Research"10) with the aim of updating the current findings on the link between fish intake and cognitive outcomes.

The role of fish in human health has been the subject of lengthy study. Its omega-3 polyunsaturated fatty acid (PUFA) content is considered to be the cause of its potentially beneficial effects on mental health.

Overall, the entire sample included a total of about 849,263 individuals, 8,537 cases of cognitive impairment, 12,148 cases of dementia and 5,320 cases of Alzheimer's Disease. The individuals who reported higher fish consumption were associated with a lower likelihood of cognitive impairment/decline, dementia and Alzheimer's Disease. In fact, the findings revealed a reduction in the risk of AD with consumption of 50 g or more of fish per day and a significant decrease in the risk of any cognitive outcome, up to about 30%, with consumption of 150 g of fish per day.

Year of project launch: **2024**

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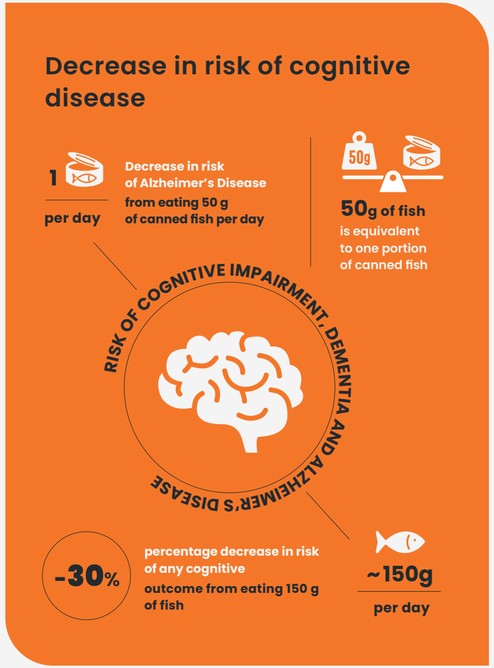

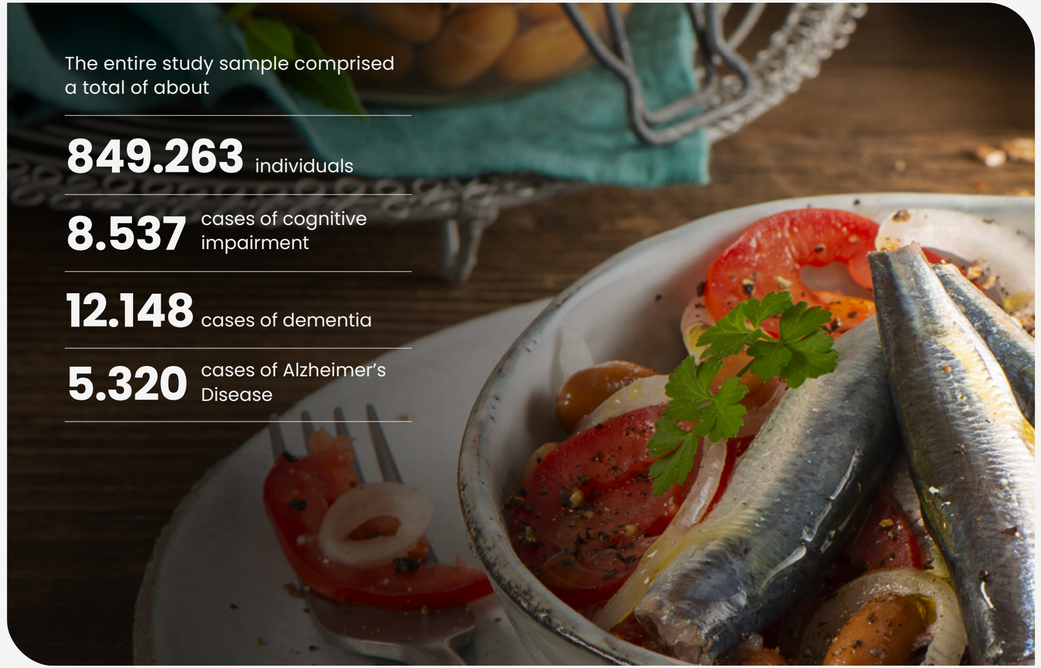

2

EFFECTIVE USE OF RESOURCES AND REDUCTION OF WASTE

Following on from our analysis of the benefits of fresh and canned fish resources in relation to human health, the second chapter will examine their value through the lens of two long-term partnership projects which aim to come up with innovative solutions to reduce seafood waste and reuse by-products in this category for purposes other than food. Global demand for fish projects is growing constantly, with projections indicating a potential increase in demand of up to 56% by 2050 (van Dijk et al., 2021).

This trend reflects the strong increase in consumption of fish products, which exceeded 22 Kg per capita in 2018 (Guillen et al., 2019). In the same year, canned fish alone reached the impressive figure of 727,000 t (Centre for the Promotion of Imports from developing countries, 2021). This rise in consumption embraces various categories of fish products, including pelagic fish, freshwater species, crustaceans, molluscs and aquaculture species, each of which offers unique challenges and opportunities for the fish sector.

Global demand for fish projects is growing constantly, with projections indicating a potential increase in demand of up to 56% by 2050.

In spite of the demand, the fish products processing industry generates a huge volume of waste, estimated at millions of tonnes per year (Gustavsson et al., 2011). For example, for tuna about 40% of the product obtained is usable for food and the remaining 60% subdivides into solid waste (about 36%) and liquid waste (about 25%–35%). This waste includes both edible and inedible by-products. The environmental consequences of disposal of fish waste in ocean waters are considerable, with adverse effects on the level of oxygen in marine ecosystems (US EPA, 2015).

Fish products are highly perishable due to microbe growth, post-mortem enzymatic autolysis and lipid oxidation. Unfortunately, fish's exceptionally high content of free amino acids and soluble nitrogen compounds means that it tends to degrade very rapidly (Kjosbakken and Larsen, 1981).
The consequences of the degradation of fish products are far-reaching, with major financial losses and worrying ecological implications. In view of these environmental and financial concerns, there is an urgent need for the development of alternative methods of conservation.

The wastage of food resources is the focus of the studies presented here as part of the **ONFOODS**[11] project, the Foundation established through an unusual new form of collaboration between 26 organisations working in the field of food and nutrition - including Bolton Food - with top university and research institutes alongside leading Italian companies and cooperatives. As already mentioned in chapter 1, the project is committed to actively improving the future of the community and the supply chain through a new, unique, distinctive sustainable dietary model and to generating a tangible impact on the wellbeing and health of communities and the planet.

40% Percentage of usable product obtained from tuna

36% Left as solid waste

25% Approx. left as liquid waste

ONFOODS is one of the 14 partnerships envisaged by the National Recovery and Resilience Plan (PNRR), established by the Italian Government in the context of the Next Generation EU programme. Falling within the "Models for sustainable nutrition" theme, it will provide funding to the member organisations to finance fundamental research and industrial and experimental development projects. The overall aim of the partnership, which will run for 36 months, will be to put the scientific projects examined into practice within the production system, making research a process enabler for industrial development and a tool for the country's economic recovery.

In June 2024 Bolton Food became a member of a second major extended partnership project. This is **ONE EARTH**, a four-year research project that sets out to develop and assess innovative bio-based solutions for the production of nutraceutical/cosmetic, bioadhesive, agriculture and aquaculture products by exploiting residual biomass of animal origin. Funded by the European Commission's Horizon Europe programme and led by the University of Bologna (UNIBO), the project brings together an international, interdisciplinary consortium of 14 highly qualified partners and experts from eight European and associated countries, including universities, research organisations and industrial leaders, guaranteeing a complete, sound approach.
The chapter will conclude this scientific survey of the field of nutrition by discussing the need to support educational and academic research programmes, to develop young people's skills and create solid foundations for the researchers of tomorrow.

2.1 Reducing food waste through new conservation technologies and strategies

Returning to the issue of population growth and the increase in the demand for foodstuffs referred to in the general introduction to this document, in this section we will deal with the direct consequence of the amount of food waste generated in global food value chains.
The reversal of this trend requires the development of new strategies and technologies for conserving food products in order to reduce waste, for example by optimising storage and packaging. With this in mind, the study[12] run by **Bolton Food** in the context of the **ONFOODS** project together with the **University of Milan** and the Italian National Research Council, together with

the **University of Bari Aldo Moro**, is investigating three ways of extending the shelf-life of foods and beverages:

1. By reducing the risk of photodegradation of packaged foods and beverages.
2. By producing a prototype modified atmosphere container to combat the degradation of fruit and vegetables.
3. By inhibiting the degrading agents in cereal-based foods.

Year of project launch: **2024** | onfoods

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Within the research programme, the project partners will:

- Study the properties of waste-derived molecules.
- Chemically modify these molecules to improve reaction mechanisms.
- Conduct tests by coating the new molecules on recyclable polymers in a photosensitive food packaging case.
- To conclude, produce improved packaging systems.

BY UNIVERSITY OF MILAN

- Simulate the transportation of products and apply a prototype modified atmosphere container which would improve their conservation.
- Assess the quality level of fresh and packaged fruit and vegetables by means of a computerised vision system.
- Examine the volatility of food products and the impact of storage conditions.

BY THE NATIONAL RESEARCH COUNCIL

- Select microorganisms with antimicrobial activity.
- Use the most promising microorganisms for controlled fermentation to synthesise bioactive compounds.
- Use the results of the study to develop prolonged storage methods.

BY UNIVERSITY OF BARI ALDO MORO

2.2 The value of canning

Canning is viewed as one of the most important fish conservation techniques since it maintains most of the resource's range of nutritional benefits. It also allows easy, creative use of the product.
However, in the canning process the raw material undergoes several industrial phases which may expose it to the risk of bacterial contamination and oxidation, and any batches that have degraded in this way have to be disposed of, wasting resources. It is therefore very important to develop more and more innovative strategies for controlling and reducing the risks of oxidation and contamination of fish-based finished products.

In the canning process the raw material undergoes several industrial phases which may expose it to the risk tof bacterial contamination.

Within the ONFOODS project, **Bolton Food** and the **Mario Negri Institute of Pharmacological Research IRCCS** are planning a study to generate innovative analytical approaches to assess early markers of the product's quality and prevent its degradation.

Expected results:

- Identification of compounds for use as quantitative biomarkers for the oxidation and quality degradation of fish products.
- Identification of safe, natural compounds able to prevent or delay the oxidation/ contamination of fish products.
- Generation of new strategies for the application of responsible practices and decisions for reducing food waste.
- Creation of guidelines for effective measures to maximise the use of raw materials when producing the finished product.

Year of project launch: **2024**

ONE EARTH

2.3 Reuse of residual biomass of animal origin: the One Earth project (Horizon Europe)

In this section, the focus of research into the reduction of food raw material waste will shift from improving products' conservation to the reuse of their waste in various contexts. This is the overall purpose of the ONE EARTH project, established to develop integrated circular value chains by using marine biomass for land products and using land biomass for the production of aquaculture products, thus promoting a sustainable and "self-reinforcing" carbon cycle.

The project's main activities are:

- Reuse of cheese whey, chicken feathers and fish residues for the development of circular goods such as cosmetic creams, bioadhesives, pet food ingredients and fertilisers.
- Complete testing of the safety and quality of the products developed.
- Assessment of the economic, environmental and social sustainability of the solutions proposed.

Within this programme, **Bolton Food is stream leader for the development of adhesives from fish waste and is involved in the pharma, cosmetic and fertiliser streams**. The aim is to develop technologies to reuse animal waste in partnership with a large number of Italian and European institutions and corporates. The vision is the improvement of the agricultural and food chain to enable the use of by-products, to reduce waste and optimise its value.

1. Application of peptides for the production of adhesives of organic origin

The fish waste molecules with the most promising adhesive properties and technological feasibility will be selected and bioadhesive formulations will be developed. The partners will test the performance levels achieved and compare them with existing industrial adhesives through laboratory trials.

2. Peptide and PUFA derivates applications for the nutraceutical and cosmetic sectors

The most promising molecular fractions in terms of functional properties and commercial opportunities will be selected and prototype formulations for the nutraceutical and cosmetic sector will be created. The most promising formulations will undergo stability tests to guarantee that the product meets the required physical and chemical, functional and aesthetic quality standards if stored in suitable conditions.

2.1 Formulation and prototyping of nutraceutical products

Three types of prototype will be produced: encapsulated powder, water-dispersable powder (instant beverage format) and liquid supplement.

2.2 Formulation and prototyping of cosmetics

Hand cream, anti-age cream, moisturising/repairing shampoo and keratin formulations will be produced. The products' moisturising properties will be assessed by testing the trans-epidermal water loss of the waste-derived peptides. The efficacy of the shampoo and keratin treatment will be assessed through hair strength/smoothing and damage repair tests performed by an external laboratory

3. Application of fertiliser to soil

Analyses will be performed to measure the contribution of the nutrients in the new product to soil fertility. The results will be used to establish the doses of fertilisers to be used in the pot tests.

Year of project launch: **2024**

ONE EARTH

2.4 Education and academic innovation

Bolton Food's commitment to research into health, nutrition and the effective use of resources is further consolidated with its investments in academic education and research programmes at top Italian universities. The aim is to make a tangible contribution to developing university students' skills by fostering their abilities and talents and supporting health and nutrition research. Bolton Food has been working for years to promote a sustainable growth model through high-value partnerships and thus contribute to the future of coming generations.
"Here at Bolton Food we're strongly committed to promoting values based on sustainability and we're aware of the importance of addressing young people. We've put this commitment into practice through partnerships with the world's top universities, to offer students important educational opportunities within a new model of public-private cooperation, also supported by the research and innovation funding made available by the EU", comments Alberto Dolci, Bolton Food's Global Strategic Health & Science Program Manager.

Study grants at University of Milan

Within the University of Milan's "Food Systems" PhD programme, Bolton Food co-funds two PhD grants for research into "Treatments to reduce the degradation of fresh tuna". It has also launched an additional PhD grant funding the exploration of the role of fish products in a healthy, sustainable diet. The research team comprises professors, researchers and students with interdisciplinary skills. The research costs of activities covered by the ONFOODS project are shared between Bolton Food and the University.

"The mission of the University of Milan's Department of Food, Environmental and Nutritional Sciences is to promote education and develop research to guarantee safe, innovative, quality foods using sustainable technologies throughout the supply chain.

The main aim is to conserve and improve environments, systems and products and provide a holistic approach to these issues, with the final aim of safeguarding and improving people's health and quality of life. Within this context, we have recently established a partnership with international food industry leader Bolton Food to reinforce our research and postgraduate education activities aimed at developing sustainable, innovative strategies in the fish sector with a "food system" approach.

We have put this vision into practice by creating an academic-industrial team that also includes a young PhD student and a post-doc grant-funded researcher in Food Systems, supported by Bolton Food," states Paolo Cortesi, Director of the Department of Food, Environmental and Nutritional Sciences.

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The new degree course at University of Naples Federico II

Since last July Bolton Food has supported the new International Master's Degree Programme in Sustainable Food Systems run by the Department of Agricultural Sciences of University of Naples Federico II, in partnership with various food industry leaders. The programme is an important opportunity to provide tangible support for education in issues of agricultural and food industry sustainability, extending the scope of the company's commitment to education and enhancing the academic offering with new contents and perspectives. Graduates of the programme will have the skills required to embark on a career as sustainability manager in this specific sector, a role crucial for businesses and for which there is strong market demand.
"Partnership with corporations of the calibre of Bolton Food is of fundamental importance for the implementation of this exciting and challenging new programme just launched by the Department of Agricultural Sciences of University of Naples Federico II. The new Master's Degree programme in Sustainable Food Systems is a key part of the educational offering of our project to provide a Department of Excellence funded by the Italian Ministry of Education, University and Research for 2023-2027. The food system sustainability experts we train will benefit from teaching activities undertaken in partnership with businesses, ensuring that the educational programme provides genuine professional

skills and enabling students to get to grips with real-life food industry sustainability cases," declares Danilo Ercolini, Director of the Department of Agricultural Sciences at University of Naples Federico II.

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The new Master's Degree in Food Engineering at University of Padua

Bolton Food, well known for its Rio Mare and Palmera brands, supports the new Master's Degree in "Food Industry Engineering" promoted by the University of Padua (Department of Management and Engineering) launched in September 2024.
Specifically, Bolton Food is on the one hand working on research projects in effective use of materials, improvement of supply chain efficiency, health and nutrition while at the same time promoting an educational approach focused on these issues.

The company has therefore chosen to support the international Master's Degree course entirely focused on the food industry, to contribute its experience and provide access to its knowledge as a player operating within a complex supply chain.
The course intends to produce highly qualified Food Industry Engineering professionals with multidisciplinary skills, able to conceive, plan, design and manage specific food industry processes, systems and services, from raw material procurement through to end product packaging, with a special focus on the issue of safety.
The course will include the one-year research projects funded by the National Resilience and Recovery Fund ("PNRR") intended to improve the efficiency of the supply chain, from the thawing of foods through to the application of artificial intelligence for a multidimensional, multicomponent, multivariable supply chain.
As part of the plan of study, a number of selected students will be offered an internship at the Rio Mare (Bolton Food) plant at Cermenate, Europe's largest and most high-tech and one of the world's leading canned tuna production facilities, where they will be able to apply their theoretical learning in the field.

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Note

1. First complete scientific review of what constitutes a healthy diet from a sustainable food system and the actions capable of supporting and accelerating the transformation of the food system.

2. Research under the aegis of ONFOODS, an extended-partnership multidisciplinary project discussed in greater detail in chapter 2.

3. Participants were recruited and selected by AZTI from various regions of the Basque Country (Biscay, Alava and Guipuzcoa) in association with IMQ Prevention and the OSARTEN Koop clinical analysis laboratory. Participation was open to healthy adults (men and women) with a body mass index (BMI) between 18.5-26.9 kg/m2 (normal and overweight) and with low fish consumption, up to 2 portions of fish per week. Non-eligibility criteria included clinical diagnosis of chronic disease, transplant recipients, use of medication and consumption of omega-3, vitamins and prebiotics in the last 4 months before the start of the study, and allergy to fish or other foods.

4. European Food Safety Authority (EFSA). Food consumption data.

5. North West University (NWU) is one of South Africa's largest universities with three separate campuses (Potchefstroom, Mahikeng and Vanderbijlpark). NWU has an enrolled student population of more than 40,000 and is outstanding in its research and social and ethical awareness. Its aim is to develop a sustainable research and innovation model based on issues of current interest and engagement of the relevant communities.

6. This is a meta-analysis based on a systematic review of the literature, which summarises all the scientific findings published in international epidemiology journals. Specifically, this study estimates the risk reduction which can be linked to fish consumption in accordance with large cohort studies, which observe a large sample group over a long period of time. This study is based on a sample of about 1,500,000 participants monitored over a median period of about 13 years.

7. Hannah Ricci, Maddalena Gaeta, Carlotta Franchi, Andrea Poli, Maurizio Battino, Alberto Dolci, Daniela Schmid, Cristian Ricci. Fish Intake in Relation to Fatal and Non-Fatal Cardiovascular Risk: A Systematic Review and Meta-Analysis of Cohort Studies.

8. Carlotta Franchi, Ilaria Ardoino, Cristina Bosetti, Eva Negri, Diego Serraino, Anna Crispo, Attilio Giacosa, Elena Fattore, Alberto Dolci, Francesca Bravi, Federica Turati, Carlo La Vecchia, Barbara D'Avanzo. Inverse Association between Canned Fish Consumption and Colorectal Cancer Risk: Analysis of Two Large Case-Control Studies.

9. Italian Institute for Planetary Health (IIPH) is a consortium founded in 2019 by the Mario Negri Institute of Pharmacological Research IRCCS and the Catholic University of Milan.

10. Justyna Godos, Agnieszka Micek, Walter Currenti, Carlotta Franchi, Andrea Poli, Maurizio Battino, Alberto Dolci, Cristian Ricci, Zoltan Ungvari, Giuseppe Grosso. Fish consumption, cognitive impairment and dementia: an updated dose-response meta-analysis of observational studies.

11. ONFOODS PE00000003, Ministry of Education, University and Research public notice no. 341 of 15 March 2022 calling for presentation of Project Proposals for the creation of "Partnerships involving universities, research centres and companies to fund basic research projects" within the National Recovery and Resilience Plan, Mission 4 "Education and Research" - Component 2 "From Research to Business" - Investment 1.3, funded by the European Union - NextGenerationEU.

12. University of Bari Aldo Moro, University of Milan, National Research Council (CNR), Free University of Bozen - Bolzano. New strategies and technologies for the storage of food commodities to reduce waste.

About the company

Bolton

Bolton is an Italian family-owned fast-moving consumer goods company with a diverse portfolio of over 60 quality brands.

Bolton has been enriching the lives of millions of people every day for more than 75 years, making their everyday more delicious, more enjoyable, useful, and beautiful.

It's these everyday moments that make the difference on families and the way they live.

All these moments together, help us to have a positive impact on people, communities, and our planet.

www.boltongroup.net

Bolton Food

Bolton Food is the Business Unit of Bolton operating as a leading player in the seafood industry. Bolton Food operates through Tri Marine, #1 leading tuna supplier, and iconic brands like Rio Mare, the only tuna brand with a global footprint, alongside Saupiquet, Isabel, Cuca and Wild Planet.

As a vertically integrated organization with 9,000 employees, 10 plants, and 11 fishing vessels, Bolton Food oversees the entire tuna supply chain – from fishing, processing to procurement, trading, and marketing – ensuring quality at every stage.

Sustainability for nature and people is integral to Bolton Food. The commitment focuses on fostering increasingly responsible fisheries, protecting marine ecosystems, and supporting the communities.

Bolton Food has the ambition to become the #1 fully integrated tuna company for the world.

The contents of the "All the Goodness of Seafood" Partnership Report were produced by Bolton Food.

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