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## Research Article

# A Smart Approach for Food Contaminants Risk Management, Complementary to Diet Nutritional Balance

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### ABSTRACT

Food is usually the major source of human exposure to environmental contaminants like heavy metals and synthetic compounds. This study proposes a quick and simple approach to combine the estimate of the intake of certain pollutants with the diet, in combination with different nutritional plans (Mediterranean diet, weight loss and for athletes). The estimation of the intake of three heavy metals and two perfluoroalkyl substances was carried out by entering the type and quantity of the foods provided by each of the three selected dietary plans in the UltraBio<sup>®</sup> app. Recurring elements are high levels of Cd and Pb and very low levels of PFASs, for all the plans considered. The Mediterranean diet scheme was the one with the lowest intake of all contaminants, which, in any case, remains within the safety limits by a large margin. The high protein diet leads to exceeding the limits for two metals and critical values for the third. The advantages of this approach are mainly represented by the possibility of having a personalized risk assessment of the intake of important food contaminants for the prevention of exposures that, over time, could put health at risk.

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## Introduction

Food safety perceptions are currently a widely investigated topic. Consumers' concerns about food consumption and potential health risks have substantially increased. However, risk perceptions by the general population do not always align with risk assessments provided by experts. The acute vs. chronic context of the hazard may differentially influence people's perceptions of risks, and hence their behaviours. International organizations such as EFSA (European Food Safety Authority) have collected information on the intake of contaminants through the diet to make risk assessments.

Food is usually the major source of human exposure to environmental contaminants like essential or nonessential elements and to a number of synthetic compounds, such as perfluoroalkylated substances (PFASs) [1]. Mercury is a toxic metal; introduction into the body can occur by ingestion, by inhalation of the vapours and by skin contact [2]. The most

dangerous form of mercury is organic, especially methylmercury, present mainly in fish and other foods of animal origin; methylmercury is absorbed and accumulated with greater efficiency, compared to the unbound form, by the tissues of organisms, including man [3]. Chronic exposure to methylmercury, in particular, generates accumulation phenomena in the body, which can lead to neurotoxic effects, impairment of enzymatic activities involved in detoxification processes, which, in turn, generate metabolic imbalances [3].

Furthermore, phenomena such as ataxia, insomnia, paraesthesia, narrowing of the visual field, dysarthria and hypoacusis have been related to exposure to this metal. The serious problem of the environmental toxicity of mercury, deriving from extractive activities and industrial use, has led to a series of initiatives by national and international organizations that deal with environmental protection and public health, committed to its progressive elimination from production cycles in all its forms [4].

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Fish consumption is the most important cause of exposure to ingestion of (methyl) mercury in animals and humans. Some large, terminal predatory and long-lived fish, such as tuna and swordfish, for example, may contain high levels of mercury [5]. FDA recommends for particular categories of people, such as children, women with the prospect of becoming pregnant or breastfeeding, not to consume more than 340 grams of low-mercury seafood (for example, shrimp, canned tuna, salmon or cod) per week. In the case of fish with a higher mercury content, such as fresh tuna or fish caught amateur in uncontrolled waters, the maximum recommended weekly consumption is reduced to 170 grams. However, large fish such as sharks and swordfish should be avoided [6].

A relatively rare metal that occurs naturally as a minor constituent of non-ferrous minerals. It is strongly associated with zinc, whose mines are a major source of pollution, together with the zinc, lead and copper smelting plants, the combustion of coal and the incineration of waste containing this metal [7]. Other uses are as a stabilizer of PVC plastics and as an electrode in nickel-cadmium rechargeable batteries [8]. Diet is the major source of exposure for the general population, even if smokers are particularly exposed: each cigarette contains 1 to 2  $\mu\text{g}$  of cadmium and smoking one or more packets a day means doubling the daily intake of the element [9-12]. Crops grown on contaminated soils or irrigated with contaminated water may contain high concentrations of this element, as well as the meat of cattle that graze on cadmium-rich soils [13]. Cadmium in animal organisms accumulates in the liver and kidney; the latter, therefore, represent, in addition to the target organs in humans, also among the foods most contaminated by this metal [9, 12]. Other foods at risk are seafood, especially shellfish, which are strong cadmium accumulators. The main long-term effects of exposure to low concentrations are chronic lung and kidney diseases and emphysema, as well as damage to the cardiovascular and skeletal systems. Acute toxicity, due to ingestion of heavily contaminated food or drink, leads to a decrease in red blood cells and consequent damage to the bone marrow; calcium metabolism is modified, and this leads to weakening of the bone structure with consequent skeleton fractures and deformations [9].

Lead (Pb) is a nonessential trace element whose biogeochemical cycle has been greatly influenced by human activities, so much so that this metal is considered a ubiquitous pollutant. It is present in some types of paints, in lead-acid batteries and is used in the construction industry for its characteristics of resistance to corrosion and absorption of sound and radiation [14]. The main routes of exposure for humans are food and water: food contributes more to the daily dose, even if the lead present in the water is completely absorbed by the body, compared to that contained in food. The third source of exposure is air, which contributes less than about half of the diet to the introduction of the metal into the body. Almost all environmental exposure to lead concerns its inorganic forms. The metal absorbed is initially present in the blood, associated with the membrane of red blood cells or haemoglobin. At high doses, the excess amount penetrates into the soft tissues, including organs, and especially into the brain; ultimately, it is deposited in the bones, where it replaces calcium [15].

Exposures even to low doses of Pb cause anaemia in humans, inhibiting the synthesis of the heme group of haemoglobin and dysfunction of the reproductive system, such as a decrease in sperm count [16, 17]. With

high doses, the central and peripheral nervous system is damaged and renal inflammation (nephritis) is one of the most common effects of long-term poisoning [18]. At the food level, it is believed that cereals, vegetables and drinking water contribute most to lead exposure for the majority of the European population [13]. Its carcinogenicity in humans has not yet found a clear demonstration: although numerous studies have been carried out on workers with occupational exposure to lead over time, the results that have emerged are controversial [19].

PFASs have been used since decades in a range of industrial and chemical application, leading to wide global distribution in the environment and tissues of organisms, including humans. Several studies towards PFASs indicated that perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) are the chemicals with the greatest adverse effects on human health among the category [20]. Their chemical structures include a totally fluorinated carbon chain that is both hydrophobic and oleophobic, while carboxylic functional group, in the case of PFOA, and sulfonic group, in that of PFOS, add polarity. Due to these peculiarities, PFOA and PFOS are characterized by extremely chemical and thermal stability and high surface activity, with water and oil repellent properties [21].

Despite PFOA and PFOS production have been largely phased out in Europe and North America, the wide use of these compounds and their resistance to degradation processes have led to global distribution in the environment. Nowadays, in fact, they are ubiquitously present in air, water, soil, sediment, biota, outdoor and indoor dust, open ocean waters and even in human tissues [22-27]. Given the ubiquitous spread of these compounds, human exposure to PFAS is inevitable and continuous; people can be exposed mainly through food, for example, through the use of non-stick containers or with the consumption of food from contaminated environments. PFOS has been found in fish, crustaceans, molluscs and drinking water, while PFOA is present to a lesser extent in all foods, with the exception of those coming from environments characterized by specific sources of contamination: food exposure is, therefore a not negligible way, other potential sources are air and dust [1, 28, 29].

The highest concentrations were found in the liver of predators, suggesting that PFAS undergo biomagnification and bioaccumulation at the top of the food chain; a similar distribution therefore also affects the human diet. After absorption, the PFAS accumulates mainly in the blood, kidneys, liver and, to a lesser extent, in other body areas [30]. PFOA and PFOS are present in the blood of mothers and foetuses [31]. These molecules can then accumulate in maternal and foetal blood and lead to delays or changes in proper prenatal development, as they act as endocrine disruptors [32, 33]. Traces of these compounds have been found in breast milk, extending the risk even in the early stages of growth after birth [1, 28]. Many studies show the ability of these substances to interfere in the endocrine system in different ways: they can mimic or block other molecules produced by the body, alter hormone levels, and therefore have repercussions on the functions regulated by hormones [32-35].

The aim of this study is to compare different food schemes to determine any critical issues related to chemical contaminated food intake, using

an easy tool for calculating the intake levels based on recent scientific literature.

- i. a Mediterranean diet pattern (D1) (Table 1)
- ii. a fast weight-loss pattern (D2) (Table 2) and
- iii. a high-animal-protein low-carbohydrate food regimen (D3) (codified in Table 3).

**Materials and Methods**

The selection of specific diet plans was established since they reflected different lifestyles and dietary needs. In this study, three food schemes have been selected:

**Table 1:** D1 - The Mediterranean diet weekly plan considered. Food quantities in grams.

| Day 1       |     | Day 2               |     | Day 3        |     | Day 4               |     | Day 5               |     | Day 6     |     | Day 7       |     |
|-------------|-----|---------------------|-----|--------------|-----|---------------------|-----|---------------------|-----|-----------|-----|-------------|-----|
| apple       | 300 | almond              | 25  | almond       | 25  | apple               | 150 | almond              | 25  | almond    | 25  | apple       | 150 |
| banana      | 120 | bread               | 140 | aubergine    | 150 | bread               | 200 | apple               | 150 | aubergine | 150 | banana      | 120 |
| barley      | 80  | broccoli            | 150 | bread        | 100 | cauliflower         | 150 | bread               | 140 | beans     | 50  | barley      | 80  |
| bread       | 210 | cow milk            | 200 | broccoli     | 150 | chicken             | 120 | cauliflower         | 150 | bread     | 250 | bread       | 140 |
| cauliflower | 150 | Grana Padano cheese | 30  | yogurt       | 125 | cow milk            | 200 | egg                 | 120 | cod       | 150 | cauliflower | 150 |
| cow milk    | 200 | grapes              | 150 | jam          | 40  | anchovy             | 100 | Grana Padano cheese | 30  | cow milk  | 200 | cow milk    | 200 |
| jam         | 40  | honey               | 30  | grapes       | 150 | Grana Padano cheese | 30  | grape               | 150 | escarole  | 150 | jam         | 40  |
| lentils     | 50  | melba toast         | 30  | ham          | 40  | honey               | 30  | honey               | 30  | jam       | 40  | lentils     | 50  |
| lettuce     | 150 | olive oil           | 20  | mackarel     | 120 | lettuce             | 150 | melba toast         | 40  | grape     | 150 | melba toast | 30  |
| melba toast | 30  | pear                | 150 | peas         | 50  | nuts                | 25  | olive oil           | 20  | ham       | 40  | nuts        | 25  |
| nuts        | 25  | red wine            | 125 | potato       | 150 | olive oil           | 20  | pear                | 150 | olive oil | 20  | olive oil   | 20  |
| olive oil   | 20  | ricotta cheese      | 80  | rice         | 80  | pear                | 150 | tomato sauce        | 200 | potato    | 150 | turkey      | 100 |
| salmon      | 100 | tomato sauce        | 200 | melba toast  | 40  | red wine            | 125 | wheat pasta         | 80  | red wine  | 125 | yogurt      | 125 |
| yogurt      | 125 | turkey              | 100 | tomato sauce | 200 | tomato sauce        | 200 | yogurt              | 125 |           |     | courgette   | 150 |
|             |     | wheat pasta         | 80  |              |     | wheat pasta         | 80  | courgette           | 150 |           |     |             |     |

**Table 2:** D2 - The fast weight loss diet weekly plan considered. Food quantities in grams.

| Day 1              |     | Day 2          |     | Day 3              |     | Day 4             |     | Day 5         |     | Day 6             |     | Day 7       |     |
|--------------------|-----|----------------|-----|--------------------|-----|-------------------|-----|---------------|-----|-------------------|-----|-------------|-----|
| espresso           | 15  | green tea      | 300 | milk               | 250 | milk              | 250 | yogurt        | 125 | milk              | 200 | milk        | 200 |
| white sugar        | 5   | cookie         | 50  | dried fruit muesli | 30  | melba toast       | 30  | barley coffee | 50  | melba toast       | 15  | melba toast | 15  |
| jam                | 30  | grapefruit     | 300 | kiwi               | 100 | honey             | 10  | white sugar   | 5   | jam               | 30  | jam         | 30  |
| melba toast        | 50  | bread          | 170 | almond             | 10  | apple             | 200 | melba toast   | 30  | apple             | 150 | orange      | 150 |
| yogurt             | 130 | rocket salad   | 100 | black rice         | 100 | wheat pasta       | 80  | wheat pasta   | 70  | lettuce           | 150 | cauliflower | 100 |
| dried fruit muesli | 20  | olive oil      | 20  | tuna fish          | 60  | fresh tomato      | 250 | olive         | 20  | mozzarella cheese | 100 | rice        | 30  |
| black rice         | 80  | beef           | 50  | fresh tomato       | 200 | anchovy           | 60  | pepper        | 150 | bread             | 30  | olive oil   | 25  |
| aubergine          | 200 | apple          | 200 | olive oil          | 20  | kiwi              | 100 | olive oil     | 10  | olive oil         | 15  | shrimps     | 100 |
| mackarel           | 80  | ricotta cheese | 70  | yogurt             | 130 | almond            | 10  | strawberry    | 160 | banana            | 100 | apple       | 100 |
| olive oil          | 20  | green beans    | 200 | apricot            | 50  | bread             | 50  | red wine      | 125 | spinach           | 150 | salmon      | 120 |
| almond             | 10  |                |     | bread              | 80  | olive oil         | 10  | beef          | 120 | turkey            | 100 | mixed salad | 120 |
| apple              | 200 |                |     | fennel             | 200 | mozzarella cheese | 80  | carrot        | 130 |                   |     | bread       | 10  |
| whole wheat bread  | 30  |                |     | turkey             | 60  | courgette         | 300 | bread         | 60  |                   |     |             |     |
| cucumber           | 200 |                |     |                    |     | asparagus         | 100 | apple         |     |                   |     |             |     |
| chicken            | 80  |                |     |                    |     |                   |     |               |     |                   |     |             |     |

**Table 3:** D3 - The high-animal-protein low-carbohydrate food regimen considered. The first table is referred to the spring/summer diet, the second to the autumn/winter diet. Food quantities in grams.

| Day 1           |     | Day 2         |     | Day 3              |     | Day 4        |     | Day 5        |     | Day 6          |     | Day 7        |     |
|-----------------|-----|---------------|-----|--------------------|-----|--------------|-----|--------------|-----|----------------|-----|--------------|-----|
| bread           | 60  | banana        | 110 | apple              | 140 | apple        | 140 | bread        | 60  | bread          | 70  | apple        | 120 |
| egg             | 55  | beef          | 100 | apricot            | 80  | fresh tomato | 40  | chickpeas    | 60  | chicken        | 150 | beef         | 80  |
| fresh cheese    | 80  | boiled potato | 200 | basil              | 12  | ham          | 30  | fresh tomato | 100 | chocolate cake | 80  | bread        | 60  |
| fresh peas      | 250 | bread         | 60  | bread              | 60  | ham          | 70  | green tea    | 5   | generic fruits | 200 | butter       | 20  |
| fresh tomato    | 50  | carrot        | 100 | dried fruit muesli | 30  | mixed salad  | 60  | ham          | 80  | mixed fruits   | 120 | ice cream    | 90  |
| oat flakes      | 30  | chicken       | 150 | ham                | 70  | olive        | 20  | jam          | 30  | mixed salad    | 160 | mixed fruits | 120 |
| olive oil       | 16  | fennel        | 100 | hazelnuts          | 30  | olive oil    | 16  | melba toast  | 25  | oat flakes     | 30  | mixed salad  | 80  |
| Parmigiano      | 10  | jam           | 30  | mixed fruits       | 120 | orange       | 100 | mixed salad  | 50  | olive oil      | 8   | nuts         | 30  |
| Reggiano Cheese |     |               |     |                    |     |              |     |              |     |                |     |              |     |

|                            |              |                     |              |                            |              |                            |     |                            |     |                   |     |                            |     |
|----------------------------|--------------|---------------------|--------------|----------------------------|--------------|----------------------------|-----|----------------------------|-----|-------------------|-----|----------------------------|-----|
| peach                      | 115          | Grana Padano cheese | 20           | olive oil                  | 41           | pineapple                  | 100 | olive oil                  | 16  | sea bream         | 200 | olive oil                  | 8   |
| tuna fish                  | 50           | green tea           | 5            | Parmigiano Reggiano Cheese | 17           | ricotta cheese             | 60  | Parmigiano Reggiano Cheese | 15  | yogurt            | 125 | sauge                      | 5   |
| wheat pasta                | 70           | lemon               | 20           | Pecorino Romano Cheese     | 60           | salmon                     | 80  | peach plum                 | 115 |                   |     | stuffed pasta              | 150 |
| yogurt                     | 125          | olive oil           | 16           |                            |              | strawberries               | 80  |                            | 140 |                   |     | yogurt                     | 125 |
|                            |              | plum                | 140          | pine nut                   | 4            | wheat pasta                | 70  | rice                       | 50  |                   |     |                            |     |
|                            |              | rocket salad        | 30           | wheat pasta                | 60           | whole wheat bread          | 100 | vegetable puree            | 300 |                   |     |                            |     |
|                            |              | melba toast         | 25           | yogurt                     | 125          |                            |     | yogurt                     | 125 |                   |     |                            |     |
|                            |              | yogurt              | 125          |                            |              |                            |     |                            |     |                   |     |                            |     |
| <b>Day 1</b>               | <b>Day 2</b> | <b>Day 3</b>        | <b>Day 4</b> | <b>Day 5</b>               | <b>Day 6</b> | <b>Day 7</b>               |     |                            |     |                   |     |                            |     |
| apple                      | 150          | apple               | 150          | barley coffee              | 125          | apple                      | 150 | banana                     | 200 | carrot            | 10  | artichoke                  | 200 |
| carrot                     | 35           | banana              | 200          | carrot                     | 100          | carrot                     | 30  | beef                       | 80  | celery            | 8   | aubergine                  | 60  |
| cauliflower                | 200          | broccoli            | 150          | egg                        | 110          | chicken                    | 100 | chickpeas                  | 100 | cod               | 150 | banana                     | 130 |
| chickpeas                  | 50           | chicken dried       | 100          | jam                        | 30           | curry                      | 4   | cod                        | 170 | fresh beans       | 25  | boiled potatos             | 200 |
| fresh peas                 | 40           | fruit muesli        | 20           | kiwi                       | 90           | espresso                   | 7   | dried fruit muesli         | 20  | fresh peas        | 25  | carrot                     | 35  |
| green tea                  | 5            | fresh peas          | 150          | melba toast                | 32           | fresh peas                 | 30  | fresh tomato               | 100 | fresh tomato      | 140 | chocolate bar              | 20  |
| kiwi                       | 80           | ham                 | 60           | millet                     | 60           | ham                        | 20  | green tea                  | 7   | kiwi              | 80  | dried fruit muesli         | 20  |
| olive oil                  | 18           | oat flakes          | 30           | mozzarella cheese          | 80           | olive oil                  | 10  | honey                      | 7   | leek              | 18  | fresh peas                 | 40  |
| Parmigiano Reggiano Cheese | 5            | olive oil           | 20           | nuts                       | 20           | orange                     | 250 | linseed                    | 15  | mozzarella cheese | 120 | fresh tomato               | 70  |
| pear                       | 150          | orange              | 150          | olive oil                  | 13           | paprika                    | 20  | olive oil                  | 13  | olive oil         | 6   | kiwi                       | 80  |
| rice                       | 40           | potato              | 200          | Parmigiano Reggiano Cheese | 25           | Parmigiano Reggiano Cheese | 5   | plum                       | 150 | olive oil         | 6   | oat flakes                 | 30  |
| ricotta cheese             | 30           | rice                | 50           | plum                       | 150          | pepper                     | 100 | rocket salad               | 50  | onion             | 20  | octopus                    | 150 |
| spinach                    | 70           | rice milk           | 125          | pumpkin                    | 250          | pomegranate                | 100 | rosemary                   | 3   | pizza             | 200 | olive oil                  | 13  |
| spinach                    | 50           |                     |              | yogurt                     | 125          | pumpkin                    | 150 | tangerine                  | 140 | pomegranate       | 100 | olive oil                  | 30  |
| veal                       | 100          |                     |              | courgette                  | 300          | rice                       | 50  | whole wheat bread          | 60  | potato            | 30  | onion                      | 8   |
| whole wheat bread          | 50           |                     |              |                            |              | sea bream                  | 150 | yogurt                     | 125 | pumpkin           | 30  | Parmigiano Reggiano Cheese | 5   |
| yogurt                     | 125          |                     |              |                            |              | tangerine                  | 150 |                            |     | ricotta cheese    | 30  | rice milk                  | 125 |
| courgette                  | 75           |                     |              |                            |              | wheat pasta                | 60  |                            |     | spinach           | 180 | ricotta cheese             | 25  |
|                            |              |                     |              |                            |              | whole wheat bread          | 50  |                            |     | tea               | 5   | sea bream                  | 130 |
|                            |              |                     |              |                            |              | courgette                  | 60  |                            |     | whole wheat bread | 50  | spinach                    | 50  |
|                            |              |                     |              |                            |              |                            |     |                            |     | yogurt            | 125 | tangerine                  | 150 |
|                            |              |                     |              |                            |              |                            |     |                            |     |                   |     | tomato sauce               | 60  |
|                            |              |                     |              |                            |              |                            |     |                            |     |                   |     | wheat pasta                | 70  |
|                            |              |                     |              |                            |              |                            |     |                            |     |                   |     | courgette                  | 75  |

The Mediterranean scheme proposed is a 2000 Kcal weight maintenance diet designed for a 75 kg sportsman, while D2 and D3 were 1200 Kcal

diets designed for a 70 kg woman. D3 was also proposed for a 60 kg woman to highlight the different inputs of contaminants in response to a

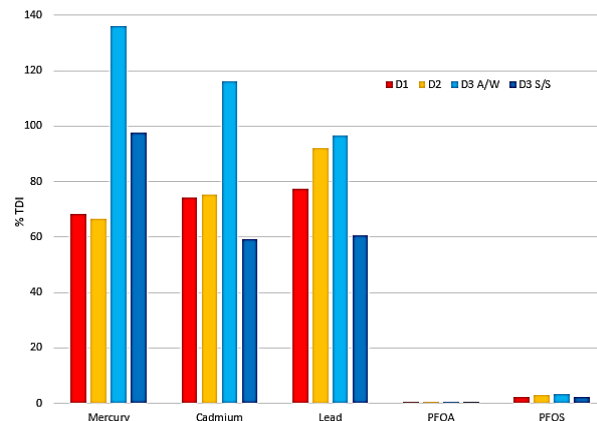
change of body mass. Tables 1-3 report detailed dietary plans considered in the study. D1 and D3, provided by nutritionists and adapted for individual tastes and needs, were two balanced diets that included an intake of carbohydrates from different sources, with the first one including mainly pasta, bread and legumes while the second characterized by consumption of various cereals according to the food pyramid.

In order to estimate the dietary contribution to the intake of contaminants, UltraBio®, the App, completely free of charges, developed by the Bioscience Research Center (BsRC), was used. UltraBio® has been developed by researchers specialized in the fields of food safety, ecotoxicology, risk assessment, environmental chemical and food contamination. The app allows to estimate, on a statistical basis, the quantities of some chemical substances potentially dangerous to health taken with the diet and to calculate the percentage of intake compared to the safety thresholds for the specific substance defined by EFSA. The basic food categories are those foreseen by the food consumption database of the European EFSA population, integrated with other foods where consolidated and scientifically reliable data are available. Chemicals considered are mercury, cadmium, lead, PFOA and PFOS. The app allows to assess weekly levels of contaminants, considering body mass and in relation to the last tolerable intake values established by EFSA. The latter are expressed on a weekly basis (tolerable weekly intakes, TWI); however, to facilitate user management of the instrument, in the UltraBio® app, these limits have been calculated on a daily basis, dividing the TWI by 7 and indicating it as ‘TDI7’ (tolerable daily intake deriving from TWI divided by seven) to distinguish it from a real TDI.

Weekly thresholds were also related to daily thresholds in order to monitor day-to-day contaminant intake. Each diet menu was manually entered into the app, as well as single portion sizes expressed in grams.

**Results and Discussion**

The three diet plans considered led to very different results in terms of contaminants’ intake. At first, what emerged from the weekly reports of the three food regimes was considered; then, what could be the critical points and strengths of each diet plan (Table 4) and (Figure 1) show the results obtained with the selected diet plans.



**Figure 1:** Weekly reports of the three diet plans in terms of percent contaminants intake in relation to TDIs. D3 is divided into autumn/winter (A/W) and spring/summer (S/S).

**Table 4:** Weekly reports of the three diet plans considered in terms of percent contaminants intake in relation to TDIs. D3 is divided into autumn/winter (A/W) and spring/summer (S/S).

| DIET | MERCURY (%) | CADMIUM (%)   | LEAD (%)      | PFOA (%) | PFOS (%) |
|------|-------------|---------------|---------------|----------|----------|
| D1   | 68.24       | <b>74.29</b>  | <b>77.51</b>  | 0.15     | 2.18     |
| D2   | 66.49       | <b>75.31</b>  | <b>92.25</b>  | 0.24     | 3.09     |
| D3   | A/W         | <b>136.27</b> | <b>116.06</b> | 0.21     | 3.37     |
|      | S/S         | <b>97.51</b>  | 59.06         | 0.19     | 2.40     |

**I D1-Mediterranean Diet**

Following the Mediterranean diet plan (including three to nine serves of vegetables, half to two serves of fruit, one to thirteen serves of cereals and up to eight serves of olive oil daily), all the contaminants remain under the safety thresholds. The highest values were observed for Pb and Cd with almost 80% of ‘TDI7’. To identify the cause of this datum, it is necessary to investigate on daily reports, which the UltraBio® app allows to consult. It has been observed that the influence is mainly due to foods such as wheat pasta for cadmium and some types of fruit such as grapes for lead.

**II D2-Fast Weight-Loss Diet**

Although the values remain below the threshold levels, following this scheme, Pb’s levels are very close to the maximum and the Cd’s near 80%. In this case, it has been observed, by daily the report, that cadmium is easily influenced by some kinds of vegetables that require the use of a lot of water for their cultivation or some crustacean meals. Contrariwise,

lead is brought by particular beverages, like barley or green tea infusions, along the whole week.

**III D3-High-Animal-Protein Low-Carbohydrate Food Regimen**

In this case, the diet pattern has been differentiated according to seasonality and the taste of the target subject and shows different results between A/W and S/S. In both cases, mercury is at the highest value and in A/W over the threshold, as well as cadmium that, on the other hand, is of lesser value in S/S. Daily intake shows that the highest values during the winter were mainly due to the frequency and quantity of fish consumed and the type available during the winter period that change drastically in S/S, which increase the number of edible species and reduce the quantity in favour of cold dishes based on cereal, cheese and vegetables.

**IV Comparison between Diet Plans and SWOT Analysis**

Mediterranean diet results in the healthiest one with the lower value of contaminants and good food variability and in agreement with other

authors, the quantity of foods appears to impact health outcomes. The D2 diet appears good, but it does not present variability among foods and the food scheme is very repetitive as well as poor in animal proteins. D3 resulted to be the less healthy diet, although this can be explained by the fact that this scheme is very subjective. Indeed, it is studied for the food and sporting habits of the subject for which it is intended. Considering D3\_A/W\_Day 7 were subject eat fish both for lunch (130g of withe fish) and dinner (150g of octopus), it is observed that Hg, Cd and Pb are all above the threshold. In light of the fact, the subject should not discontinue eating fish but only has to defer it during the week and maybe change the species, as happens for the S/S.

Recurring elements are high levels of Cd and Pb and very low levels of PFASs. Cd and Pb levels, except for cases in which fish raise these values, are influenced by some type of vegetables like carrots or green beans. For PFASs, in general, and with minimal exceptions, only animal foods contribute to the intake and the latter is always far from levels considered harmful to health.

## Conclusion

The D1 Mediterranean diet scheme was found to be the one with the lowest intake of all contaminants, which, in any case, remains within the safety limits by a large margin. Also, from SWOT analysis, considering the overall characteristics of the nutritional plans considered, the Mediterranean diet was preferable. At the opposite extreme, the D3 diet, with a high protein content formulated for athletes, shows the exceeding of the limits for two metals and critical values for the third. Recurring elements are high levels of Cd and Pb and very low levels of PFASs, for all the plans considered. The advantages of this approach, to be used in addition to the elaboration of a nutritionally balanced and personalized diet plan, are mainly represented by the possibility of having a personalized risk assessment of the intake of important food contaminants. This makes the estimate more consistent with reality, even in cases of very special diets. Furthermore, being able to modulate the assessment day by day, on the basis of real consumption data, provides a tool for the prevention of exposures that, over time, could put health at risk.

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