Communication

Update of Dietary Supplement Label Database Addressing on Coding in Italy

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Abstract: Harmonized composition data for foods and dietary supplements are needed for research and for policy decision making. For a correct assessment of dietary intake, the categorization and the classification of food products and dietary supplements are necessary. In recent decades, the marketing of dietary supplements has increased. A food supplements-based database has, as a principal feature, an intrinsic dynamism related to the continuous changes in formulations, which consequently leads to the need for constant monitoring of the market and for regular updates of the database. This study presents an update to the Dietary Supplement Label Database in Italy focused on dietary supplements coding. The updated dataset here, presented for the first time, consists of the codes of 216 dietary supplements currently on the market in Italy that have functional foods as their characterizing ingredients, throughout the two commonly most used description and classification systems: LanguaL^{TM} and FoodEx2-. This update represents a unique tool and guideline for other compilers and users for applying classification coding systems to dietary supplements. Moreover, this updated dataset represents a valuable resource for several applications such as epidemiological investigations, exposure studies, and dietary assessment.

1. Introduction

An integrated and multidisciplinary approach, and the creation of a network, for the study of nutrients and bioactive compounds represent a great challenge [1,2]. The availability of harmonized composition data for foods and dietary supplements are needed in research and policy [3–8]. Current and updated models of specialized databases are fundamental tools for studying the functions and relationships between bioactive components. Metrological approaches are being considered [8]. Such approaches are necessary for a correct assessment of dietary intake and for the categorization and classification of food products and dietary supplements in databases that were structured by starting from specific analytical and compiling data, produced and collected through a standardized and harmonized approach. Particularly, there is consolidated awareness of the importance of nomenclature and description of foods and dietary supplements. Misidentification of foods and dietary supplements related to different methodologies of identifying products makes it difficult to exchange data between countries or even between different institutions of the same nation [6–8]. A database standardized throughout coding allows the presentation of data in a standardized and harmonized format; this is necessary in order to "speak a common language" that allows to compare data from different databases for quick data exchanges and collaborations between countries.

A food supplements-based database has, as a principal feature, an intrinsic dynamism related to the continuous changes in formulations, which consequently leads to the need for constant monitoring of the market and for regular updates of the database.

As defined by the European Commission [9]: As an addition to a normal diet, food business operators market food supplements, which are concentrated sources of nutrients (or other substances) with a nutritional or physiological effect. Such food supplements can be marketed in 'dose' form, such as pills, tablets, capsules, liquids in measured doses etc." [9].

In recent decades, marketing of dietary supplements has increased. Many thousands of products have been advertised as granting health benefits, preventing illness, or even improving psychological or physical performance [10]. The ingredients within the supplements can be minerals, vitamins, amino acids, herbs, botanicals, enzymes, concentrates, extracts, or metabolites and can be used alone or in combination.

Work and stress can cause a hectic lifestyle that forces people to eat fast, and eating frugal meals is one of the main causes of an increased intake of dietary supplements. Other factors have also contributed to the increase in the number of supplements such as the rejection of chemicals in favor of natural products; also, a population of aging baby boomers who care about wellness, fitness, and a better quality of life and a desire to "try everything" in the search for a cure for a chronic condition [10].

In monitoring Europe's market growth [11], it can be seen that key driving factors include a large number of commercialized products available for a wide base of target consumers, as well as an increasing health consciousness of consumers and a growing willingness to spend on nutrition and dietary supplements. The Europe nutrition and supplements market size was 61.8 billion USD in 2021 and is predicted to expand at a compound annual growth rate (CAGR) of 5.8% from 2022 to 2030 [11]. The segment of functional foods and beverages consisted of the largest revenue share with over 55.0% in 2021. The request for these products has increased significantly in relation to an increased consciousness of people towards their health [11].

This study presents an update to the Dietary Supplement Label Database in Italy focused on dietary supplements coding [3]. The updated dataset presented here consists of the codes of 216 dietary supplements currently on the market in Italy that have functional foods as their characterizing ingredients, throughout the two commonly most used description and classification systems: -LanguaL^{TM} and FoodEx2-.

2. Materials and Methods

Dietary Supplement Selection and Coding of Food Items According to International Standards

We have focused our research on a selection of dietary supplements that have functional ingredients as their main ingredients. Dietary supplements have been selected based on their main components; namely, fruits, vegetables, mushrooms, and algae, and so on. Only supplements with clear labels and labels containing all the necessary information for our research purposes have been selected; all pharmaceutical forms have been taken into consideration. The dietary supplements that have been chosen are all marketed in Italy, both in physical stores and in online stores.

LanguaL^{TM} and FoodEx2 were chosen for carrying out the coding procedure because they represent the main classification and description systems, are well developed, and are widely used and recognized at the European and International levels; their common use represents the future direction from the perspective of an automated interchangeability system. The adequate application of classification and description systems are based on official protocols, continuous updating, and multi-disciplinary skills.

Two qualified compilers, which constantly follow the description and classification system updates, carried out the coding procedure.

The procedure is consisted of reporting information on ingredients of dietary supplements from labels, and then assigning a code to each item in line with the classification and description systems, LanguaL^{TM} [12,13] and FoodEx2, Revision 2 [14–21].

LanguaL™ is a faceted categorization system allowing for the systematic description of a food through a set of facet terms. LanguaL™ is a generally recognized method for describing, capturing, and retrieving data about foods. A set of standard and controlled terms is used to describe each product. The facet terms can be used to describe the nutritional

attributes and/or the hygienic quality of a food, such as the biological origin, the cooking techniques, conservation methods, technological treatments; the use of descriptor codes and the arrangement of facet terms in a hierarchic structure allows for the identification of meaningful characteristics.

The FoodEx2 system consists of 21 clearly defined food groups. The system is based on detailed food groups: a food only fits in one group and each food group consists of a parent–child structure. Facet descriptors (32 in total) can be considered to be food characteristics from several view points; additional information for a peculiar aspect of food, i.e., part nature, ingredient, packaging material, production method, qualitative information, process, target consumer, is given by means of facets. Examples of facets are as follows: F01 indicates Source, F04 Ingredient, F09 Fortification agent, F10 Qualitative-info, F28 Process. For FoodEx2, Revision 2, the exposure hierarchy was utilized for the coding procedure. Moreover, the FoodEx2 categories (terms) belonging to the FoodEx2 group "Products for non-standard diets, food imitates and food supplements" (A03RQ) were considered for the classification of the items.

From comparing the LanguaL™ and FoodEx2 systems, some highlights are reported below.

LanguaL^{TM} requires the use of the LanguaL™ Food Product Indexer Software, while the FoodEx2 requires the use of the EFSA Catalogue Browser.

The LanguaL^{TM} code is assigned following a scheme of facets set a priori, which exactly describe the food (food source, origin, physical state, heat treatment, cooking method, treatment, conservation, packaging, etc.) and this scheme should be applied and maintained for all food items; in FoodEx2, for each food product, the terms can be aggregated in different ways depending on the needs (without following a general scheme).

FoodEx2 uses implicit descriptors to reduce the length of the code, while for LanguaL^{TM} all descriptors are fully explicit and structured.

Both LanguaL^{TM} and FoodEx2 are periodically updated thanks to feedback and suggestions from compilers and users. User training courses are run for both LanguaL^{TM} and FoodEx2.

3. Results and Discussion

A total of 216 products have been inserted into the database in order to provide a current representation of supplement/formulation based on functional ingredients. Ingredients of items are reported, and each item was codified by LanguaL^{TM} and FoodEx2, Revision 2.

In Table S1 (see Supplementary Material), ingredients of the 216 products have been reported; in Table S2 (see Supplementary Material), the LanguaL^{TM} codes of the 216 products have been reported; in Table S3 (see Supplementary Material), the FoodEx2 codes of the 216 products have been reported.

3.1. Dietary Supplements Coding

3.1.1. LanguaL^{TM}

In Table S2 (see Supplementary Material), the LanguaL^{TM} codes of the 216 products have been reported. For LanguaL^{TM}, the facet set a priori included: A=PRODUCT TYPE; B=FOOD SOURCE; C=PART OF PLANT OR ANIMAL; E=PHYSICAL STATE, SHAPE OR FORMAT; H=TREATMENT APPLIED; P=CONSUMER GROUP/DIETARY USE/LABEL CLAIM; Z=ADJUNCT CHARACTERISTICS OF FOOD. This facet set a priori scheme was applied to all 216 products items.

The items distributed by Facet A (PRODUCT TYPE) are: 157 DIETARY SUPPLEMENT, HERBAL OR BOTANICAL [A1306]; 33 DIETARY SUPPLEMENT, COMBINATION, OTHER [A1325]; 7 BOTANICAL SUPPLEMENT WITH VITAMIN(S) [A1320]; 7 YEAST SUPPLEMENT [A1307]; 2 DIETARY SUPPLEMENT, OTHER [A1326]; 6 BOTANICAL SUPPLEMENT WITH MULTI-VITAMIN/MINERAL [A1319]; 1 DIETARY SUPPLEMENT, FIBRE [A1328]; 3 [A1318]=BOTANICAL SUPPLEMENT WITH MINERAL(S) (Table S2).

Particularly, the category DIETARY SUPPLEMENT, HERBAL OR BOTANICAL [A1306] indicates supplements based on plants, algae, yeast, and fungi.

The main descriptors used belonging Facet B (FOOD SOURCE), as reported in Table S2, are: PLANT USED FOR DIETARY SUPPLEMENTS [B4168]; FOOD SUPPLEMENTS, MINERAL SUBSTANCES (EC) [B3764]; FRUIT-PRODUCING PLANT [B1140]; VEGETABLE-PRODUCING PLANT [B1579]; OIL-PRODUCING PLANT [B1017]; SPIRULINA [B2039]; ALGAE [B1301]; ALGAE, BROWN [B2395]; ALGAE, RED [B1743]; ALGAE, GREEN [B2502]; YEAST [B1345]; FUNGUS [B1261]; MUSHROOM [B1467]; REISHI MUSHROOM [B2361]; SHIITAKE MUSHROOM [B1635]; MAITAKE MUSHROOM [B3726]; BASIDIOMYCETES [B2035]; POMEGRANATE [B1162]; BLUEBERRY [B1491]; BILBERRY [B2013]; PINEAPPLE [B1484]; PAPAYA [B1249]; GINGER [B1265]; GARLIC [B1233]; ARTICHOKE [B1466]; CARROT [B1227]; PARSLEY [B1550]; SAFFRON [B1459]; OAT [B4319]; FISH [B1222]; OLIVE [B1299]; FOOD ADDITIVE [B2972]; LYCOPENE [B3134]; CAROTENES [B4414].

For each FOOD SOURCE, it was linked the related Facet C to indicate the anatomical part of the plant or animal from which the food product or its major ingredient is derived, components of parts, extracts, and concentrates or isolates. Some examples, from Table S2, are as follows: EXTRACT, CONCENTRATE OR ISOLATE OF PLANT OR ANIMAL [C0228] can be found associated to PLANT USED FOR DIETARY SUPPLEMENTS [B4168]; FAT OR OIL [C0190] can be found associated to OIL-PRODUCING PLANT [B1017] or FISH [B1222]; PART OF ALGAE OR FUNGUS [C0247] can be found associated to MUSHROOM [B1467], ALGAE [B1301], ALGAE, BROWN [B2395], ALGAE, RED [B1743], ALGAE, GREEN [B2502], or SPIRULINA [B2039], and, where not applicable, the descriptors PART OF PLANT OR ANIMAL NOT APPLICABLE [C0005] can be found associated, for example, to YEAST [B1345].

Facet E indicates the physical state of the food product (liquid, semiliquid, semisolid, or solid) and shape and form. Generally, the following Facet E descriptors for dietary supplements are used: POWDER [E0162]; TABLET [E0155]; CAPSULE [E0159]; LIQUID, SUPPLEMENT FORM [E0165]; GEL CAP [E0160]; CHEWABLE TABLET [E0156]; SOFTGEL CAPSULE [E0161] (Table S2).

The descriptor [H0225]=INGREDIENT ADDED refers to the addition of secondary ingredients and it is considered to be a treatment applied to the product. It includes, for example, the following descriptors: NUTRIENT OR DIETARY SUBSTANCE ADDED [H0194], FOOD ADDED [H0180], FAT OR OIL ADDED [H0221], CARBOHYDRATE OR RELATED COMPOUND ADDED [H0301], FOOD ADDITIVE ADDED [H0399], etc.

As an example, in coding the 216 items, the descriptor NUTRIENT OR DIETARY SUBSTANCE ADDED [H0194] has been used to indicate substances added such as: coenzyme Q10, uridine 5′-monophosphate, inulin, enzymatic complex, gamma oryzanol, trans-resveratrol, bromelain, enzymes from fermented maltodextrins, inositol, cholin, bioflavonoids, methylsulfonylmethane, papain, quercetin, L-carnitine, as specified in the "Remark" field.

Moreover, the descriptors used to indicate vitamins, minerals, and other specified nutrients or substances added are as follows: THIAMINE ADDED [H0309]; VITAMIN B6 ADDED [H0771]; BIOTIN ADDED [H0773]; NIACIN ADDED [H0311]; RIBOFLAVIN ADDED [H0658]; PANTOTHENIC ACID ADDED [H0770]; FOLIC ACID ADDED [H0761]; VITAMIN B12 ADDED [H0772]; VITAMIN A ADDED [H0316]; VITAMIN C ADDED [H0215]; VITAMIN E ADDED [H0217]; VITAMIN K ADDED [H0769]; VITAMIN D ADDED [H0214]; ZINC ADDED [H0273]; SELENIUM ADDED [H0777]; COPPER ADDED [H0775]; CHROMIUM ADDED [H0778]; MAGNESIUM ADDED [H0774]; POTASSIUM ADDED [H0195]; MANGANESE ADDED [H0776]; AMINO ACID ADDED [H0210]; CAROTENES ADDED [H0317]; LYCOPENE ADDED [H0559], CAFFEINE ADDED [H0849]; MILK PROTEIN ADDED [H0748].

As an example, in coding 216 items, FLAVORING OR TASTE INGREDIENT ADDED [H0117] has been used to indicate orange and apple flavors. Moreover, the descriptor

SPICE OR HERB ADDED [H0151] has been used according to the scope note: whenever whole or ground spice or herb is added to a food product at any level.

The descriptor used hierarchically included in FOOD ADDED [H0180] is: VEGETABLE ADDED [H0212]. The descriptors used hierarchically placed under CARBOHYDRATE OR RELATED COMPOUND ADDED [H0301], are: CARBOHYDRATE ADDED [H0209]; HONEY ADDED [H0149]; OLIGOSACCHARIDE ADDED [H0240]; MALTODEXTRIN ADDED [H0315].

For indicating the target consumers, the main descriptor used in coding the 216 items is [P0188] = HUMAN CONSUMER, ADULT; for some products, other descriptors are used such as: MENOPAUSED WOMEN [P0261], WOMEN [P0252], or HUMAN CONSUMER, FOUR YEARS AND ABOVE [P0250].

Additional information is given by means of Facet Z. For instance, [Z0291] = ORGANIC PRODUCTION is used to indicate the presence of organic ingredients.

As an example, LanguaL^{TM} codifies a dietary supplement containing as main ingredient garlic bulb dry extract and in form as tablet (from Table S2), by using the string terms: [A1306]=DIETARY SUPPLEMENT, HERBAL OR BOTANICAL; [B1233]=GARLIC; [C0228]=EXTRACT, CONCENTRATE OR ISOLATE OF PLANT OR ANIMAL; [E0155]=TABLET; [P0188]=HUMAN CONSUMER, ADULT. A similar example (from Table S2) is given by coding a dietary supplement containing as main ingredient pineapple stems extract and as a liquid formulation: [A1306]=DIETARY SUPPLEMENT, HERBAL OR BOTANICAL; [B1484]=PINEAPPLE; [C0228]=EXTRACT, CONCENTRATE OR ISOLATE OF PLANT OR ANIMAL; [E0165]=LIQUID, SUPPLEMENT FORM; [P0188]=HUMAN CONSUMER, ADULT.

3.1.2. FoodEx2 (Revision 2)

Table S3 (Supplementary Material) reports the FoodEx2 codes of 216 products. Exposure hierarchy was used for coding.

For each product item, the terms were aggregated in different ways according to their needs, without following a general scheme: a typical case is given by a base term followed (optionally) by a hashtag "#" and a sequence of facet descriptors separated by a dollar character "$". The procedure consists of organizing them to reduce the coding time and prevent general imprecision.

The distribution of the base terms is as follows: 105 products for Herbal formulations and plant extracts [A03SS], 61 products for Mixed supplements/formulations [A03TC], 24 products for Algae-based formulations (e.g., Spirulina, chlorella) [A03ST], 18 products for Other common supplements [A03SV], 7 products for Yeast based formulations [A03TB], 1 product for Fiber supplements [A03SR] (Table S3).

Additional facets used for describing the dietary supplements are as follows: FACET F03 "PHYSICAL STATE", FACET F04 "INGREDIENT", FACET F33 "LEGISLATIVE- CLASSES".

Within the herbal formulations and plant extracts group, the additional descriptors used for indicating ingredients (Table S3) are: Powdered extract of plant origin [F04.A0ETZ], Dried vegetables [F04.A00ZQ], Liquid extract of plant origin [F04.A0EVA], Extracts of plant origin [F04. A0ETY], Dried herbs [F04.A016T], Dried fruit [F04.A01MA], Other plant oils [F04.A037L], Other oil fruits [F04.A016R], Fruit juice concentrates [F04. A03BN], Vegetable juice concentrate [F04.A03CZ], Fruit/vegetable juice concentrate [F04.A0ETV], Herbal infusion extracts [F04.A16GX], Herbal infusion extracts (liquid) [F04.A16GZ], Herbal and other non-tea infusions [F04.A03LG].

Some examples of the application of FoodEx2 code on dietary supplements containing functional foods as main ingredients is as follows. As reported in Table S3, and shown above for LanguaL^{TM}, a dietary supplement containing as main ingredient garlic bulb dry extract and in form as tablet, is codified by FoodEx2 with the terms string: A03SS#F04.A0ETZ$F03.A06JH$F33.A0C16, and as Re-coded: Herbal formulations and plant extracts, INGREDIENT = Powdered extract of plant origin, PHYSICAL-STATE = Tablets, LEGISLATIVE-CLASSES = FA-17.1 Food supplements supplied in a solid form, excluding food supplements for infants and young children, and by inserting into the "Re-

mark" field: "The ingredient indicated as powdered extract of plant origin is garlic bulb dry extract". As another example (Table S3), the FoodEx2 code of a dietary supplement containing as main ingredient pineapple stems extract and as liquid formulation, is: A03SS#F04.A0ETY$F03.A06JL$F33.A0C15 with Re-coded: Herbal formulations and plant extracts, INGREDIENT = Extracts of plant origin, PHYSICAL-STATE = Liquid, LEGISLATIVE-CLASSES = FA-17.2 Food supplements supplied in a liquid form, excluding food supplements for infants and young children, and by inserting into the "Remark" field: "The ingredient indicated as Extracts of plant origin is Pineapple stems extract".

Within the Algae based formulations [A03ST], the main descriptors indicating ingredients, as reported in Table S3, are as follows: Spirulina (platensis) [F04.A0DCQ], Spirulina (maxima) [F04.A0DCR], Green algae [F04.A00VB], Brown algae [F04.A00VK] (Fucus tallus, kelp algae tallus, and so on), Other algae [F04.A0DCP](klamath algae tallus,..). One example of FoodEx2 coding of a product, having as ingredient Spirulina and as tablet formulation, is as follows: A03ST#F04.A0DCQ$F03.A06JH$F33.A0C16, with Re-coded: Algae based formulations (e.g., Spirulina, chlorella), INGREDIENT = Spirulina (platensis), PHYSICAL-STATE = Tablets, LEGISLATIVE-CLASSES = FA-17.1 Food supplements supplied in a solid form, excluding food supplements for infants and young children.

The Yeast based formulations group [A03TB], as indicated in the scope note, includes any type of yeast (normally *Saccharomyces cerevisiae*) based supplements. Yeast formulation found here are enriched with B-group vitamins, coenzyme Q10, or dried fruit.

The FoodEx2 string code of the only product, resulting from coding the 216 items, belonging to Fiber supplements [A03SR], is as follows: A03SR#F03.A06JL$F33.A0C15, with Re-coded:Fiber supplements, PHYSICAL-STATE = Liquid, LEGISLATIVE-CLASSES = FA-17.2 Food supplements supplied in a liquid form, excluding food supplements for infants and young children, by inserting into the "Remark" field that the dietary fiber derived from corn.

Within 18 products classified in the group Other common supplements [A03SV], 2 products have carotenoids as main ingredients and 16 have mushrooms as main ingredients. Mushroom based dietary supplements represent an emerging category of dietary supplements on the market, even if safety aspects should be taken into account [22], so we suggest adding the category into FoodEx2. Mushrooms are not only found as main ingredients but also as ingredients in the Mixed supplements/formulations category. The main species of mushroom used as ingredients for dietary supplements are: *Cordyceps* sporophore, *Mycelium*, Reishi sporophore, Maitake sporophore, Shiitake sporophore, Hiratake sporophore, Bukurio sclerotia, Shiitake, *Hericium*, *Agaricus blazei* Murrill, Lion's mane mushroom.

Some examples of FoodEx2 coding of dietary supplements belonging to the Mixed supplements/formulations are as follows. As an example from Table S3, a dietary supplement containing Orange (*Citrus × aurantium* L.) immature fruits dry extract; Maqui (*Aristotelia Chilensis* (Molina) Stuntz) fruits dry extract; coleus (*Coleus forskohlii*) root dry extract; L-Carnitin, vitamin B5, and in form as tablet, is codified by FoodEx2 by means of the following terms string: A03TC#F04.A0ETZ$F04.A0EXT$F04.A0F4N$F03.A06JH$F33.A0C16, and re-coded: Mixed supplements/formulations, INGREDIENT = Powdered extract of plant origin, INGREDIENT = Vitamin B5 (pantothenic acid), INGREDIENT = Carnitine, PHYSICAL-STATE = Tablets, LEGISLATIVE-CLASSES = FA-17.1 Food supplements supplied in a solid form, excluding food supplements for infants and young children, by inserting into the "Remark" field: "Ingredients indicated as Powdered extract of plant origin are orange immature fruits dry extract, maqui fruits dry extract, coleus root dry extract". Another example, from Table S3, is given by a product having as ingredients: Cranberry dry extract and Bromelain, and formulated as a tablet, is codified by FoodEx2 as follows: A03TC#F04.A0ETZ$F04.A0BXY$F03.A06JH$F33.A0C16 and re-coded: Mixed supplements/formulations, INGREDIENT = Powdered extract of plant origin, INGREDIENT = Microbiological or enzymatic ingredients, PHYSICAL-STATE = Tablets, LEGISLATIVE-CLASSES = FA-17.1 Food supplements supplied in a solid form, excluding food supplements for infants and young children, and by inserting into the "Remark" field:

"The ingredient indicated as Powdered extract of plant origin is Cranberry dry extract. The ingredient indicated as Microbiological or enzymatic ingredients is Bromelain".

4. Conclusions

An updated database of the Dietary Supplement Label Database in Italy focused on dietary supplements coding has been presented here for the first time.

A total of 216 products, as a representative sample of dietary supplements currently on the market in Italy that have functional foods as their characterizing ingredients have been coded by using LanguaL™ and FoodEx2.

LanguaL^{TM} and FoodEx2 represent the main description and classification systems, are well developed, and are widely used and recognized at the European and International levels; their common use represents the future direction, from the perspective of an automated system of interchangeability.

The maintenance and updates of both systems are carried out in a synergistic way through the exchange/interface between users and developers, particularly when considering the evolution of the food market and the new food classification needs in different application fields.

This update represents a valuable tool and guideline for other compilers and users for applying the coding systems specified for products having functional foods as their characterizing ingredients, in the perspective of boost up the relationship between food, nutrition, health, and databases.

Few datasets are present in the literature regarding the application of both systems, LanguaL^{TM} and FoodEx2, on coding dietary supplements. This updated dataset represents one of the first examples of building a dietary supplement database including both LanguaL^{TM} and FoodEx2 coding. This updated dataset represents a valuable and unique tool for nutritionists, dietitians, food developers, and researchers for different applications: i.e., dietary assessment, exposure studies, and epidemiological studies.

Continuous cooperation and sharing of data and ideas between individual compilers and organizations from the perspective of an integrated approach at the food, nutrition, and health interfaces to make data more findable, accessible, interoperable, and reusable is an ongoing challenge.

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