Review on chemical composition of gluten-free food for celiac people

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Abstract

Gluten free food lead to possible nutrient unbalance resulting in improper nutritional quality of diet. The aim of this review is to show and discuss the composition of main components of common gluten free products in order to provide doctors and nutritionists the necessary data to compile balanced diets for users of gluten-free products and to determine their contribution to the daily intake of nutrients and micro elements. Special emphasis has been addressed to metal contents, fatty acid profiles and fibers.

Scopus Library was used to search for articles published and particular attention was focused on literature published from 2007 to 2018. A total of 68 research papers were taken into considerations. Compared to common food, GF products show deficit for nutrients and, at this regard, a GF-diet was found to be poor in essential metals such as iron, zinc, magnesium and calcium. On another hand, higher content of fatty acids, especially saturated fatty acids, were founded in several GF industrial products, bakery products and cookies. For these reasons, despite the GF-diet is necessary in celiac disease treatment, in order to determine diet quality, the evaluation of nutritional value or concentration of macro and micro nutrients they must be considered.

Introduction

Celiac disease (CD) is a common chronic enteropathy disease which affects approximately 1-2% of the word population [1]. CD is intolerance for gluten in genetically predisposed individuals and is characterized by an inappropriate immune response of the T-lymphocytes of the small intestines to gluten peptides [2]. In celiac people, ingestion of gluten leads to inflammation and mucosal damage of the small intestine [3]. The typical lesion in the small intestinal epithelium is villous atrophy with crypt hyperplasia, leading to malabsorption of most nutrients such as minerals (Fe, Ca, Zn, etc.) and others essential components (folic acid, fat-soluble and vitamins) [4]. Today, the only available treatment is a lifelong strict gluten-free diet, which leads to restoration of the atrophied intestinal villi. By removing gluten food from the diet of celiac patients will result, in the majority of cases, a normalization of symptoms and cytological and histological parameters [5]. Generally, coeliac people need assistance from a dietician that has no knowledge on mineral contents or fatty acids, proteins, sugars compositions of available gluten-free products, and, for this reason, it is necessary to know the composition of gluten free foods commonly consumed by individuals with celiac disease.

The increasing number of cases of celiac disease consequently favored the production of numerous commercial food products. In several cases, food companies, in order to improve workability of products, use raw materials at low prices, for an example palm and palmist oils [6,7]. Moreover, in the last ten years, there has been increasing interest on gluten-free bakery and breads. A large type of flours and starches (rice, corn, carob, etc.) as well as many ingredients such as gums, enzymes, soybean proteins, and have been used to mimic the viscoelastic properties of gluten and contribute to improve acceptability and shelf life of gluten-free food [8]. Unfortunately, the use of several bad raw materials long-term can cause several health damages.

On another hand, gluten free diet may lead to possible nutrient deficiencies (such as fiber, micro and macro elements, fatty acids, etc.). In detail, common ingredients used in of gluten-free foods are starch and flour of corn, potato, tapioca, rice, etc) and, these raw materials can be considered poor of several micro and macro nutrients. Moreover, in several cases, gluten-free foods tend to be high in fat and calories to enhance flavor, texture and appearance [9]. Several authors [10] assert that many gluten-free cereal products, compared with the enriched wheat products contain lower amounts of thiamin, riboflavin, niacin, folate and iron products that they are intended to replace.

Generally, literature report inadequate intakes of fiber, iron, and calcium in 50% of celiac females studied [11]. To moderate this leak of nutrients, in few cases, flours are fortified with vitamins and minerals, such as B vitamins and iron [12].

Jason [13], analyzing nearly 1200 gluten free foods (Table 1), affirms that these products have a low average proteins content and are carbohydrate-rich. Considering that the used ingredients are often very low in vitamins and minerals, the Jason findings highlight the need of future researches to examine the levels of these nutrients in foods for celiac people. In addition, Jason affirms that results today do not support the contention that gluten free foods are consistently lower in fiber content or that the nutritional quality of these foods are seriously adversely influenced by the addition of saturated fat or sugar.

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Table 1. Metal contents in raw materials used for gluten free products

Ref.	Sample	Element																	
		P	Ca	Mg	K	Na	Mn	Fe	Ni	Cu	Zn	Cr	Co	As	Se	Cd	Sb	Hg	Pb
		mg/g	mg/g	mg/g	mg/g	mg/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
[13]	Flour corn	-	6.10	4.70	120	1000	-	1100	29	-	500	2.6	-	-	3.2	-	-	-	-
[55]	Flour rice	-	-	-	-	-	22.5	31.2	0.7	2.4	14.9	54	30.6	112	117	26	1.8	2.2	4.0
[55]	Flour wheat	-	-	-	-	-	25.9	38	0.3	3.3	20.1	10	12.8	11	375	45	4.8	0.9	3.0
[55]	Other	-	-	-	-	-	31.7	72.4	2.3	10.3	38	52	108.5	13	199	31	5.3	0.6	8.0
[55]	Whole grain rice	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[55]	White	-	-	-	-	-	7.8	3.7	0.4	2.3	13.1	48	9.3	94	92	38	2.2	1.4	19
[55]	Brown	-	-	-	-	-	28.9	11.5	0.4	3.1	22.5	18	26.4	183	404	27	1.7	1.8	8.0
[55]	Enriched white	-	-	-	-	-	9.3	19.4	0.2	1.8	12.3	58	12.1	177	137	10.9	6.9	1.9	21
[23]	Teff seed	4.29	1.80	1.84	4.27	0.12	-	76.3	-	-	36.3	-	-	-	-	-	-	-	-
[23]	Flour	-	-	-	-	-	18.7	7	-	-	16.6	27	56	101	62	16	-	-	50
[19,22]	Amaranth	-	1.80	2.88	-	-	-	92	-	-	16	-	-	-	-	-	-	-	-
[19,22]	Quinoa	-	0.33	2.07	-	-	-	55	-	-	18	-	-	-	-	-	-	-	-
[19,22]	Buckwheat	-	0.61	2.03	-	-	-	47	-	-	10	-	-	-	-	-	-	-	-
[19,22]	Wheat	-	0.35	0.96	-	-	-	33	-	-	12	-	-	-	-	-	-	-	-
[29]	Quinoa	3.83	1.48	2.50	9.27	-	-	-	-	510	440	-	-	-	-	-	-	-	-
[29]	Wheat	4.68	0.50	1.69	5.78	-	-	-	-	70	470	-	-	-	-	-	-	-	-
[29]	Rice	1.38	0.07	0.74	1.18	-	-	-	-	20	60	-	-	-	-	-	-	-	-
[29]	Barley	5.03	0.43	1.29	5.03	-	-	-	-	30	350	-	-	-	-	-	-	-	-
[33]	Flour for cakes	-	9.8	-	-	-	0.39	9.8	0.04	0.33	6.7	0.08	-	0.01	0.07	0.03	-	-	0.03
[33]	Flour	-	2.6	-	-	-	1.3	-	0.02	0.1	1.1	0.02	-	0.09	0.07	0.03	-	-	0.01
[39]	Teff	-	0.79	-	-	-	-	800	-	-	20.2	-	-	-	-	-	-	-	-
[54]	Teff flour	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	-	-

In two researches, authors [14,15] affirm that the gluten free diets of children and adults are unbalanced, with a appreciably higher protein and fat content. Bardella [15] finds that the diets of adult celiac people furnish lower percentage of energy as carbohydrates compared to that of the non-celiac subjects.

Several studies [16] conducted in the United States found that the abduction of iron, calcium and fiber of the celiac patients is of concern, in particular among female subjects, moreover, Netherlands [17] researches on 111 celiac peoples revealed that, mean intakes of fiber and iron were significantly lower than Dutch recommendations (DRDA) but comparable with the effective Dutch population intakes while saturated fat intake significantly higher.

In celiac diet, two of the most important sources of essential elements is representing from rice, corn and their derivatives. Rice flour contain about 0.04% ashes, 0.21% lipids and 10.7% proteins. Corn flour contains 0.33% ashes and 7.50% proteins. In several cases, field bean semolina (*Vicia faba*) is used in the gluten free food production that contains 0.08% ashes, 1.08% lipids, 30.0% proteins [18].

Recently, pseudo cereals are used in the preparation of gluten free food. A pseudo cereal is defined as any plant that does not belong to the grass family but produces fruits and seeds used as flour for bread and other staple foods. The preminent pseudo cereals known so far are grain amaranth (*Amaranth caudatus*, *Amaranth cruentus*, *Amaranth hypochondriacus*), quinoa (*Chenopodium quinoa*), and buckwheat (*Fagopyrum esculentum*).

The better nutritional properties of pseudo cereals are well known [19], having higher protein percentages than wheat, and constituting a good source of calcium, magnesium and iron. Consequentially, in several cases, pseudo cereals constitute a valid alternative to common gluten-containing grains, add variety and improve nutritional quality of gluten free food.

Protein content in amaranth and quinoa (Table 2) [19] is generally higher than in cereals containing gluten such as wheat [20,21] and is usually highest in amaranth followed by quinoa and buckwheat.

In pseudocereals the protein bioavailability is high, and the amino acid composition is well balanced, with a high content of essential amino acids, and is higher compared to that of cereals containing gluten [19].

Amaranth, quinoa and buckwheat represent good sources of fiber; in buckwheat seeds the content is significantly higher than that of amaranth and quinoa, which have fiber levels comparable to those of common cereals [22].

Teff is a gluten free grain [23] gaining attractiveness due to its positive nutritional properties [24]. The teff flour is rich in fiber due to the incorporate of the bran components. It is also a source of bioactive compounds such as polyphenols [25].

Despite the great rise in consumption of gluten free foods, there is a lack of evaluation of their composition and nutritional profile and how they compare foods containing gluten. Another important issue in environmental and food quality regard to pollution from organic or inorganic substances, because many of these substances are not degradable and can be bioaccumulate in food chain [26,27]. Food and Agriculture Organization of the United Nations (FAO) has discussed the tolerable intake for several food contaminants, including toxic metals as As, Cd and Pb (FAO, 2010). These microelements can be founded in celiac food and their detectable can by scripted by two different origins. The first one depends on the use of massive use of pesticides, the second from possible release from raw materials employed during food manufacturing.

The aim of this review is to show the chemical compositions and discuss the nutritional qualities of GF products in order to provide doctors and nutritionists the necessary data to compile balanced diets for users of gluten-free products and to determine their contribution to the daily intake of nutrients and micro elements. Special emphasis

Table 2. Macro compounds in raw materials and products

Reference	Sample	Fatty acid	Saturated fatty acids	Unsaturated fatty acids	Sugar	Protein	Fiber	Carbohydrites
		ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
[13]	Flour corn	49000	-	800	-	110000	-	-
[29]	Quinoa	63000	-	-	-	165000	3800	690000
[29]	Barley	19000	-	-	-	108000	44000	807000
[29]	Maize	47000	-	-	-	102000	23000	810000
[29]	Rice	22000	-	-	-	76000	64000	804000
[29]	Wheat	23000	-	-	-	143000	28000	784000
[29]	Oat	52000	-	-	-	116000	104000	698000
[29]	Rye	18000	-	-	-	134000	26000	801000
[29]	Bean	11000	-	-	-	280000	50000	612000
[29]	Lupine	70000	-	-	-	391000	146000	353000
[29]	Soya	189000	-	-	-	361000	56000	341000
[23]	Teff seed	23800	44900	16600	18400	133000	80000	730000
[19,22]	Amaranth	57000	-	-	-	165000	206000	-
[19,22]	Quinoa	52000	-	-	-	145000	142000	-
[19,22]	Buckwheat	21000	-	-	-	125000	295000	-
[28]	Amaranth	50000	-	-	-	110000	135700	-
[28]	Buckwheat	25200	-	-	-	130700	119400	-
[28]	Quinoa	34400	-	-	-	113200	145000	-
[32]	Bread	110500	-	-	-	48300	-	811800

has been addressed to metal contents, fatty acid profiles, fibers and vitamins.

Materials and methods

In the last 10 years, documents concerning to gluten free aspects are increasing (Figures 1A-1C). Most of studies concerning to gluten free food, were conducted by US researchers, on another hand, Italy was the second country in term of report produced. At July 2018, literature reporting gluten free as key word shows 6627 documents and only 466 documents are relative at chemistry field. In this context, was necessary to focused attention concerning to several aspect regarding food nutrients in gluten free.

The researches in literature were performed by used the key words *gluten free nutrients* using Scopus as search engine. From the search resulted 58 articles and only 23 are related to nutritional aspects, published from 2007 to spring 2018. The last were considered for the purpose of this review. Other relevant papers concerning to food quality and their chemical analyses were considerate.

Main components in celiac food

Carbohydrates

Starch, the main biopolymeric constituents of plants (grains, tubers and seeds), is the major source of physiological energy in the human diet and accordingly it is classified in general as an available carbohydrate. Some authors [28,29] affirms that in the quinoa, carbohydrates ranges from 67-74% and the amylose content is about 11% which is lower than in cereals. Other carbohydrates are in small amounts: monosaccharide's (2%), disaccharides (2.3%), crude fiber (2.5-3.9%) and pentosans (2.9-3.6%) [30,31]. María Estela Matos [8] established that gluten-free breads show a high contribution to the carbohydrate dietary reference intake (Table 2), moreover, starch is the most important component of teff grain [23] and may amount up to over 70% of the dry weight.

Macroelements

In food, metals and other elements [32-35] can be founded by naturally source or can enter as the result of human activities such

as industrial and agricultural processes. The macro elements are very important in several biochemical processes and play a fundamental role in human homeostasis [36]. The content of some minerals in amaranth, quinoa, buckwheat and teff, determinate by several authors, are shown in Table 1 [37]. High calcium content in amaranth seeds were founded, and about teff grain [23], calcium and magnesium have similar concentration (1800 and 1840 mg Kg⁻¹ respectively), similarly, potassium and phosphorous content are 4270 and 4290 mg Kg⁻¹ respectively. Teff seeds contain 120 mg Kg⁻¹ of sodium. Baye *et al.* [38] showed that the Ca contents of whole grain teff are 788 mg Kg⁻¹. Moreover, numerous researchers have also highlighted the high minerals content of pseudocereals [19-21,38].

In a paper [39] researchers report the results for the quantification of K, Li, Sr, Na, Ca, Mg and Al in seventeen gluten-free food (Table 3). Considering all analyzed food, potassium ranged from 14 to 3747 mg kg⁻¹. The highest contents were found by us in a flour for cakes (3747 mg kg⁻¹), crouton (2479 mg kg⁻¹) and in the two local bread samples (1327 and 1082 mg kg⁻¹). The mean K concentration was 716 mg kg⁻¹ and is very lower those measured in Hispanic products that showed K concentration in the interval 4000 and 5000 mg kg⁻¹ [40-42].

The sodium content of the gluten free food samples ranged from 306 to 12315 mg kg⁻¹ with average of 3015 mg kg⁻¹ and, the highest sodium levels were measured in three bread samples. The sodium concentrations in the analyzed samples are very high, for example the mean Na concentration in some Hispanic wheat cultivars varied significantly between 41.0 and 273 mg kg⁻¹ [43]. The concentration of calcium in samples ranged from 5 to 1682 mg kg⁻¹. The mean value was 413 mg kg⁻¹. The highest values were detected in the Local bread (1682 mg kg⁻¹), Flour for cake (1658 mg kg⁻¹) and Biscuit (1288 mg kg⁻¹), while the lowest concentrations were found in two pasta samples. Magnesium content was in the range 30-1207 mg kg⁻¹. The mean value was 333 mg kg⁻¹. The highest values were detected in the of breadsticks (1207 mg kg⁻¹) and flour for cakes (813 mg kg⁻¹).

Considering the average concentrations of the elements analyzed, excluding lithium, authors concluded that they are inadequate if compared with the recommended daily intake by international

Documents by year

Documents by country or territory

Compare the document counts for up to 15 countries/territories

Documents by subject area

Figure 1. (A) Number of documents concerning to gluten free food from 2007 to 2017; (B) Number of documents produced in several nations concerning to gluten free food from 2007 to 2017; (C) Percentages of studied on gluten free food in several scientific fields from 2007 to 2017

organisms [40], providing only from 1.5 to 20% of the RDI for the essential metals. In particular, considering that many celiac people consume small quantities of potassium which contribute to regulate blood pressure and prevent hypertension. The tolerable upper level intake is exceeded by consuming more than 200 grams of gluten free bread during a day.

Generally, analyses of food were carried out by four steps; sampling, homogenization, mineralization and analyses. Concerning the quantifications of micro and macro constituents of gluten food

matrices, the analyst often has to determine the characteristics of a large quantity of product. Theoretically, the chemist or biologist it should to analyze every part of the material to obtain accurate measures of the property of interest, but, considering practical and economical aspects, this is impossible. At this regard, analyst carry out the analyses on a representative sample and to extend results to all the lot of food. Homogenization is part of the sample preparation procedure and includes mixing and blending of the sample, particle size reduction, and mass reduction.

Literature reported several methods able to mineralize food samples. The most used analytical technique employs sample digestion in a microwave oven by means of HNO_3 (63%) and H_2O_2 (30%). Regarding to determination aspects, at present, official methods for the analysis of micro and macro elements content in food matrices can be conducted by several instrumental and analytical techniques as reported in Table 4. Based on data reported in Table 4, the choice of method depends on several aspects, from metals to concentration levels in sample.

Microelements

The heavy metals of particular concern in relation to harmful effects on health are mercury, lead, cadmium, tin and arsenic. The toxicity of these metals can be expressed by acute or chronic, depending to the fact that they accumulate in biological tissues, for a process known as bioaccumulation. This process of bioaccumulation occurs in all living organisms as a result of exposure to metals in food and the environment and includes biomagnifications processes. On another hand, high levels of several metals, due to pollutant contamination, release during manufacturing process and food

Table 3. Macro-element contents in traditional gluten free food [40]

Sample	K	Li	Sr	Na	Ca	Mg	Al
	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
Pasta	250	3.0	6.6	1205	5	102	21
Noodles	331	19	2.5	409	133	423	0.8
Flour	208	2.8	6.2	905	57	86	16
Biscuits	635	2.8	6.1	1986	69	280	18
Pasta fusilli	386	8.0	0.2	306	106	359	0.6
Pasta linguine	611	2.9	6.3	923	5	207	19
Egg noodles	211	15	102	793	272	373	1.5
Finger biscuits	109	43	4.5	1136	340	291	1.7
Buckwheat biscuits	1238	2.7	6.0	4172	105	495	17
Croutons	14	4.5	78	808	265	256	1.3
Rice noodles	131	2.8	6.3	682	237	224	9.5
Couscous	940	2.6	5.8	838	100	247	18
Corn couscous	905	2.7	48	874	196	273	16
Flour for cakes	3747	2.8	6.2	5427	1658	813	10
Lasagna	1171	2.8	6.2	4071	1098	210	14
Corn flakes	855	2.7	6.0	5245	123	160	1.0
Dietetic biscuits	73	9.1	12	909	826	231	1.0
Breadsticks	322	68	3.5	3209	374	1207	1.5
Local bread B.	1327	5.8	19	10383	1682	317	12
Local bread P.	1082	2.8	6.2	12315	490	308	13
Corn flakes	855	2.7	6.0	5245	123	160	17
Shortbread	72	25	3.5	792	264	279	1.0
Biscuits	33	7.7	2.0	382	1288	436	1.4
Butter cookies	42	15	56	1134	40	314	1.2
Croutons	2479	248	36	5816	637	441	13
Egg biscuits	195	40	3.9	1070	297	30	12
Industrial bread	1115	2.9	13	10520	361	456	23

packaging, can cause health damage because can be considered as interference with essential metals.

Trace amounts of some metals, manganese, copper, and zinc are essential micro nutrients and have a variety of biochemical functions in all living organisms. For example, copper, is present in enzymes and proteins that protecting the body from free radicals [44]. On another hand, these elements can be considered as toxic when taken in excess and some minerals may constitute a potential health risk if consumed above the tolerable upper in-take levels over extended periods. Examples of these are iodine, lead, arsenic, cadmium and mercury poisoning. For other minerals, the negative effects are less hazardous, producing e.g. gastrointestinal problems. For non-essential elements exposures are undesirable, but acceptable levels are determined by the World Health Organization (WHO) and other international authorities [40,45,46]. Indeed, since rice-based foods are widely consumed by celiac people, the exposure to non-essential elements such as arsenic, cadmium and lead is a global concern [47-50].

A study on whole grain teff showed that the Fe and Zn contents are 316 and 23.1 mg Kg⁻¹ (dry basis), respectively [38]. The total iron content (76.3 mg Kg⁻¹) is high if compared with other microelements, is reduced (about 50%) by washing. Another research [23] shows that Mn and Cu contents are higher compared to that of other Ethiopian foods such (maize, wheat, etc.) [51,52]. Rayman [52] quantified selenium in several commercial gluten free products on the European Union market because of its health effects on health. In particular, teff flour contained 120 µg Kg⁻¹ of selenium which results higher than that of the other common flours (14–47 µg Kg⁻¹) but lower than that of oat flour (235 µg Kg⁻¹). A pasta containing Teff, shows a higher Selenium content (90 µg Kg⁻¹) compared to other pasta samples (17 and 25 µg Kg⁻¹) [52].

Punshon [53] analyzing sixty-seven gluten free food products established that the total arsenic concentration in whole grain rice,

rice flour and processed foods containing rice was significantly higher (94000-183000 µg Kg⁻¹) than non-rice flours and processed foods based on other grains (11000-18000 µg Kg⁻¹). This in good agreement to other researches on rice and rice products [54]. The same authors affirmed that rice and rice-based products were significantly lower in iron, nickel, copper, zinc and cobalt compared to wheat flours and food products and the other (rice-free) gluten free flours. Other microelements (Mn, Fe, Cu, Zn, Cr, Co, Se, Sb and Pb) concentrations determined by same authors are shown in Table 5. Moreover, literature [32] affirms that Hg concentrations in gluten free food are lower 4 µg Kg⁻¹, concentration that is much lower than that of fish and seafood, which is generally the major source of mercury to diet. On the contrary, instead, cadmium concentrations (10900-38000 µg Kg⁻¹) are considerably lower in rice based prepared foods compared to foods containing other grains (31000-52000 µg Kg⁻¹).

The aluminum content quantified [39] in seventeen gluten-free food samples ranged from 0.6 to 23 mg kg⁻¹ with average of 10 mg kg⁻¹ and is in agreement to those (0.4-13 mg kg⁻¹) determined by several authors [55,56] in cereals. In this case, the highest Al levels were measured in two pasta samples. Considering that Al additives are contained in specific processed foods, contrary to our expectations, the lower concentrations (about 1 mg kg⁻¹) were found in some that generally, in foods with gluten, contain additives. NaAl₃H₁₄(PO₄)₈ is used in the food industry as a leavening agent in baked goods and Na₈Al₂OH₂(PO₄)₄ as an emulsifying agent [57]. The concentrations of Al in convenience and fast foods analyzed by some researches [58] ranged from 0.85 to 38 mg kg⁻¹, (referred to fresh weight of the edible portion) are higher than gluten free food. In food, aluminum may be: a natural contaminant of vegetal and animal ingredients; a contaminant of industrial food processing; contained in additives; released from kitchenware used for food preparation and/or serving stocking and packaging food materials.

Table 4. Analytical techniques used in metals analyses in food

Analytical techniques	Metal analyzed	Linear range µg Kg ⁻¹	Reference
Flame atomic adsorption	Alkaline and alkaline earth metals	1000-100000	[34]
Furnace atomic adsorption	Alkaline, alkaline earth and transition metal	1-5	[35]
Plasma atomic emission inductively coupled spectroscopy (ICP-OES)	All metals whit some exceptions	1-200	[36]
Inductively coupled plasma-time of flight-mass spectrometry	All metals	1-500	[34]
Electro-analytical techniques	All metals or substance that can be oxidized or reduced	0.1-10	[36]

Table 5 . Microelement contents and total fatty acids in several gluten free food

Ref.	Samples	Salts	Metal													Total fatty acid
	Prepared foods e pasta	ug/g	Mn ug/g	Fe ug/g	Ni ug/g	Cu ug/g	Zn ug/g	Cr ug/g	Co ug/g	As ug/g	Se ug/g	Cd ug/g	Sb ug/g	Hg ug/g	Pb ug/g	ug/g
[55]	Rice	-	20.1	13.3	0.4	2	14.3	189	23.5	141	115	15.9	2.9	3.4	22	-
[55]	No rice	-	13.9	26.1	0.2	3.4	20.9	111	6.7	15	340	52.4	1.7	1	7	-
[55]	Rice	-	17.9	14	0.3	2.2	15	108	19.3	147	114	21.3	3.3	2.5	18	-
[55]	Other	-	33.1	70.7	2.4	10.4	38.1	55	113.8	13	207	31.5	5.2	1.7	1	-
[2]	Snacks	19400	-	-	-	-	-	-	-	-	-	-	-	-	-	22470
[2]	Fast food	14600	-	-	-	-	-	-	-	-	-	-	-	-	-	11660
[2]	Nuts and oilseed	8300	-	-	-	-	-	-	-	-	-	-	-	-	-	45620
[2]	Cereal products	4300	-	-	-	-	-	-	-	-	-	-	-	-	-	11770
[2]	Sauces	19700	-	-	-	-	-	-	-	-	-	-	-	-	-	29910
[2]	Potato products	11600	-	-	-	-	-	-	-	-	-	-	-	-	-	25580
[23]	Pasta	-	6.4	6.1	-	2	9.9	41	19	94	55	14	-	-	55	-

The concentrations of seventeen microelements (As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, Sn, V and Zn) were quantified by Orecchio [32] in twenty-seven samples (Table 6) of gluten-free products (pasta, biscuits, flours, etc.) produced in Italy and collected in 2013 from markets and pharmacies in Palermo (Italy). Inductively coupled plasma mass spectrometry technique (ICP-MS) was used to quantify all the analytes. The highest arsenic and molybdenum concentrations were measured in Rice Noodle from China (0.088 and 0.47 mg kg⁻¹ respectively). The highest concentrations of some metals (Cu, Ba, Cd, Pb, Hg, Sr and V) were found in bread and breadstick samples produced in different bakeries located at Palermo. The analytical results indicate a large variability between samples with respect to metal concentrations, which could be due to the proportion of different ingredients used in the food compositions and to different levels of contaminants in the production laboratories. In particular, foods analyzed contain levels of hazardous trace elements under the limits tolerated by the law and the contribution of the foods to the daily intake of all the elements analyzed remains under the recommended levels by international organisms. Considering the average concentrations of some microelements found in this study, authors concluded that they are inadequate if compared with the recommended daily intake by international organisms, providing from 1.1 to 53% of the RDI for the essential metals. These conclusions are in good agreement to some authors affirming that commercial gluten-free cereal foods, made of refined flours or starches, are of lower nutritional value compared to their wheat counterparts.

Fatty acids

Fatty acids play important roles in human activities. A large variety of fatty acids has been founded in the diet of humans, in the bloodstream and in cells and tissues. Fatty acids, in addition to be energy sources, represent membrane constituents. Indeed, they have

biological activities those explicate actions on tissue metabolism, function, and responsiveness to hormonal and other signals. Through several effects, fatty acids influence health, wellbeing, and disease risk. In this context, food characterization regarding by fatty acids, represents an important tool in order to prevent some health effect. For example, Polyunsaturated Fatty Acids (PUFA) constitute an important group of molecules that promote health, while Saturated Fat Acids (SFA) intake represent a risk for atherosclerotic cardiovascular disease in humans. Substituting polyunsaturated fat for saturated fat reduces LDL cholesterol and the total cholesterol to high-density lipoprotein cholesterol ratio. Epidemiologic studies and randomized clinical trials have provided evidence that replacing saturated fat with polyunsaturated fat is beneficial for coronary heart disease.

Generally, for food analyses, total fatty acids must be extracts from sample and subsequently analyzed directly by weighing. The most important procedures and instruments involved in fatty acid profile determinations in food after derivatization procedures are reported in Table 7.

Many studies were conducted about lipid profiles in food analyses, however, on fatty acids in gluten free foods, literature reported only few studies [7,19]. Alvarez [19] found that lipid content in amaranth and quinoa is between 2 and 3 times higher than in buckwheat and common cereals such as wheat (Table 2). Amaranth, quinoa and buckwheat lipids contain fatty acids having high degree of unsaturation, which is favorable from a nutritional point of view. Linoleic acid is the most abundant fatty acid (50% of the total fatty acids in amaranth and quinoa, and approximately 35% in buckwheat) followed by oleic acid (25% in amaranth and quinoa and 35% in buckwheat) and palmitic acid [10,19,59-61]. High α -linolenic acid (C18:3 n-3) percentage is contained in quinoa seeds ranging from 3.8-8.3%

Table 6. Microelement contents in gluten free food [33]

Sample	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo	Cd	Sn	Sb	Ba	Hg	Pb	Fe
	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
Pasta	0.0001	0.0091	0.47	0.0003	0.016	0.3	1.2	0.0004	0.010	0.016	0.074	0.0019	0.0071	0.0018	0.04	0.0010	0.33	1.1
Noodles	0.0008	0.0268	1.6	0.0026	0.049	0.6	4.4	0.013	0.026	0.36	0.134	0.0043	0.0085	0.0044	0.38	0.0008	0.0061	4.6
Biscuits	0.0044	0.015	3.9	0.0086	0.22	0.94	4.6	0.0064	0.016	0.18	0.108	0.010	0.0039	0.0045	0.17	0.0004	0.0051	4.6
Pasta fusilli	0.0039	0.011	1.4	0.0008	0.25	0.49	3.8	0.0004	0.017	0.11	0.033	0.0019	0.0026	0.0025	0.09	0.0001	0.0033	6.2
Pasta Linguine	0.0075	0.078	1.4	0.0570	0.53	0.49	3.8	0.0004	0.014	0.11	0.035	0.0018	0.0009	0.027	0.08	0.0001	0.0035	9.5
Egg noodles	0.0021	0.031	1.9	0.0025	0.06	0.46	4.0	0.011	0.058	0.77	0.093	0.0084	0.0034	0.0026	0.26	0.0001	0.0014	5.4
Finger biscuits	0.0065	0.16	0.80	0.0028	0.10	0.4	5.6	0.017	0.065	1.13	0.20	0.0024	0.0026	0.0096	0.31	0.0024	0.04	8.9
Buckwheat biscuits	0.0093	0.040	5.0	0.0178	0.33	1.6	6.5	0.019	0.015	0.23	0.26	0.0174	0.0026	0.0093	0.45	0.0030	0.03	8.3
Croutons	0.028	0.21	7.5	0.0270	0.50	0.63	3.6	0.022	0.037	4.7	0.37	0.0079	0.0028	0.019	0.76	0.0031	0.04	13.7
Rice noodles	0.0033	0.13	5.1	0.0151	0.14	1.7	10.7	0.088	0.027	0.44	0.47	0.026	0.0028	0.0083	1.00	0.0049	0.03	3.6
Couscous	0.0029	0.040	1.0	0.0101	0.31	0.48	3.2	0.0081	0.023	0.16	0.20	0.0044	0.0026	0.0053	0.15	0.0015	0.02	4.3
Corn couscous	0.0054	0.063	0.81	0.024	0.12	0.37	2.9	0.0078	0.0088	0.16	0.11	0.0028	0.0026	0.010	0.14	0.0010	0.02	5.0
Lasagna	0.071	14.4	2.5	0.54	15.0	1.5	7.2	0.017	0.062	1.8	0.41	0.021	0.0030	0.026	0.88	0.0325	0.21	99
Corn flakes	0.028	8.4	2.1	0.15	10.3	1.1	3.3	0.0086	0.062	0.70	0.30	0.040	0.0084	0.0066	0.91	0.0183	0.34	55
Dietetic biscuits	0.049	9.1	1.5	0.15	10.0	1.2	3.7	0.014	0.016	1.4	0.24	0.013	0.0031	0.014	0.61	0.065	0.19	62
Breadsticks	0.035	8.7	4.4	0.16	10.5	1.1	5.0	0.036	0.026	0.75	0.28	0.020	0.0030	0.013	0.44	0.082	0.10	62
Local bread B.	0.074	8.7	3.1	0.17	10.3	1.7	5.8	0.014	0.019	5.1	0.24	0.023	0.0031	0.017	2.8	0.037	0.26	66
Local bread P.	0.036	8.7	4.8	0.16	10.2	1.8	8.4	0.056	0.013	2.2	0.33	0.032	0.0046	0.016	0.63	0.13	0.39	70
Corn flakes	0.031	8.1	2.1	0.15	10.0	1.1	3.5	0.0086	0.065	0.56	0.29	0.024	0.0035	0.0049	0.88	0.013	0.20	60
Shortbread	0.033	9.7	3.8	0.19	12.4	1.4	137	0.044	0.033	0.51	0.36	0.12	0.0031	0.0096	0.62	0.015	1.09	80
Biscuits	0.057	14.0	4.7	0.20	14.0	1.6	7.4	0.032	0.051	0.94	0.35	0.016	0.0028	0.028	0.46	0.022	0.074	83
Butter cookies	0.054	14.0	4.6	0.19	13.8	1.1	6.0	0.043	0.009	0.32	0.42	0.024	0.0028	0.016	0.58	0.021	0.063	75
Croutons	0.005	0.031	4.4	0.013	0.11	1.8	6.7	0.062	0.021	1.5	0.36	0.014	0.0026	0.0011	0.38	0.017	0.026	10
Egg biscuits	0.014	0.035	6.1	0.011	0.21	1.3	6.3	0.055	0.016	1.6	0.32	0.021	0.0026	0.0013	0.32	0.0095	0.028	4.6
Industrial bread	0.052	0.054	2.2	0.015	0.17	0.94	3.7	0.020	0.014	1.5	0.28	0.0050	0.0026	0.0031	0.60	0.0059	0.052	21

[61]. A high percentage of α -linolenic acid is advantageous because reduces cardiovascular disease, cancer, osteoporosis, inflammatory and autoimmune diseases [62].

Several authors [23,51] affirm that the lipid content of teff (3.7 - 4.4 %) is higher than that of wheat (3.6%), rice (0.9%), sorghum (3.5%), and maize (2.5%) flours, and was lower than that of oat (6.7%) and quinoa (8.6%) [23,63]. The majority of the free fatty acids are unsaturated (84%) and are similar to that of maize, sorghum, and quinoa. Linoleic (50%) and oleic (29%) are the predominant acids and are similar to those of sorghum and maize [63]. Other analyses carried out by Gebremariam [24] showed that the content of oleic acid (32%) was higher than that of linoleic acid (24%) as affirmed previously. As in other cases, the variances may be due to the different analytical methods and teff genetics (Table 8).

A recent study [7] carried out by us included 35 different products (snacks, biscuits, bakery products, pasta, flours, etc.) from several Italian manufacturers. Table 9 shows the data concerning proteins, energy, carbohydrates, and salts of the foods taken into consideration for the determination of individual fatty acids. The data in Table 9, with the exception of the total and saturated fatty acids content, were obtained from the labels of the aforementioned gluten free products. Furthermore, Table 9 shows, for comparison (R_{flour0} , R_{flour00} , etc.), the data concerning some containing gluten. After extraction and esterification, the fatty acid composition was determined by gas chromatography (Table 10). The mean content of total lipids was 12.6 %. The highest percentages were found in a wafer biscuit (25%) and in a muffin (23%) sample, while the lowest in a flour mix for bread (1.2%). Saturated fatty acids were contained in all analyzed samples ranging from 2.8 to 72%. The highest contents were found in the wafer biscuit (72%) in an Easter cake (66%) and in the rice, corn, and red fruit flakes sample (63%),

while the lowest (2.8%) percentage in a biscuit sample. Palmitic acid was the major component, and high amounts of this fatty acid were detected in all samples. Meanly, monounsaturated fatty acids (MUFAs) were found to be the major constituents (57%), followed by saturated fatty acids (SFAs) (30%), and polyunsaturated fatty acid (13%). Only 15 of the 35 gluten-free products analyzed supply adequate energy intake, while, in 11 samples, saturated fatty acids were found to give more energy than that recommended by the European Food Safety Authority EFSA [64]. Moreover, data analyses showed that, although gluten-free commercial products are high added-value foods, industrial products in many cases contain palm and palm kernel oils, whereas the local producers generally use the finest raw materials, such as olive oil.

Albuquerque [65] studying nuts and oilseeds, often used in the preparation of gluten free cakes, showed the highest fat content of these ingredients followed by sauces, potato and potato-products, and snacks samples. These were also the ingredient showed a higher MUFA and PUFA contents, whose percentages were significantly higher in the nuts and oilseeds.

Proteins

According to information furnished by suppliers, an evaluation on the nutritional characteristics of gluten-free breads representative of the Spanish market was carried out by Matos Segura [32]. The authors established that the protein, fat and mineral content of the gluten-free breads showed great variation, ranging from 9.0 to 155 g Kg⁻¹ g, 20.0 to 261 g Kg⁻¹ and 11.0 to 54.3 Kg⁻¹, respectively. Furthermore, gluten-free breads show very low contribution to the recommended daily protein intake, with a high contribution to the carbohydrate dietary reference intake. A research affirms that the protein contents of two variety of teff are 12.8 and 10.5%, which result higher compared to that of other cereals [63,66].

Table 7. Procedures and instruments used in fatty acid determination in food sample

Sample	Extraction/purification procedure	Derivatization procedures	Analytical instrument
Oil	SPE; Dilution	KOH in methanol CH ₃ NaO in methanol BHT in methanol	GC-FID; GC-MS; GC-FID; GC-MS; GC-FID; GC-MS; HPLC-MS; HPLC-MS;
	SPE; Dilution Bligh and Dyer method		
Liquid sample (milk, fruit juice)	Funnel separation	KOH in methanol CH ₃ NaO in methanol BHT in methanol	GC-FID; GC-MS; GC-FID; GC-MS; GC-FID; GC-MS; HPLC-MS; HPLC-MS;
Solid samples	Soxhlet Ultrasonic bath	KOH in methanol CH ₃ NaO in methanol	GC-FID; GC-MS;

Table 8. Micro and macro nutrient contents in several gluten free food

Ref.	Sample	Minerals	Na	Mn	Fe	Cu	Zn	Cr	Co	As	Se	Cd	Pb	Fatty acid	Protein	Sugar
		ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	mg/g	mg/g
[18]	G. F. products from Vicia faba	-	-	-	-	-	-	-	-	-	-	-	-	18000	300000	-
[2]	Bakery Products	760	-	-	-	-	-	-	-	-	-	-	-	174600	-	-
[2]	Cookies, biscuit and wafers	700	-	-	-	-	-	-	-	-	-	-	-	201600	-	-
[23]	Cookies, cereal bars	-	-	9	13.5	2.1	8.4	43	13	53	101	11	69	-	-	-
[13]	Cereal bars	-	54	-	-	-	-	-	-	-	-	-	-	50000	90	300
[13]	Cake	-	300	-	-	-	-	-	-	-	-	-	-	340000	50	440
[13]	Sweet biscuits	-	183	-	-	-	-	-	-	-	-	-	-	130000	45	310
[13]	Ice Cream	-	490	-	-	-	-	-	-	-	-	-	-	51000	33	184
[13]	Corn and potato chips	-	5960	-	-	-	-	-	-	-	-	-	-	40000	60	30
[13]	Cured meats, sausages and hot dogs	-	10560	-	-	-	-	-	-	-	-	-	-	80000	180	90
[13]	Sugar-based confectioneries	-	5100	-	-	-	-	-	-	-	-	-	-	20000	3400	380

Table 9. Nutritional characteristics of analyzed gluten free samples and reference food (R_x) [7]

N°	Sample	Energy (Kcal/100 g)	Total fats (g/100 g)	Saturated fatty acids (g/100 g)	Carbohydrates (g/100 g)	Proteins (g/100 g)	Sals (g/100 g)
Flours							
1	Rice flour	365	1.3	0.29	80.15	6.67	0.1
2	Red teff flour	380	1.4	0.27	-	-	-
3	Flour for bread	352	1.2	0.3	79.6	5	0.01
Rflour0	Flour 0 with gluten	363	1.5	0.27	73.8	11.5	-
Rflour00	Flour 00 with gluten	366	1.5	0.3	76.2	9.7	-
Rfrice	Rice flour	366	1.4	0.39	80.1	5.9	-
Rfcorn	Corn flour	375	1.4	0.17	82.8	5.6	-
Bread							
4	Handcrafted bread	360	3.7	0.9	-	-	-
Rbread1	Bread with gluten	271	3.5	0.86	50	8.8	-
Rbread2	White Bread with gluten	238	2.1	0.63	43.9	10.6	-
Breadsticks							
5	Breadsticks a	425	9	1.8	75	2.4	1.9
6	Breadsticks b	416	8.5	3.2	79.9	4	2.7
7	Breadsticks c	462	17.2	2.54	73.57	0.99	1.6
8	Breadsticks d	446	14.6	2.9	75	2.4	1.9
9	Breadsticks with olive oil	431	12	3.5	79	1.3	2.12
10	Breadsticks with rosemary	460	16	5.13	76.32	2.04	2.8
11	Mini breadsticks	427	12.8	1.7	74.9	1.4	1.2
Crackers							
12	Buckwheat crackers	369	3.6	0.6	72	9.1	2
13	Crackers with rosemary	446	12	7.1	79	3.3	1.3
14	Rice Crackers	454	13.8	1.3	78.5	2.8	1.9
15	Turmeric crackers	455	17	1.8	66	7.6	2.1
Rcrackers	Crackers with gluten	421	8.9	2	74.3	9.5	-
16	Corn and quinoa crackers	422	9.8	0.9	79.5	1.8	1.7
Snack							
17	Apricot snack	620	7.5	0.99	71	2.5	0.23
18	Crispy sheets	436	12	1.5	78.5	2	1.86
22	Rice and corn flakes	382	2	0.4	83	6.4	0.3
Biscuits							
19	Chocolate biscuits	453	14	7.7	77	4	0.55
20	Biscuits d	422	18.4	2.3	66.3	4.6	0.3
21	Biscuits f	451	15	7.8	72	5.4	0.4
23	Lemon biscuits	435	11	1.5	78	4.6	0.9
24	Seven cereal biscuits	456	16.5	9.1	72	3.5	3
25	Biscuits o	456	13	4.6	83	2	0.57
26	Chocolate wafer	505	25	16	62.1	6.4	0.25
Rw	Wafer with gluten	433	14.2	4.2	72.4	6.6	-
29	Biscuits n	439	14	4.2	69.4	7	0.7
30	Tumeric biscuits	441	16	1.8	78	2.3	0.33
31	Chocolate biscuits	425	11.7	2.7	73.6	5.1	0.8
33	Buckwheat biscuits	444	14	8.9	72	4.2	0.85
34	Biscuits c	372	19.9	2.5	52.8	4.4	0.07
35	Crunchy cereal biscuits	472	18	8	70	5.3	0.75
Muffin and cakes							
27	Easter cake	410	18	14	-	-	-
32	Quinoa cake	407	17	2.5	55	7.3	0.5
28	Chocolate muffin	441	23	8.6	52	3.9	0.5
Rm	English muffin with gluten	223	2	0.29	44.8	8.7	-

Table 10. Fatty acids composition (% on total fats) of gluten free food (the numbering and the description of the samples correspond to those of table 8) [7]

Fatty acid	Samples																																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	mean	
C4:0	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,22	0,01	0,01	0,01	0,01	1,29	0,21	0,01	0,08	0,01	0,01	0,01	0,01	0,01	0,01	0,4	0,01	0,01	0,071
C6:0	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,03	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,54	0,01	0,06	0,3	0,01	2,25	0,24	0,1	1,3	0,01	0,01	0,01	0,01	0,01	0,01	0,6	0,01	0,01	0,162
C8:0	0,01	0,01	0,01	0,01	0,01	0,04	0,01	0,04	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,42	0,01	0,8	1,84	0,01	3,06	0,23	1,7	0,87	0,01	0,01	0,01	0,01	0,01	0,94	0,01	0,01	0,291	
C10:0	0,01	0,01	0,01	0,01	0,01	0,01	0,05	0,01	0,03	0,01	0,01	0,05	0,01	0,02	0,01	0,01	0,01	0,01	0,63	0,01	0,82	1,65	0,01	0,65	0,67	2,32	1,5	0,03	0,01	0,04	0,01	0,01	2,5	0,01	0,01	0,321	
C11:0	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,06	0,01	0,04	0,01	0,01	0,14	0,01	0,02	0,03	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,017		
C12:0	0,01	0,01	0,01	0,01	0,16	0,39	0,01	0,08	0,01	0,01	0,2	0,01	0,21	0,01	0,01	0,02	0,01	0,01	0,88	0,01	10,1	16,9	0,01	1,89	0,96	20,6	2,8	0,67	0,01	0,01	0,01	0,01	3,5	0,01	0,04	1,70	
C13:0	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,1	0,01	0,01	0,01	0,01	0,45	0,04	0,04	0,09	0,01	0,01	0,01	0,01	0,01	0,11	0,01	0,01	0,03	
C14:1	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,22	0,01	0,01	0,01	0,01	4,0	0,49	0,01	0,62	0,01	0,01	0,01	0,01	0,06	1,1	0,01	0,01	0,20	
C14:0	0,18	0,01	17,7	1,2	0,01	1,3	0,01	0,32	0,1	0,01	0,79	0,05	1,3	0,0	0,03	0,05	0,09	0,17	3,3	0,2	4,6	10,6	0,05	8,11	3,15	12,6	9,3	0,26	0,01	0,16	0,06	0,12	11,0	0,04	0,64	2,50	
C15:1	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
C15:0	0,01	0,01	0,01	0,01	0,01	0,1	0,01	0,01	0,01	0,01	0,05	0,03	0,11	0,01	0,01	0,0	0,01	0,02	0,64	0,05	0,17	0,01	0,01	0,7	0,6	0,08	0,76	0,16	0,01	0,02	0,01	0,03	1,44	0,01	0,03	0,15	
C16:1	0,01	0,01	0,01	0,01	1,3	0,6	0,01	7,4	1,23	0,01	1,1	1,7	0,53	0,01	0,01	0,0	0,11	0,58	1,16	0,01	1,2	0,01	0,29	1,03	1,02	0,26	0,98	2,87	0,01	0,5	0,43	0,71	1,77	0,38	0,01	0,77	
C16:0	15,4	13,6	0,01	17,6	11,5	33,3	4,5	22,8	11,9	34,3	7,4	18,6	51,1	2,8	4,9	2,2	9,7	10,9	29,4	10,1	33,3	24,0	6,1	28,0	16,0	22,0	34,6	33,4	1,3	4,1	8,9	12,1	28,9	4,8	41,0	17,4	
C17:1	0,01	0,01	0,01	0,01	0,23	0,14	0,01	0,74	0,13	0,01	0,2	0,01	0,2	0,01	0,07	0,01	0,01	0,17	0,01	0,19	0,15	0,01	0,03	0,01	0,48	0,01	0,01	0,01	0,01	0,09	0,03	0,05	0,01	0,08	0,01	0,09	
C17:0	0,01	0,01	0,01	0,01	0,15	0,19	0,01	0,51	0,12	0,01	0,12	0,01	0,31	0,01	0,03	0,02	0,01	0,13	0,32	0,08	0,33	0,01	0,03	0,19	0,28	0,2	0,31	1,12	0,02	0,06	0,06	0,06	0,7	0,04	0,05	0,158	
C18:3 w6	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,0		
C18:2n6 cis	38,0	40,7	29,4	4,5	3,9	5,1	7,9	22,8	1,6	6,0	4,1	26,8	3,9	1,9	10,6	8,4	13,5	12,5	3,1	11,4	7,1	10,5	47,2	3,2	2,1	5,75	3,58	6,9	0,92	4,2	40,9	47,0	6,55	7,84	14,7	13,3	
C18:1n9 cis	42,9	40,7	52,9	70,5	74,5	55,4	82,0	22,8	78,7	56,3	79,2	48,9	37,3	92,3	79,9	83,5	71,8	67,4	42,2	72,0	35,3	26,2	42,7	33,8	67,4	22,7	28,0	37,4	96,5	80,2	43,9	34,3	25,1	79,3	37,6	55,5	
C18:2 n6 tr	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
C18:1 n9 tr	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
C18:0	3,0	4,8	0,01	6,2	5,9	2,3	4,6	16,7	4,2	3,3	1,4	3,2	3,9	3,1	2,0	1,4	4,0	5,4	16,7	4,9	4,2	8,0	2,8	9,2	4,9	12	14,2	8,7	0,23	1,4	2,5	3,7	12,2	2,6	5,8	5,41	
C20:4 n6	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,21	0,27	0,01	0,01	0,01	0,01	0,01	0,01	0,02		
C20:5 n3	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
C20:3n3+n6	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,42	0,01	0,01	0,1	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,024		
C20:2 n6	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
C20:1	0,01	0,01	0,01	0,01	0,97	0,47	0,01	2,09	0,7	0,01	0,01	0,36	0,01	0,01	0,49	0,01	0,01	0,73	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	1,6	0,01	1,7	0,49	0,08	0,01	0,85	0,01	0,307	
C20:0	0,59	0,18	0,01	0,01	0,98	0,66	0,29	2,9	0,91	0,01	1,9	0,4	0,99	0,01	0,59	0,96	0,41	0,88	0,25	0,43	1,0	0,01	0,22	1,1	0,45	0,24	0,39	4,6	0,45	1,7	1,2	0,11	0,19	0,96	0,17	0,746	
C21:0	0,01	0,01	0,01	0,01	0,05	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,06	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,013		
C22:6	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,03	0,03	0,01	0,07	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,013		
C22:2	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
C22:1n9	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01		
C22:0	0,01	0,01	0,01	0,01	0,51	0,27	0,73	0,58	0,36	0,01	2,8	0,01	0,07	0,01	1,1	2,9	0,31	0,81	0,16	0,62	0,34	0,01	0,49	0,42	0,9	0,18	0,09	0,9	0,65	4,8	1,4	0,24	2,9	2,9	0,01	0,787	
C23	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,05	0,12	0,01	0,07	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,04	0,01	0,01	0,02	0,7	0,01	0,07	0,01	0,16	0,01	0,01	0,043		
C24:0	0,01																																				

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