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SPANISH NUTRITION FOUNDATION

NUMBER 16

ANIBES

Iron Intake and Dietary Sources in the Spanish Population: Findings from the ANIBES Study

With the participation of:

Spanish Nutrition and Food Sciences Academy (AEN)

Spanish Nutrition Society (SEN)

Spanish Society of Community Nutrition (SENC)

Spanish Foundation for Nutritional Research (FIN)

Nutrition Studies Association (ASEN)

Improvement of Health by Fitness, Nutrition and Exercise Research Group

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Introduction

Iron is a nutrient required for many metabolic processes in the human body. Iron deficiency is the most common and widespread nutritional disorder in the world. As well as affecting a large number of children and women in non-industrialized countries, it is the only nutrient deficiency that is also significantly prevalent in virtually all industrialized nations.

There are no current global figures for iron deficiency, but they can be estimated using anaemia prevalence as an indirect indicator. Most preschool children and pregnant women in non-industrialized countries, and at least 30 % - 40 % in industrialized countries, are iron deficient. According to the World Health Organization (WHO), in the Spanish population anaemia prevalence ranges from 14 % to 18 % in children and in women of reproductive age, respectively.

Considerable amounts of iron must be provided by the diet to replace the iron that is lost from the body and growth requirements. Many dietary factors can hamper or promote absorption of this mineral, but the most important determinant is systemic iron need: more is absorbed in a state of iron deficiency and less is absorbed when mineral depots are replete. In circumstances of marked iron requirements, however, the influence of dietary factors on iron absorption may become limiting. There are three main dietary factors related to iron status: quantity of iron, quality of iron, and the composition of diet.

With respect to mechanisms of absorption, there are two kinds of iron in the usual diet: haem and non-haem iron. Haem iron is between 2 and 6 times more bioavailable from the diet than non-haem iron, being meat and meat products group the main source in the diet. In this regard, it is also important to consider a number of recommendations by public health authorities that designate that meat and meat products should be limited. As for non-haem iron, cereals constitute the main source, followed by vegetables, fruits and pulses, although we must bear in mind that its bioavailability might be low in this case.

In this sense, it is important to acknowledge that there are a number of factors that affect iron absorption into the gastrointestinal system and thus iron bioavailability: calcium, phytates in cereals and legumes, and phenolic compounds found in tea, coffee, and other beverages bind iron and restrict its availability for absorption, while meat and vitamin C found in fruit and vegetables enhance the potential availability of iron for mucosal uptake.

Concerning the amount of iron provided by the diet, there is a need for better and updated knowledge of micronutrient intakes in the Spanish population to prevent and/or delay adverse effects resulting from inadequate intakes at different stages of life.

The purpose of this pioneer study was to evaluate dietary intakes of iron in the Spanish population according to age and gender, and to examine the contribution from different food and beverage groups and subgroups as dietary source of this mineral. This is the first representative Spanish study considering plausible and non-plausible reporters for assessing dietary iron intake.

Materials and Methods

The design, protocol and methodology of the ANIBES Study have been already described in detail in Ruiz E. et al, 2015 and Varela-Moreiras G. et al, 2015.

The assessment of energy intake records carried out in an insufficient or non-plausible way is detailed in a previous scientific work belonging to the ANIBES Study, particularly in Olza J. et al, 2017. In this respect and following the EFSA protocol, data reported by the ANIBES population were classified as plausible or non-plausible.

After the classification of dietary intakes was established, these were compared with iron Dietary Reference Intakes by the European Food Safety Authority (EFSA, 2015) and iron daily Recommended Intakes for the Spanish Population as reviewed by Moreiras O. et al, 2015. Prevalence of adequacy for iron intakes (% population above 80 % Recommended Dietary Intakes) was calculated for each of the recommendations.

Recommended Dietary Intakes (RDI) by Moreiras and EFSA

Age Group (Years)	Moreiras O. et al, 2015 Iron (mg/Day)	EFSA, 2015 Iron (mg/Day)
Men		
9	9	11
10	12	11
11	12	11
12	12	11
13 - 17	15	11
18 - 19	15	11
20 - 49	10	11
50 - 59	10	11
≥ 60	10	11
Women		
9	9	11
10	18	11
11	18	11
12	18	13
13 - 17	18	13
18 - 19	18	16
20 - 49	18	16*
50 - 59	10	16*
≥ 60	10	11

* For postmenopausal women, Daily Recommended Iron Intake (DRI) is the same as for women ≥ 60 years.

General overview of iron intake

Median iron dietary intake levels observed were lower for women than for men in the total studied population. For its part, the major proportion of dietary iron sources were cereals and grains in the entire population included in this study. This could indicate that the higher iron proportion comes from non-haem iron dietary sources.

The results of research show that the prevalence of adequacy for iron by the EFSA criteria was higher than the one from the national standard (Moreiras O. et al, 2015). Data show that males had higher iron intakes than females in the whole sample.

By sex

Median iron intake data amongst female was 9.8 mg/day while males was 11.3 mg/day. Significantly higher intake values were observed in the plausible reporters in both male and female.

The analysis assessed the prevalence of adequacy for iron intakes (% population above 80 % Recommended Dietary Intake) in the study population by sex and according to the different diagnostic criteria previously mentioned: national (Moreiras O. et al, 2015) and international (EFSA, 2015). In this sense, the proportion of adequacy for total iron intake among females in the ANIBES population was 17.0 % and 27.3 % according to the Spanish and EFSA references respectively, and likewise, for male it was 57.3 % and 77.2 %, respectively.

Iron intake (mg/day) and prevalence of adequacy (% population above 80 % RDI) in ANIBES population by gender and reporting according to the Spanish and EFSA references, 2015

Gender	Iron (mg/Day)	% Above 80 % RDI Moreiras O. et al, 2015 (Spain)	% Above 80 % RDI EFSA, 2015
Women			
Total n= 996	9.8 (7.9 - 11.9)	17.0	27.3 ##
Plausible n= 331	12.0*** (10.3 - 13.8)	24.8	50.5 ###
Non-plausible n= 685	8.8 (7.3 - 10.6)	13.4	19.8 ###
Men			
Total n= 1,013	11.3 (9.0 - 14.0)	57.3	77.2
Plausible n= 232	14.7*** (12.4 - 17.1)	84.0	100.0 ##
Non-plausible n= 781	10.3 (8.4 - 12.7)	49.3	70.4 ##

Values are median (interquartile range) per group.
*** p < 0.001 difference plausible vs. non-plausible (Mann-Whitney's U test)
p < 0.01 differences between Moreiras O. et al, 2015 and EFSA, 2015 references (McNemar test for paired proportions).
p < 0.001 differences between Moreiras O. et al, 2015 and EFSA, 2015 references (McNemar test for paired proportions).

By age group

With regards to age, higher iron intakes were observed in adolescents (11.4 mg/day) and children (11.0 mg/day) than in adults and the elderly, which were 10.4 mg/day and 10.2 mg/day in each case. Iron intake values in plausible reporters were significantly higher in all age groups than in non-plausible reporters.

Iron intake (mg/day) and prevalence of adequacy (% population above 80 % RDI) in ANIBES population by age group and reporting according to the Spanish and EFSA references, 2015

Age Group	Iron (mg/Day)	% Above 80 % RDI Moreiras O. et al, 2015 (Spain)	% Above 80 % RDI EFSA, 2015
Children			
Total n= 213	11.0 (9.2 - 12.8)	40.9	77.9 ###
Plausible n= 120	12.2*** (10.4 - 14.0)	54.2	94.2 ###
Non-plausible n= 93	9.2 (8.0 - 11.1)	23.7	57.0 ##
Adolescents			
Total n= 211	11.4 (9.1 - 13.4)	15.2	73.0 ###
Plausible n= 76	13.3*** (11.6 - 15.4)	27.6	90.8 ###
Non-plausible n= 135	10.0 (8.1 - 11.8)	8.2	63.0 ###
Adults			
Total n= 1,655	10.4 (8.4 - 12.9)	36.9	47.9 ###
Plausible n= 433	13.0*** (11.0 - 15.6)	47.8	63.3 ##
Non-plausible n= 1,222	9.6 (7.8 - 11.8)	33.0	42.5 ###
Elderly			
Total n= 206	10.2 (7.9 - 12.6)	52.9	68.0 ###
Plausible n= 45	12.7*** (10.9 - 17.2)	88.9	100.0 ###
Non-plausible n= 161	9.5 (7.5 - 11.5)	42.9	59.0 ###

Values are median (interquartile range) per group.
*** $p < 0.001$ difference No misreporting vs. Misreporting (Mann-Whitney's U test)
$p < 0.01$ differences between Moreiras O. et al, 2015 and EFSA, 2015 references (McNemar test for paired proportions).
$p < 0.001$ differences between Moreiras O. et al, 2015 and EFSA, 2015 references (McNemar test for paired proportions).

By geographical distribution

Overall, the study observed that North Central region of Spain and Northeast presented higher daily iron intakes, while the Center of the peninsula, Canary Islands and the South region had the lowest iron intakes.

Iron intake (mg/day) by geographical distribution

Geographical Distribution (Nielsen Areas)	**Iron (mg/Day)**
Barcelona (Metropolitan Area)	10.8 (8.8 - 13.1)
Madrid (Metropolitan Area)	10.2* (8.1 - 12.7)
Center	9.9 (8.2 - 13.2)
East	10.6 (8.3 - 13.2)
Northeast	10.9 (8.7 - 13.4)
Northwest	10.6 (8.6 - 12.7)
North Central	11.4 (9.6 - 14.0)
South	10.1** (8.2 - 12.4)
Canary Islands	10.1 (7.8 - 13.3)

Values are median (interquartile range per group).
*p<0.05 difference vs. North Central (Bonferroni test).
**p<0.01 difference vs. North Central (Mann-Whitney's U test).

Contribution of Food and Beverage Groups and Subgroups to Iron Intake

Detailed information on dietary iron sources is essential to better understand the strengths and weaknesses of the Spanish diet quality and to identify vulnerable population groups.

The food and beverage groups with the highest mean contribution to iron dietary intake in both males and females were firstly cereals and grains (27.4 % in males and 26.7 % in females) followed by meat and meat products group (22.7 % in males and 19.8 % in females). In both cases, intakes were significantly higher in the male population. Thirdly, vegetables group accounted for a 10.3 % and 12.4 % of iron intakes in males and females respectively, being significantly higher in females. Together, these three previous food groups contributed to 60 % or more of iron intakes of the ANIBES Study population.

According to age, cereals and grains group was the main source of iron for the entire sample, especially for adolescents (33.1 % males and 31.3 % females) and children (30.7 % boys and 31.8 % girls), being significantly higher than adults and the elderly.

Regarding meat and meat products group, the elderly had a lower contribution (18.0 % males and 17.0 females), being significantly higher for children (23.1 % boys and 20.1 % girls), adolescents (23.5 % males and 20.3 % females) and adults (22.9 % in males compared with 20.1 % in females).

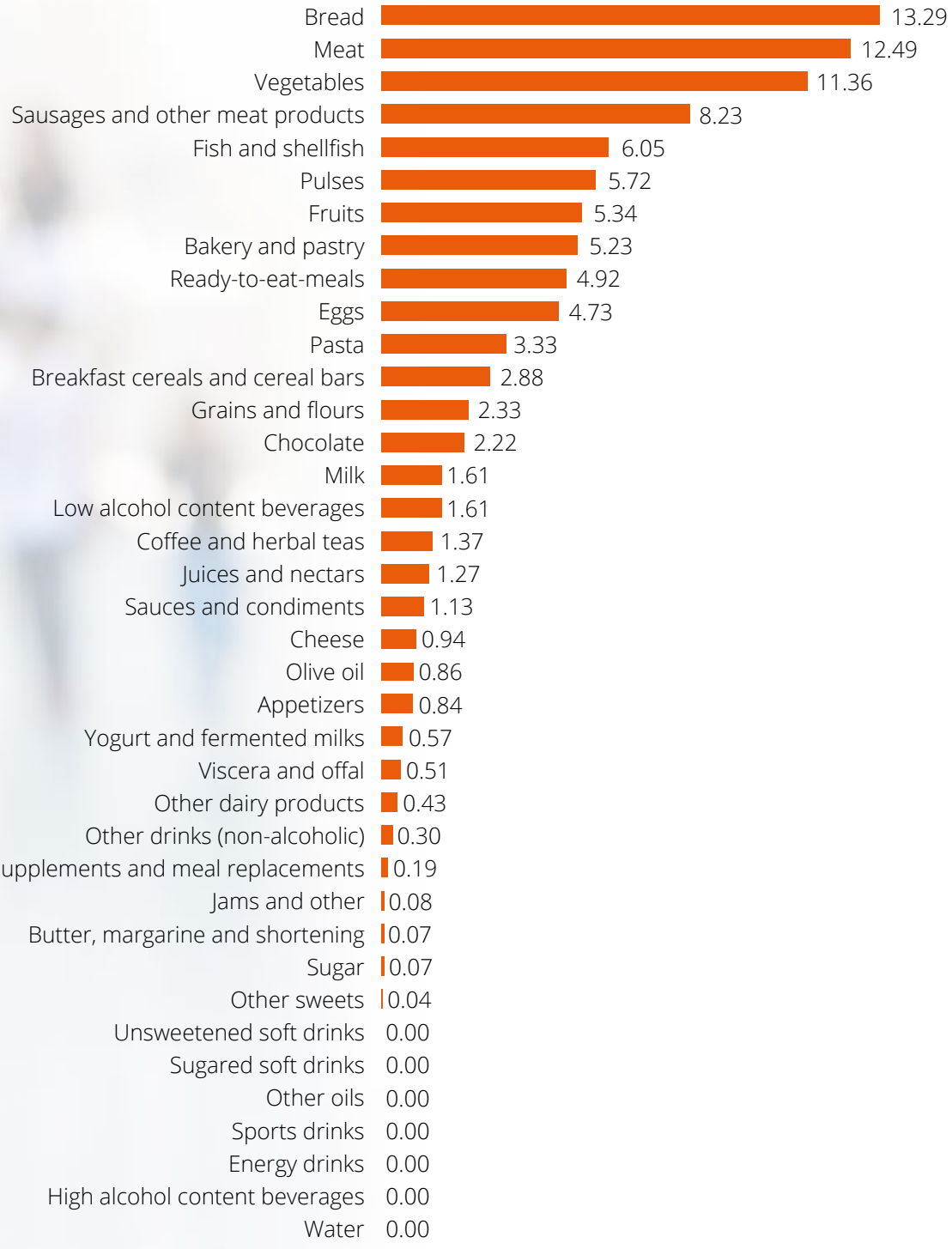
Since meat and meat products group is the highest source of bioavailable heme iron, this work has further explored the different food subgroups and their contribution to iron intakes. In this respect, within the meat subgroup, red meat provided the same contribution for all age groups, except for female adolescents, where the percentage was slightly lower (2.8 %). For its part, sausages and other meat products provided between 5.5 % and 10.2 % of total iron intakes, especially in children, adolescents and adult male, with a contribution significantly higher than in adult female and the elderly. On the other hand, the fish and shellfish group contribution was significantly higher in groups older than 18 years.

Iron dietary sources (%) from food and beverage groups and subgroups.

Iron dietary sources (%) from food and beverage groups and subgroups.

1. GENERAL 9-75 YEARS

Sample: 2,009 individuals*

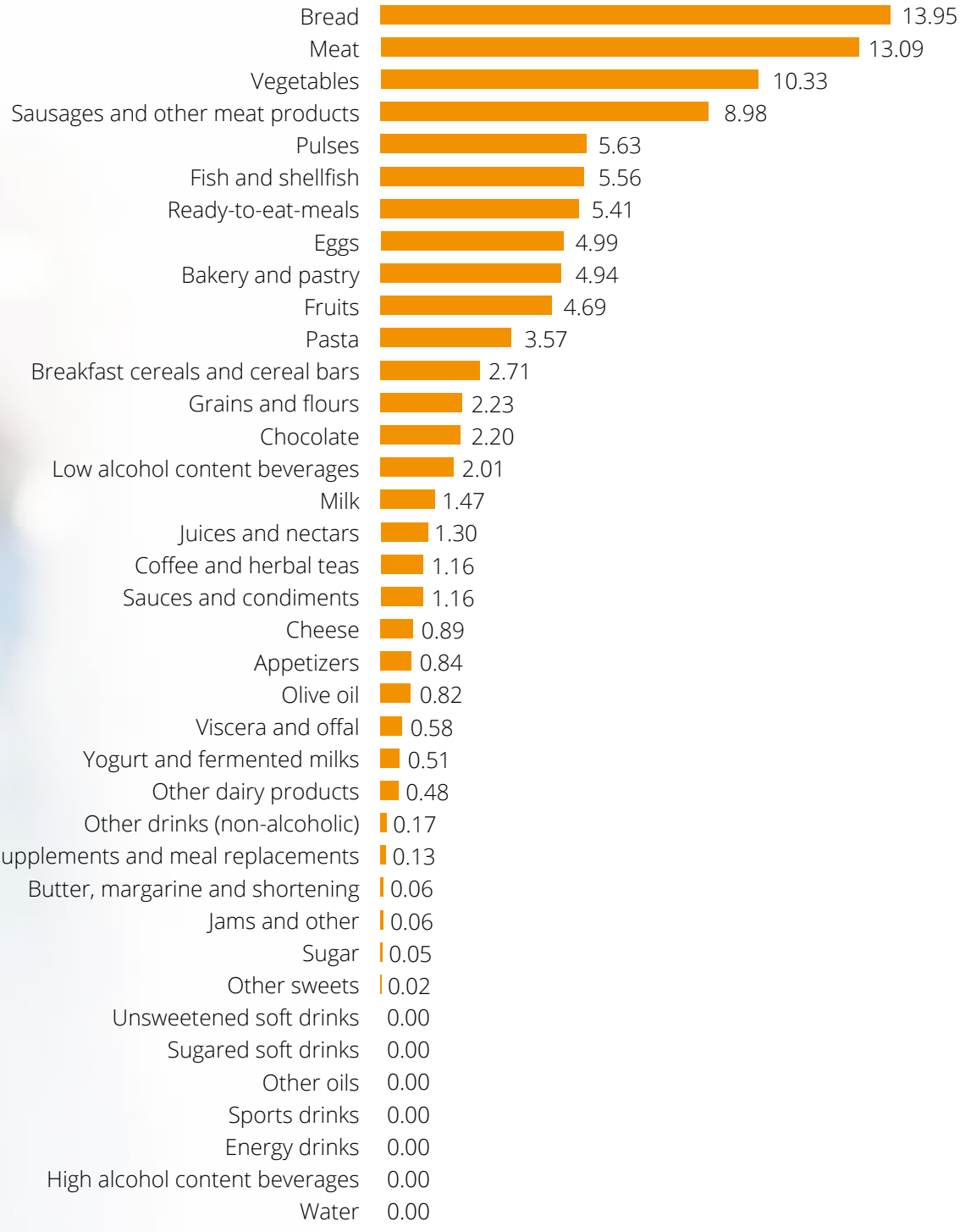


*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

2. GENERAL MEN 9-75 YEARS

Sample: 1,013 individuals*

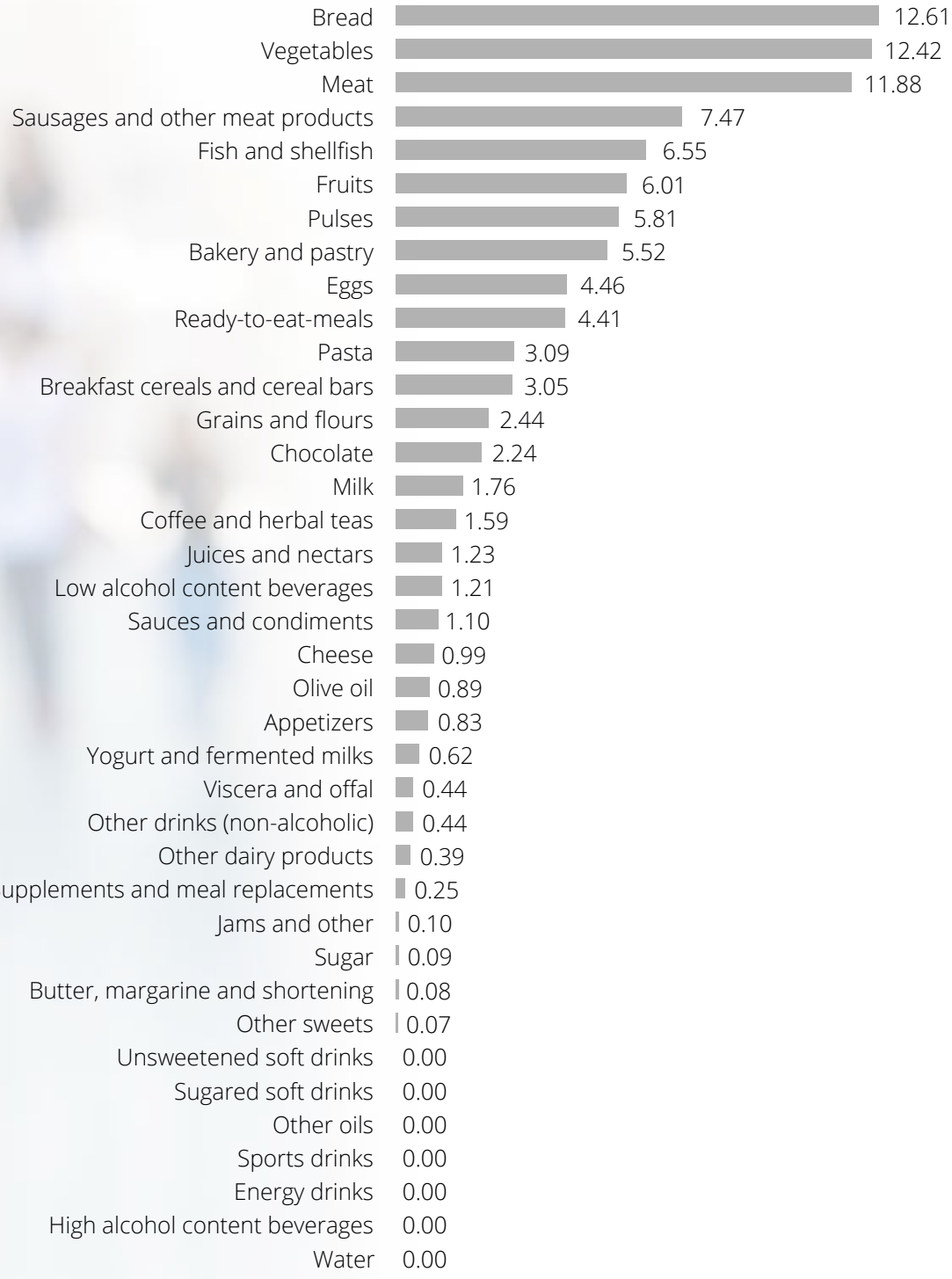


*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

3. GENERAL WOMEN 9-75 YEARS

Sample: 996 individuals*



*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

4. CHILDREN BOYS AND GIRLS 9-12 YEARS

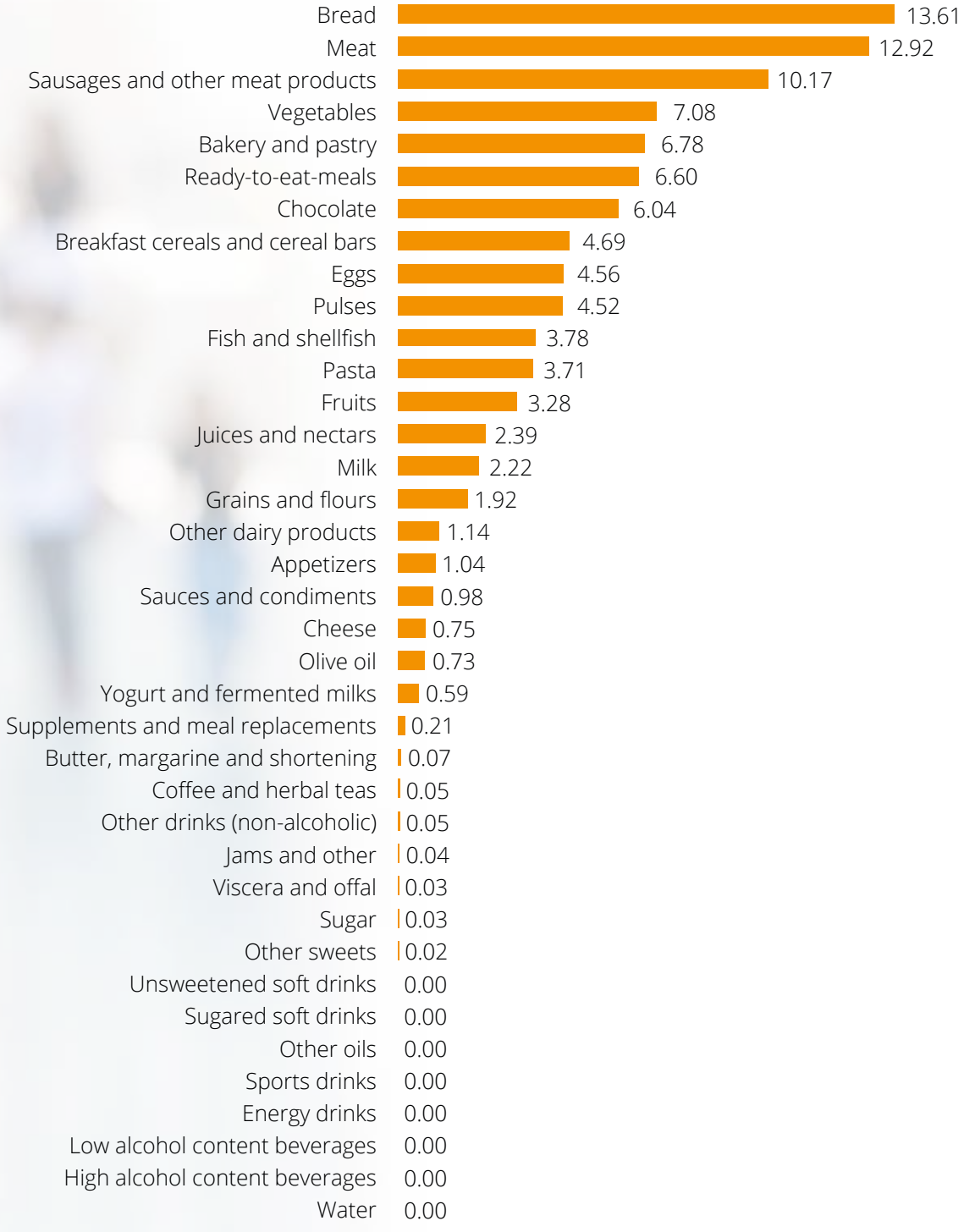
Sample: 213 individuals*

*Random sample plus boost

Iron dietary sources (%) from food and beverage groups and subgroups.

5. CHILDREN BOYS 9-12 YEARS

Sample: 126 individuals*

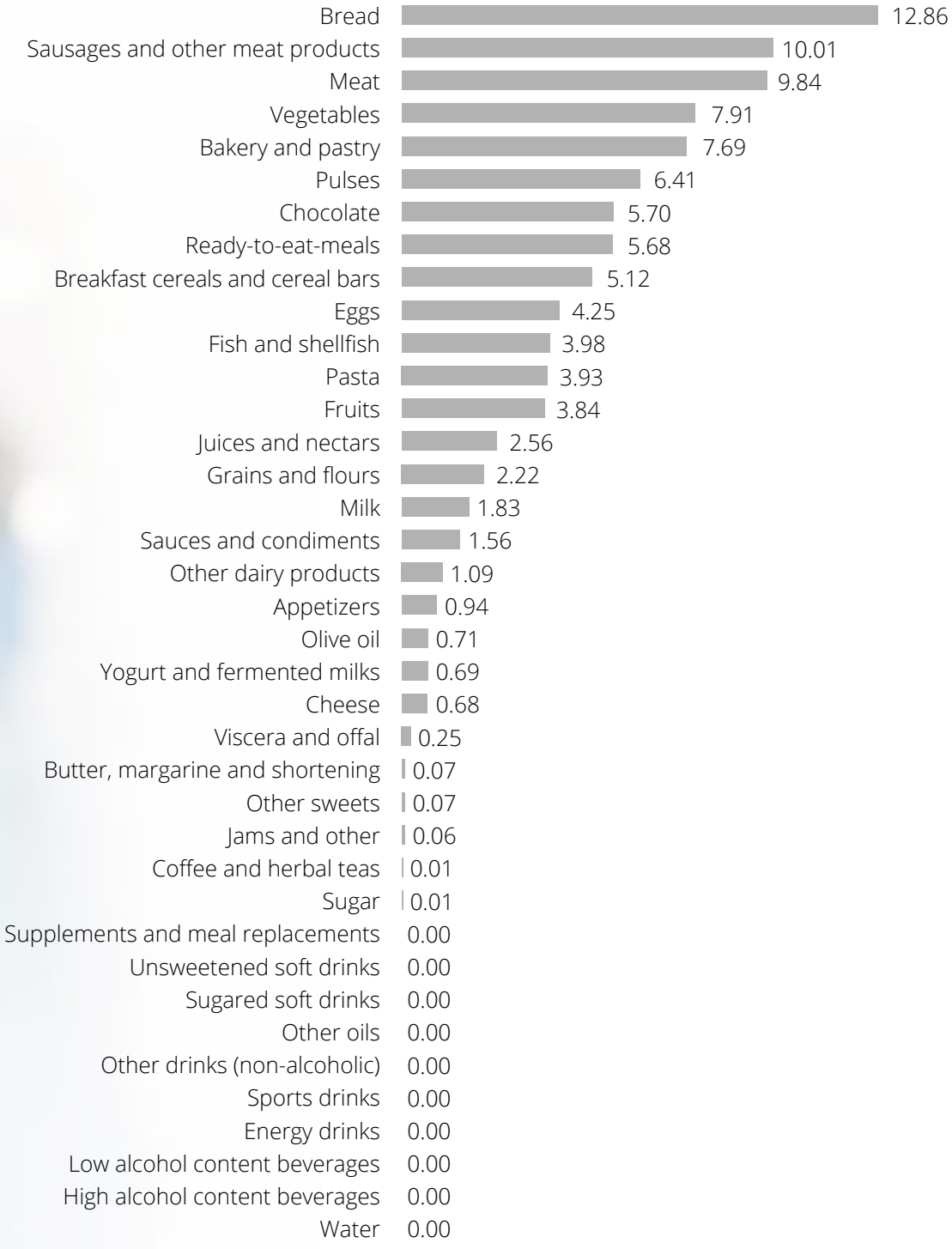


*Random sample plus boost

Iron dietary sources (%) from food and beverage groups and subgroups.

6. CHILDREN GIRLS 9-12 YEARS

Sample: 87 individuals*

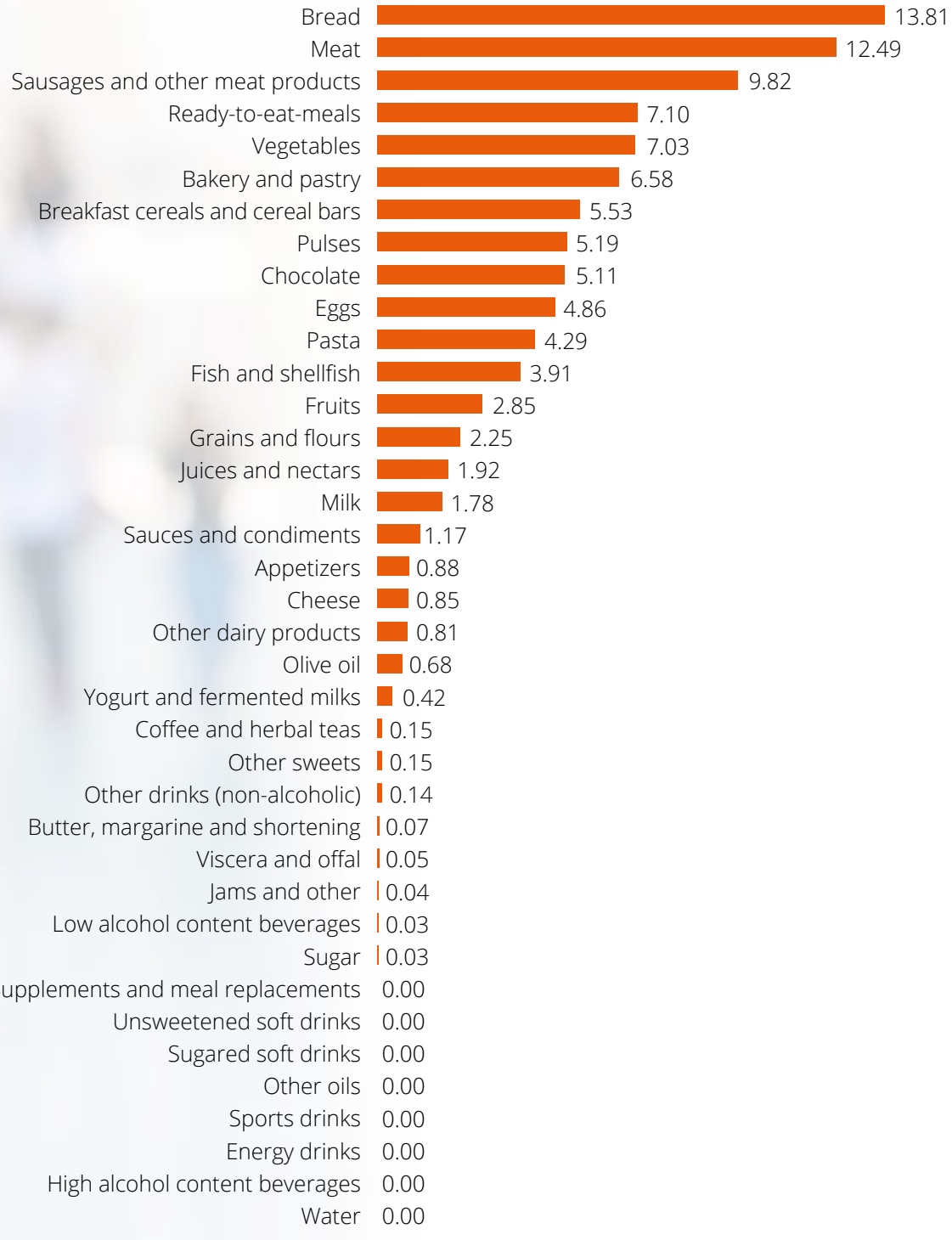


*Random sample plus boost

Iron dietary sources (%) from food and beverage groups and subgroups.

7. ADOLESCENTS 13-17 YEARS

Sample: 211 individuals*

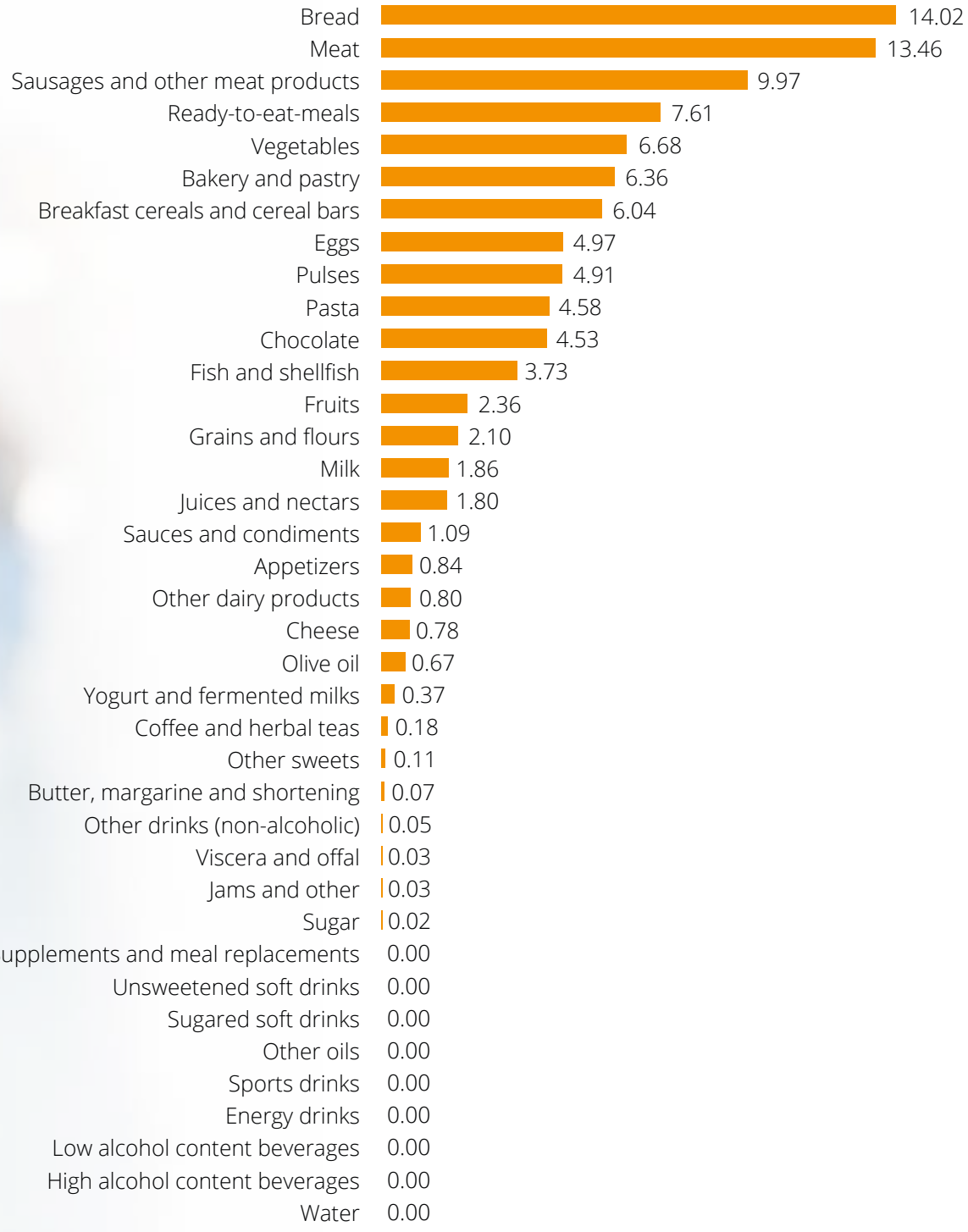


*Random sample plus boost

Iron dietary sources (%) from food and beverage groups and subgroups.

8. ADOLESCENT BOYS 13-17 YEARS

Sample: 137 individuals*

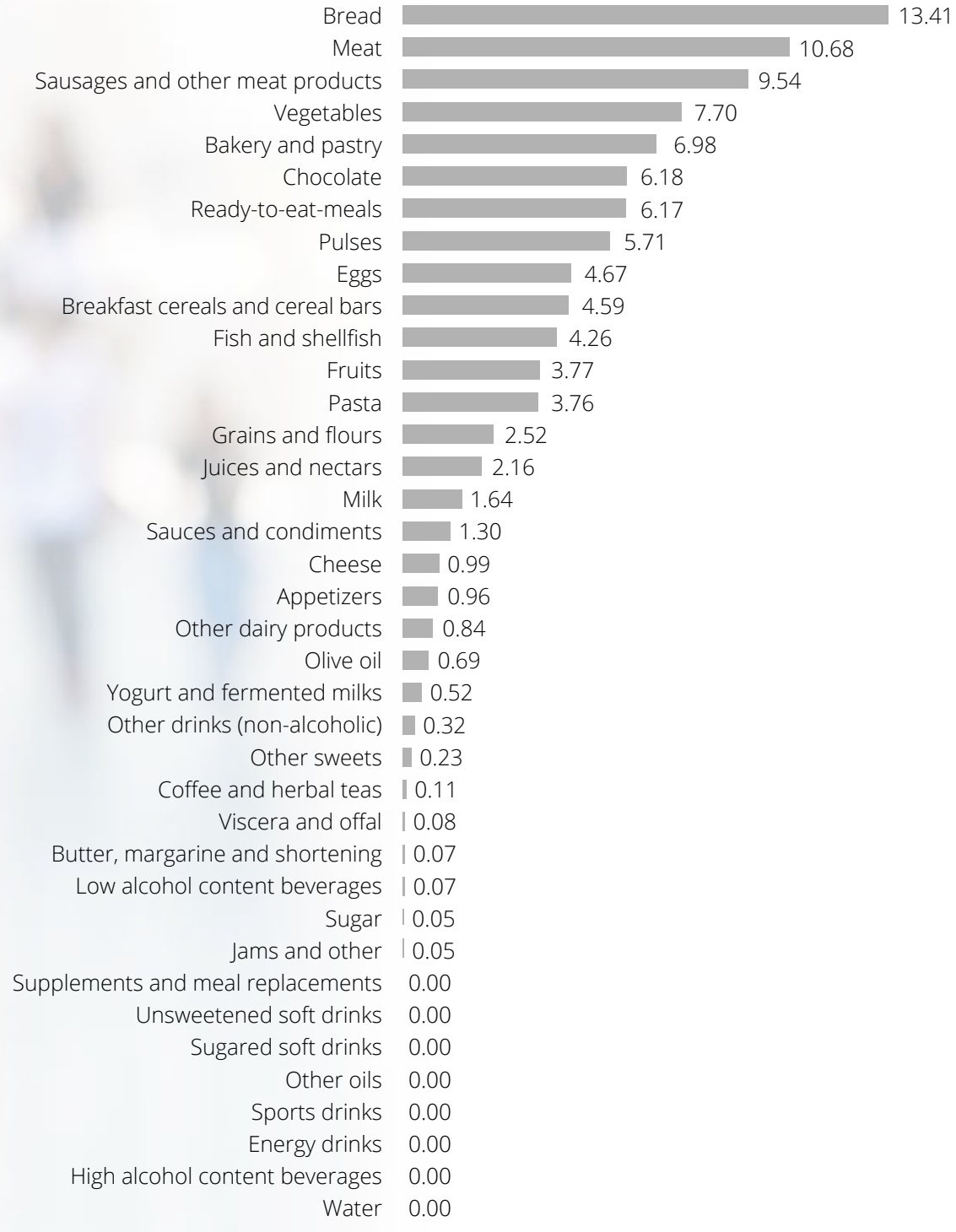


*Random sample plus boost

Iron dietary sources (%) from food and beverage groups and subgroups.

9. ADOLESCENT GIRLS 13-17 YEARS

Sample: 74 individuals*

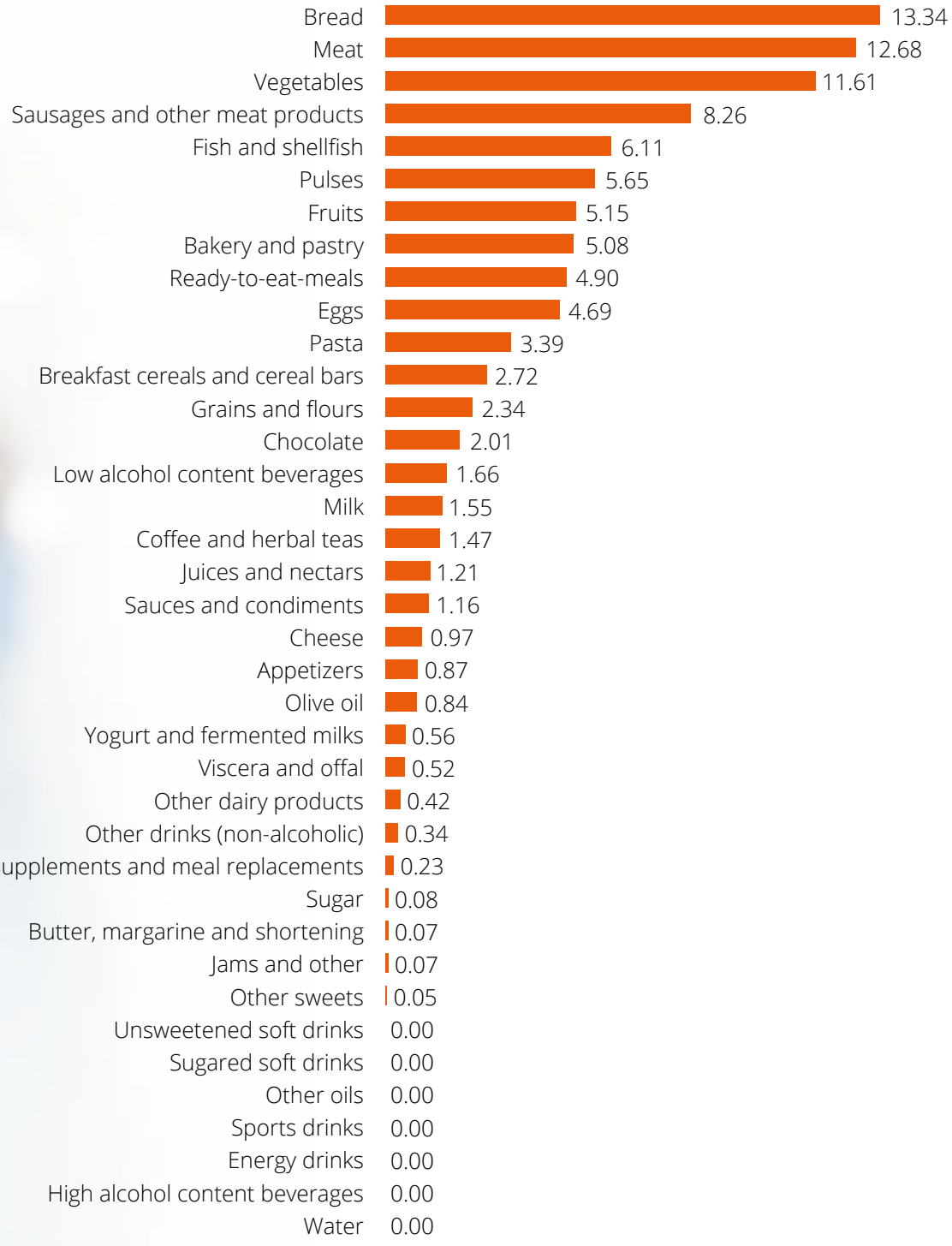


*Random sample plus boost

Iron dietary sources (%) from food and beverage groups and subgroups.

10. ADULTS 18-64 YEARS

Sample: 1,655 individuals*

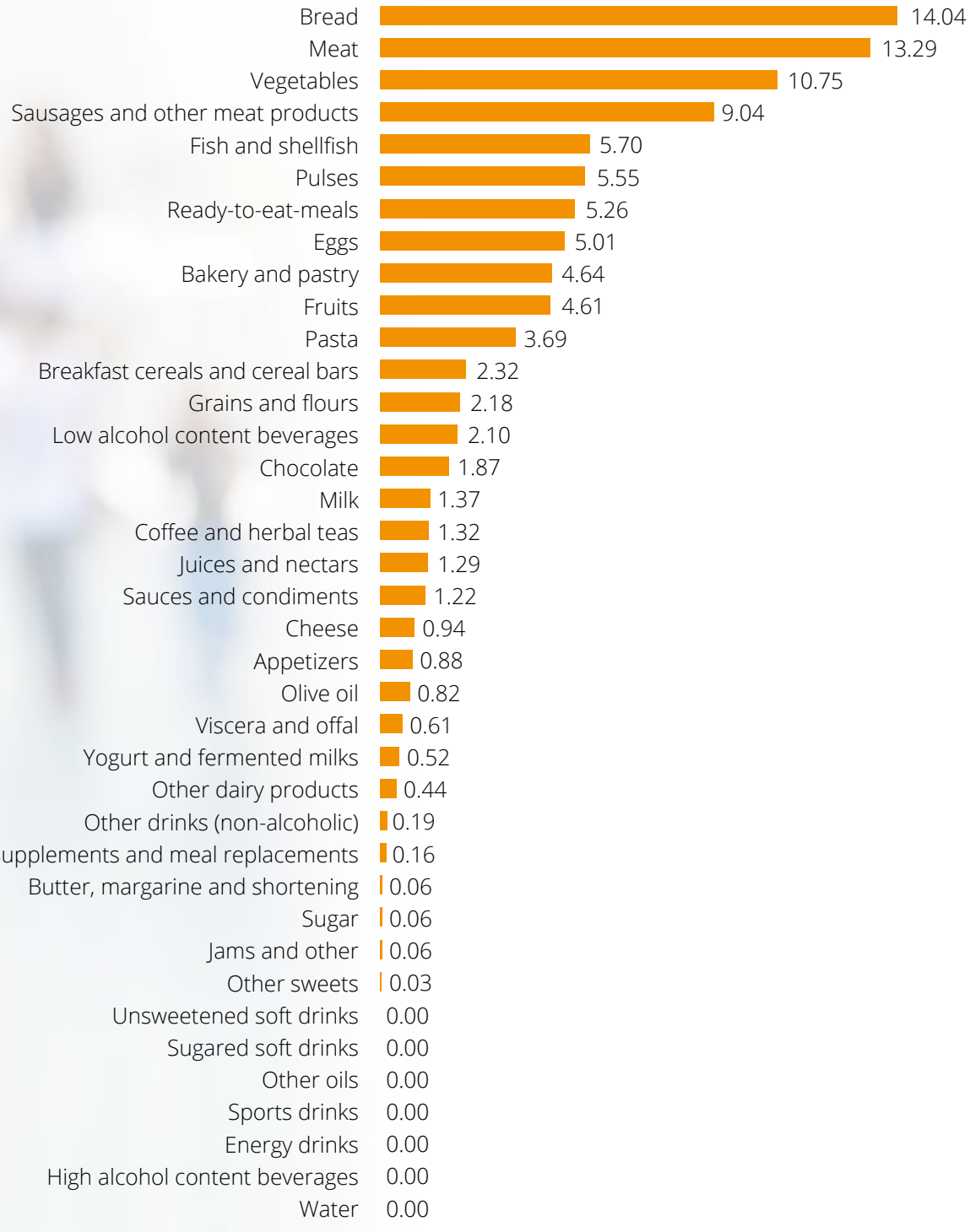


*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

11. ADULT MEN 18-64 YEARS

Sample: 798 individuals*

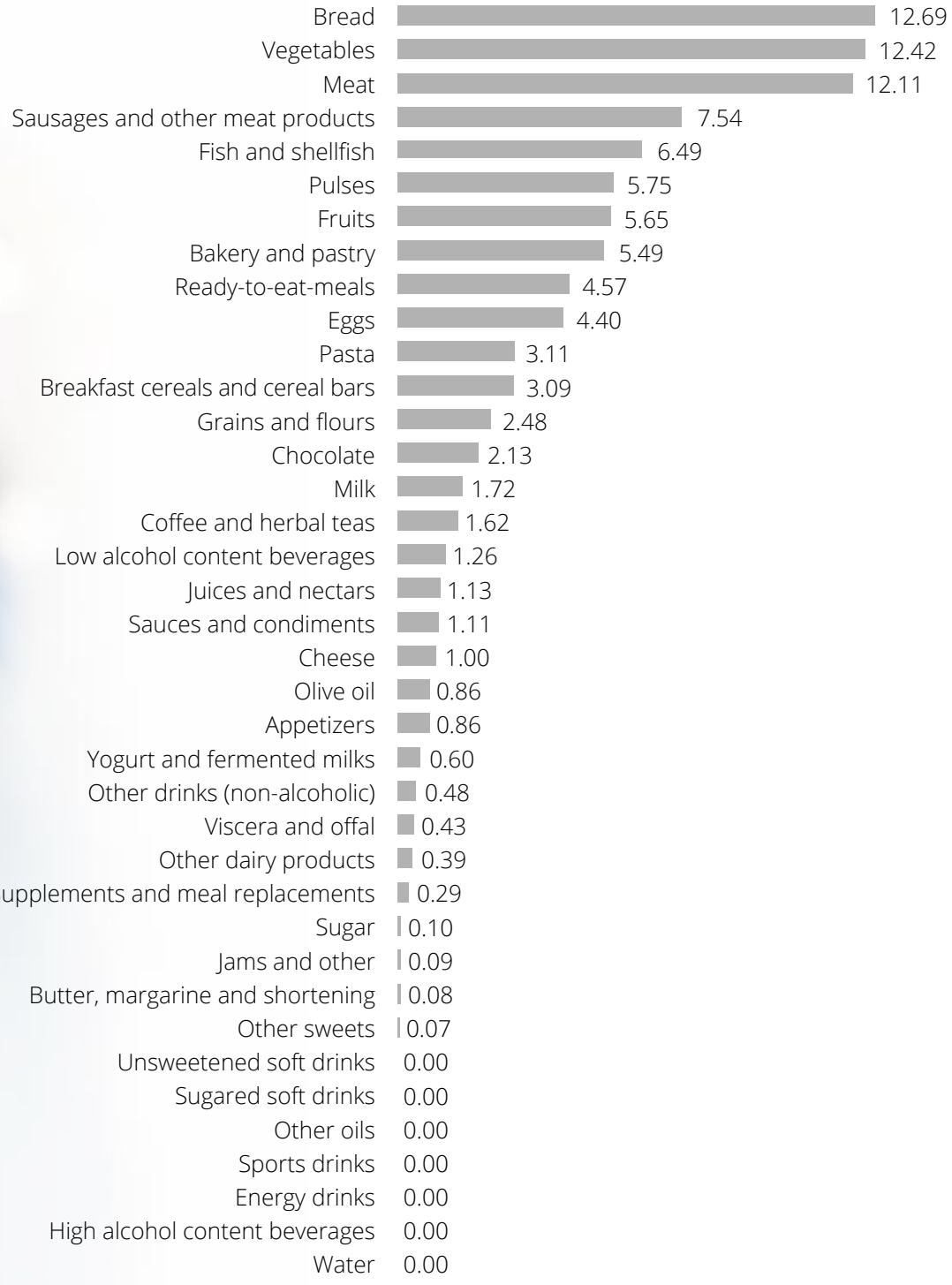


*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

12. ADULT WOMEN 18-64 YEARS

Sample: 857 individuals*

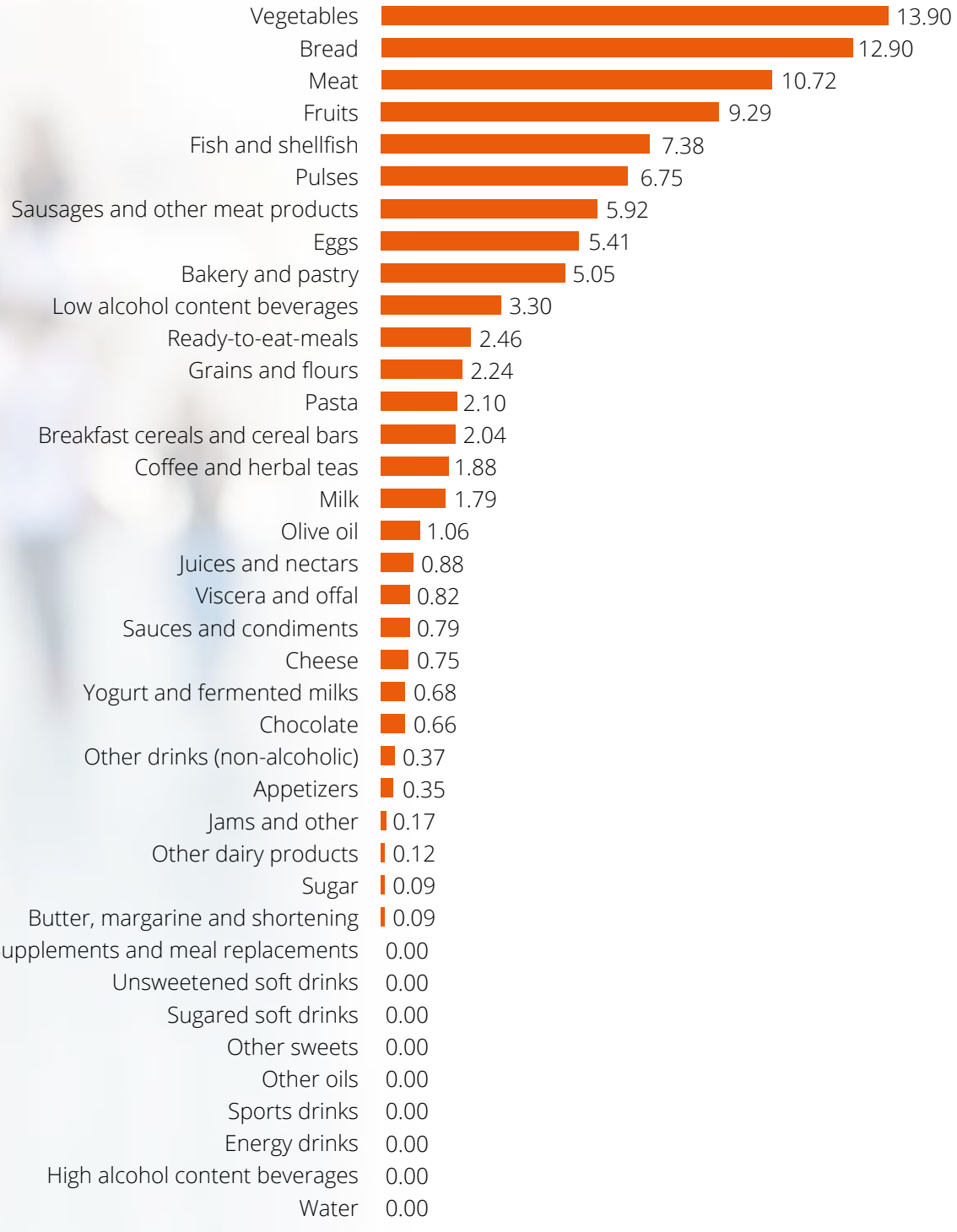


*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

13. **ELDERLY** 65-75 YEARS

Sample: 206 individuals*

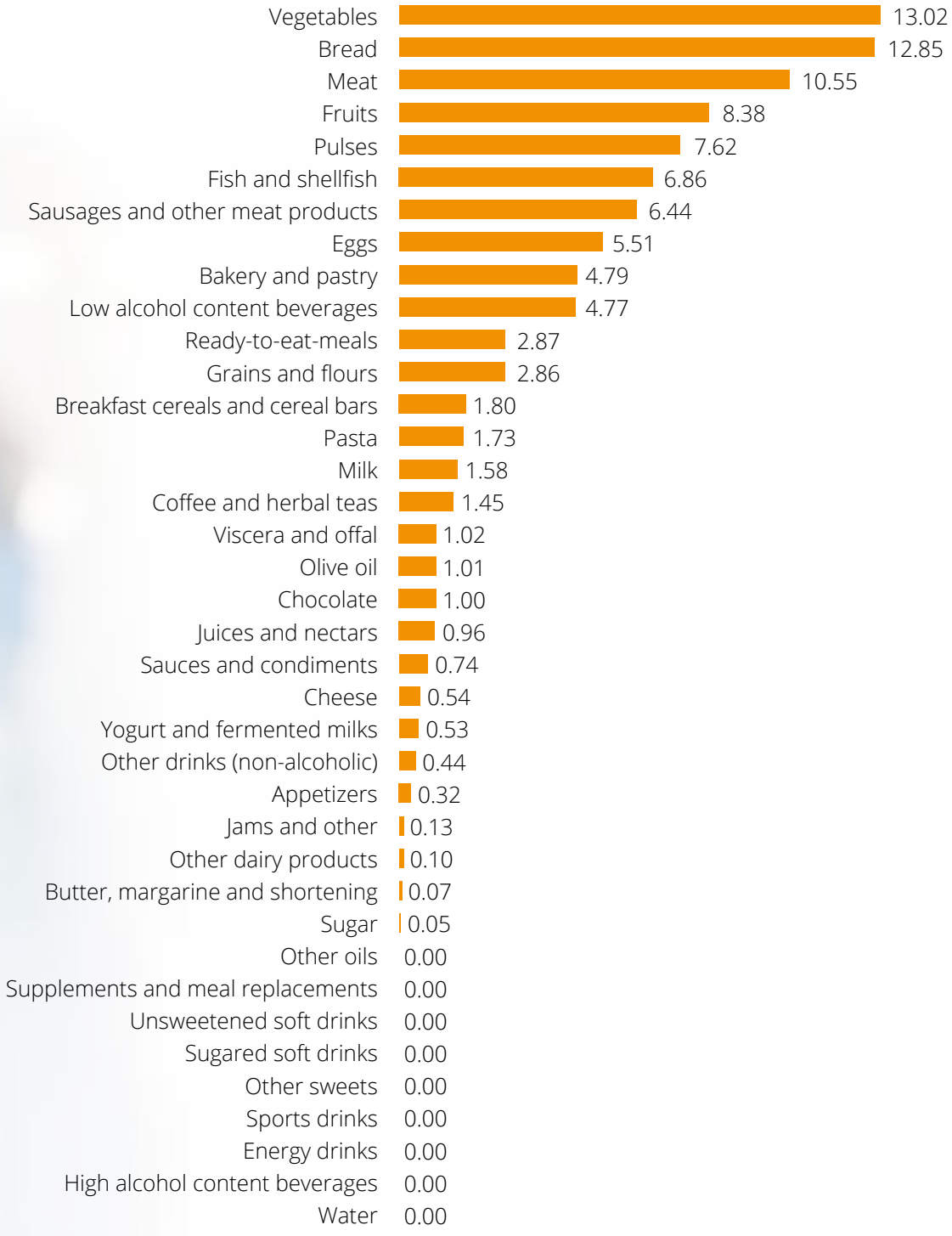


*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

14. ELDERLY MEN 65-75 YEARS

Sample: 99 individuals*

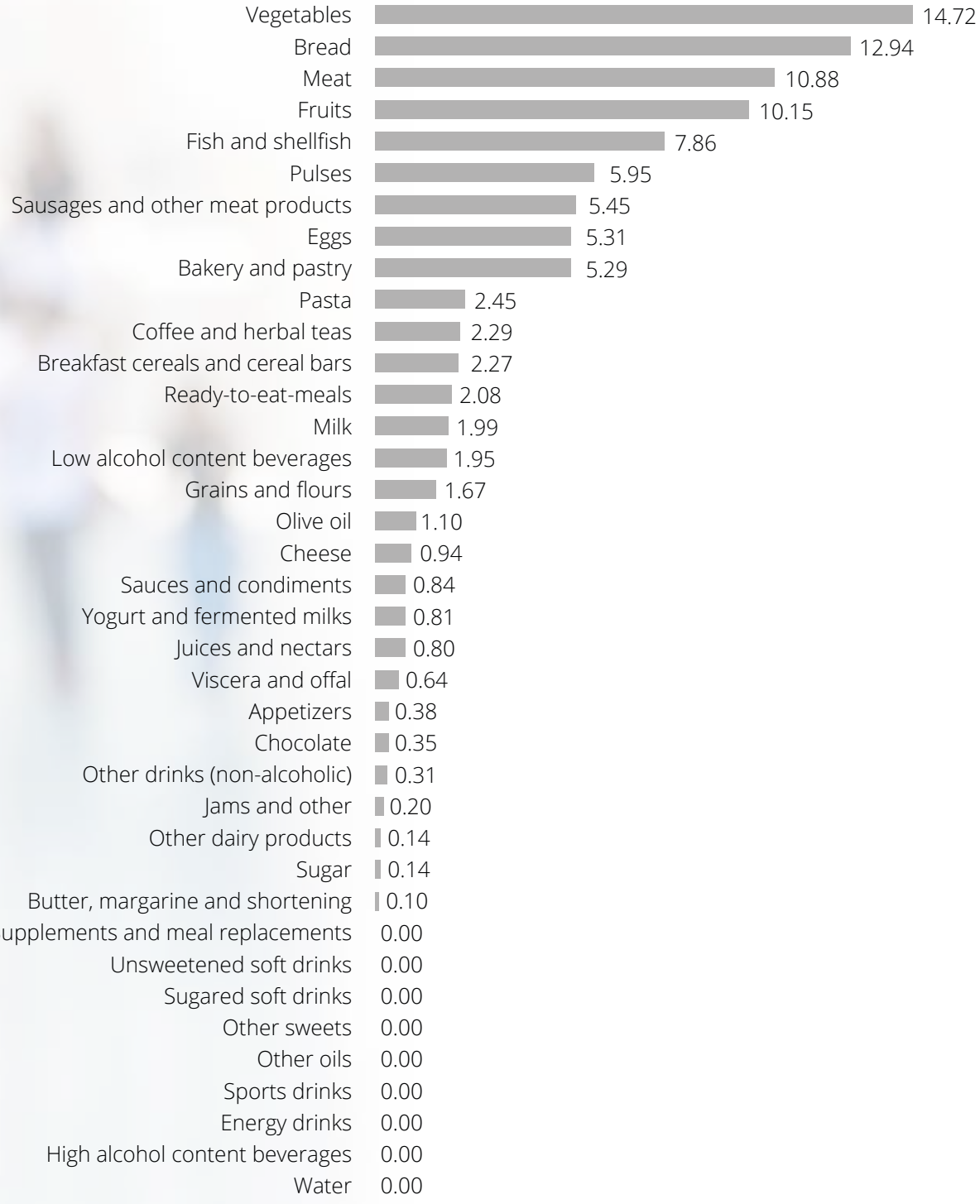


*Random sample

Iron dietary sources (%) from food and beverage groups and subgroups.

15. ELDERLY WOMEN 65-75 YEARS

Sample: 107 individuals*



*Random sample

Particularly Vulnerable Population Groups

In Europe, iron deficiency is considered to be one of the main nutritional deficiency disorders affecting large fractions of the population, particularly groups such as children and fertile or pregnant women.

Children and adolescents are consistently considered a group at risk for nutritional deficiencies as their needs increase during growth stage. Women of childbearing age are another vulnerable population for iron deficiency. The large difference between men and women regarding prevalence of adequate iron intake calls for attention. Women are at high risk of iron deficiency and should be the ones to increase their intake. However, women's Recommended Dietary Intake for iron are more difficult to reach (18 mg/day compared to 8 mg/day for men and postmenopausal women).

To optimize iron status, it is desirable to encourage a varied diet with attention to sources of haem iron, and more emphasis should be given to the enhancing or inhibitory factors influencing non-haem iron by means of adequate recommendations regarding dietary habits.

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Scientific Committee

- **Prof. Javier Aranceta-Bartrina, MD, PhD**
  Chairman of the Scientific Committee of the Spanish Society of Community Nutrition (SENC), Clinical Director of the Spanish Foundation for Nutritional Research (FIN) and Professor of Community Nutrition at the University of Navarra

- **Prof. Ángel Gil, PhD**
  Chairman of the Iberoamerican Nutrition Foundation (FINUT), Director of the BioNit Scientific Group and Professor of Biochemistry and Molecular Biology at the University of Granada

- **Prof. Marcela González-Gross, PhD**
  Vice President of the Spanish Nutrition Society (SEÑ), Head of the ImFine Research Group and Professor of Sports Nutrition and Exercise Physiology at the Technical University of Madrid

- **Prof. Rosa Mª Ortega, PhD**
  Director of the VALORNUT Research Group and Professor of Nutrition at the Complutense University of Madrid

- **Prof. Lluìs Serra-Majem, MD, PhD**
  Chairman of the Spanish Foundation for Nutritional Research (FIN), Chairman of the Spanish Nutrition and Food Sciences Academy (AEN), Director of the Biomedical and Health Research Institute and Professor of Preventive Medicine and Public Health at the University of Las Palmas de Gran Canaria

- **Prof. Gregorio Varela-Moreiras, PhD**
  Chairman of the Spanish Nutrition Foundation (FEN), Director of the Nutrition and Food Sciences Research Group (CEUNUT) and Professor of Nutrition and Bromatology at CEU San Pablo University of Madrid

The final protocol of the ANIBES scientific study was previously approved
by the Clinical Research Ethics Committee of the Autonomous Region of Madrid (Spain).


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