

# AHFES

## A QUADRUPLE HELIX ATLANTIC AREA HEALTHY FOOD ECOSYSTEM FOR GROWTH OF SMES

### Nutrition and brain Report

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## Abbreviations and Acronyms

mg	Milligrams
RDAs	Recommended Dietary Allowences
µg	Micrograms

## Executive summary

Nutrition is a field of science that is increasingly at the centre of research. All this interest in this concept is related to the awareness of human beings about the importance that our food affects our health in general.

Recent studies have shown that food affects the chemical composition of our brains. Food is made up of essential nutrients for the proper functioning of our body. It is necessary to remember that the basis of our health is directly linked to the base of our diet.

Bearing that nutrition affects alertness and the production or release of neurotransmitters (chemical messengers that carry information from one nerve cell to another), this report addresses the importance of food for the proper functioning of our brain. The essential nutrients for the health of our brain are highlighted, highlighting selenium, zinc, b6 vitamin, folate and iron. For each of these elements, it is mentioned its function in the brain and which products we should consume to increase the absorption of these nutrients.

# 1 Introduction

Our food has the function of providing the body with energy-building material while preventing and protecting from some diseases. Recent studies have provided significant evidence for the influence of dietary factors on specific molecular systems and mechanisms that maintain mental function.

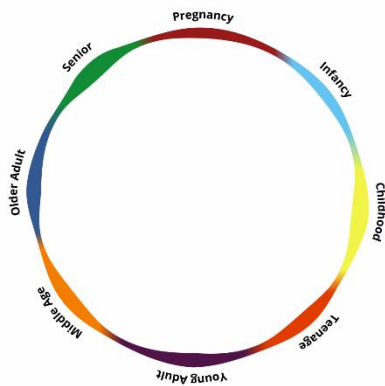
Based on the fact that the food we consume affects the functioning of our brain, it is necessary to



step back and understand that food is composed of various nutrients that will directly have a positive/negative effect on our body. Eating foods containing vitamins, minerals and antioxidants allow us to nourish the brain and protect it from the oxidative stress of free radicals produced when the body uses oxygen. These radicals can damage cells resulting in cognitive and memory problems as you age.

Further studies must be carried out on the effect of food on the brain to determine the mechanisms of action and the conditions for therapeutic applications in humans<sup>1</sup>.

It should be noted that recent studies have shown the ability of our diet to modulate cognitive abilities may have long-term implications, as nutritional effects can be transmitted across generations, thus influencing epigenetic events<sup>1,2</sup>.



Finally, it is necessary that over time the ideal differences for the development of health and the development of nutritional needs are significant in considering this factor when developing new products and who is the target consumer.

In the following chapter, we will talk about the essential nutrients for the human brain<sup>34</sup>.

<sup>1</sup> Gómez-Pinilla, F. (2008). Brain foods: The effects of nutrients on brain function. *Nature Reviews Neuroscience*, 9(7), 568–578. <https://doi.org/10.1038/nrn2421>

<sup>2</sup> Moore, K., O’shea, M., Hughes, C. F., Hoey, L., Ward, M., & McNulty, H. (2017). Current evidence linking nutrition with brain health in ageing. *Nutrition Bulletin*, 42(1), 61–68. <https://doi.org/10.1111/NBU.12250>

<sup>3</sup> <https://foodforthebrain.org/life-stages-approach/>

<sup>4</sup> *Nature Reviews | Neuroscience*. (2008). [www.nature.com/reviews/neuro](http://www.nature.com/reviews/neuro)

## 2 Nutrients and Brain

There are several important nutrients for the better functioning of our brain. In this report, we highlight the most important ones (figure 1) for the future of the health of populations considering the current state<sup>1</sup>.



Figure 1. Important nutrients for brain health

### 2.1 Selenium

Selenium is one of the essential trace elements for living organisms, involved in several physiological and metabolic processes. For the proper functioning of the human body in general, our body needs small amounts of selenium daily.

However, the intake of selenium by humans is generally balanced. Still, with climate change, the low concentration of this element in food has become increasingly common, affecting the amount ingested by humans. Furthermore, in the case of selenium, its bioavailability depends on its chemical form, with organic selenium being the most available after ingestion<sup>5</sup>.

#### 2.1.1 Selenium functions and reference dose

Selenium is essential for the functioning of our body, as it is used to produce 25 selenoproteins. These play critical roles in protecting our cells and supporting the immune system and thyroid function.

Se behaves as a protective agent for neurons through selenoproteins. These regulate the redox state under physiological conditions and in antioxidant defence. On the other hand, this micronutrient plays a crucial role in maintaining the proper functioning of the nervous system<sup>6</sup>.

<sup>5</sup> D'Amato, R., Regni, L., Falcinelli, B., Mattioli, S., Benincasa, P., Dal Bosco, A., Pacheco, P., Proietti, P., Troni, E., Santi, C., & Businelli, D. (2020). Current Knowledge on Selenium Biofortification to Improve the Nutraceutical Profile of Food: A Comprehensive Review. In *Journal of Agricultural and Food Chemistry* (Vol. 68, Issue 14, pp. 4075–4097). American Chemical Society. <https://doi.org/10.1021/acs.jafc.0c00172>

<sup>6</sup> Schweizer, U., Bräuer, A. U., Köhrle, J., Nitsch, R., & Savaskan, N. E. (2004). Selenium and brain function: A poorly recognized liaison. In *Brain Research Reviews* (Vol. 45, Issue 3, pp. 164–178). <https://doi.org/10.1016/j.brainresrev.2004.03.004>

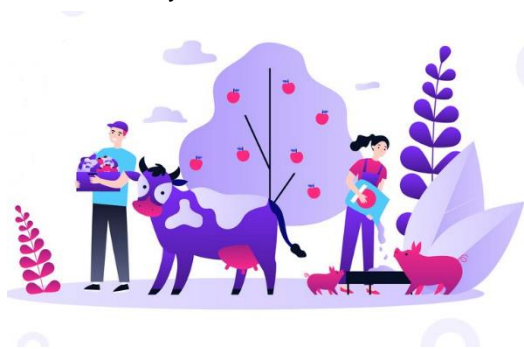
In this way, for the excellent functioning of our brain, we must balance selenium levels throughout our lives. It is important to remember that the reference dose varies according to age, sex and stage of life in which we are. The table 1 refers to the reference doses for each stage and age.

**Table 1. Recommended dietary allowances (RDAs) for selenium intake<sup>7</sup>**

Group	Selenium content (µg/day)
Infants	10–15
Children 1–3	15–20
Children 4–8	20–30
Children 9–13	40–45
Adults (men, women)	55–70
Pregnant women	60
Lactating women	60–75

### 2.1.2 Food rich in selenium

Selenium is present in foods of animal and plant origin. When we analyze the case of foods of plant origin, we observe that there is variability in the levels of this element. However, the variability is also complex, as it will depend on the selenium content of the soil in which the plants are grown, as well as on the ability of the soil to absorb and accumulate this mineral. Therefore, it is necessary to consider several factors as to which sources of selenium are the best. More



recent studies have concluded that there is a decrease in the concentration of this element in soils due to climate change. On the other hand, when we think about food products of animal origin, the amount of selenium in foods varies according to the content of this element in the foods that make up the animal's diet. That is, it will also depend on the selenium content in the plants<sup>5,8</sup>.

In this way, it is increasingly important to consider at what stage we can add selenium so that it is possible to increase our selenium intake, speaking of selenium biofortification. Several foods contain selenium, in the figure 2 the most important ones for our diet are represented <sup>8</sup>.

<sup>7</sup> Kieliszek, M., Bano, I., & Zare, H. (n.d.). *A Comprehensive Review on Selenium and Its Effects on Human Health and Distribution in Middle Eastern Countries*. <https://doi.org/10.1007/s12011-021-02716-z> Published

<sup>8</sup> <https://www.eufic.org/en/vitamins-and-minerals/article/selenium-foods-functions-how-much-do-you-need-more>





Figure 2. Examples of selenium-rich food<sup>8</sup>

## 2.2 Zinc

Zinc is one of the important chemical elements for the functioning of the human organism. As with selenium, our bodies only need small amounts of zinc to stay healthy. However, in the case of zinc, it is crucial to have a balance, as it can be harmful in cases of deficiency and excess. Indeed, zinc deficiency is a global public health problem in developing countries. It has recently been verified that there is a disability in the older population of developed countries. Thus, developing products and alternatives for zinc supplementation is increasingly vital for the future health of the global population<sup>9,10,11</sup>.

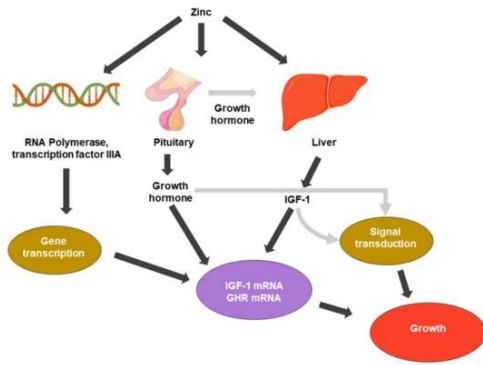
### 2.2.1 Zinc functions and reference dose

Zinc is present in all human body cells, performing three main biological functions: catalysis, structure and regulation. More precisely, this element contributes to the antioxidant function and the proper functioning of the immune system and plays a crucial role in neurophysiology: cell growth to proliferation<sup>9</sup>.

<sup>9</sup> <https://www.eufic.org/en/vitamins-and-minerals/article/zinc-foods-functions-how-much-do-you-need-more>

<sup>10</sup> Choi, S., Hong, D. K., Choi, B. Y., & Suh, S. W. (2020). Zinc in the brain: Friend or foe? In *International Journal of Molecular Sciences* (Vol. 21, Issue 23, pp. 1–24). MDPI AG. <https://doi.org/10.3390/ijms21238941>

<sup>11</sup> Portbury, S. D., & Adlard, P. A. (2017). Zinc signal in brain diseases. In *International Journal of Molecular Sciences* (Vol. 18, Issue 12). MDPI AG. <https://doi.org/10.3390/ijms18122506>



The amount of zinc we need to ingest per day varies according to age, sex, stage of life and also with the composition of the diet of each one. This last factor is related to the presence of phytates in foods. Phytates bind to zinc and prevent our bodies from absorbing zinc. Phytates can be found in foods such as grains, cereal seeds, legumes and some vegetables.

Based on the factors mentioned above, the dietary reference value for healthy adults is between 7.5 and 16.3 mg of zinc per day, always taking into account the diet of the person in question<sup>9</sup>.

### 2.2.2 Food rich in zinc

Many foods contain zinc, both in animals and vegetables. However, the human body absorbs zinc from certain foods better than others. This variation depends on the phytate content of the food. Thus, foods rich in highly absorbable zinc are meat, poultry, fish, eggs and dairy products. Foods already known to the scientific community as foods rich in zinc but with limited absorption include pulses, grains and grain-based products<sup>9,10</sup>.

## 2.3 B6 vitamin

Vitamin B6 is the general name used for a group of water-soluble compounds that belong to the B-complex family of vitamins. Of all, vitamin B6 is the most important concerning mental and brain health during the early years of life.

### 2.3.1 B6 vitamin function and reference dose

As already mentioned, vitamin B6 is essential for maintaining the healthy function of our brain and nervous system, as it actively participates in brain development during pregnancy and childhood. This vitamin is necessary for producing neurotransmitters and can help reduce the harmful effects of everyday stress<sup>12</sup>.



Vitamin B6 helps produce calming neurotransmitters that help humans feel more stable and less overloaded. In addition, it helps with the biological effects of stress also caused by stress, such as memory loss and ulcers.

Recently, scientific animal studies have observed that vitamin B6 can reduce brain inflammation and brain death.

The amount of vitamin b6 the body needs each day changes according to age, sex and life stage. The dietary reference value for healthy adults, including during pregnancy and lactation, is between 1.6 and 1.8 mg/day<sup>13</sup>.

### 2.3.2 Food rich in B6 Vitamin

Vitamin B6 is present in many foods, but there are richer sources: whole grains. Pulses, nuts and seeds and potatoes<sup>12</sup>.

<sup>12</sup> <https://www.eufic.org/en/vitamins-and-minerals/article/vitamin-b6-foods-functions-how-much-do-you-need-more>

<sup>13</sup> Kennedy, D. O. (2016). B vitamins and the brain: Mechanisms, dose and efficacy—A review. In *Nutrients* (Vol. 8, Issue 2). MDPI AG. <https://doi.org/10.3390/nu8020068>

## 2.4 Folate

Generally, folate and folic acid are often used interchangeably. However, folate and folic acid are two different forms of the same vitamin. Folate is the natural vitamin found in food and the human body, while folic acid is its synthetic form applied in supplements and food fortification. Folate also belongs to the group of vitamin B, which are water-soluble<sup>14</sup>.

### 2.4.1 Folate functions and reference dose

Folate performs many functions that support the structure and function of young brain cells. One of the effects of folate on the brain is to reduce inflammation and homocysteine, both of which are associated with degenerative brain disorders<sup>15</sup>.

The amount of folate our body needs daily changes according to age, sex and stage of life. Given that our bodies absorb folic acid from fortified foods or supplements significantly better than folate from foods, folate recommendations are measured in ug of folate equivalents (DFE) (table 2).

**Table 2. Folate equivalents**

<b>1 µg of DFE is equivalent to:</b>	1 µg of folate from foods
	0.6 µg of folic acid from fortified foods
	0.6 µg of folic acid supplement taken with food
	0.5 µg of folic acid supplement take non an empty stomach

The dietary reference value for healthy adults is 330 ug/day for healthy adults. In the case of pregnancy and lactation, it can be increased to 600 and 500 ug/day, respectively<sup>14,16</sup>.

### 2.4.2 Food rich in Folate



In general, folate is present in small amounts in various foods. Some of the richest sources of this element are: dark green vegetables, legumes, orange and grapefruit juice and almonds<sup>14</sup>.

<sup>14</sup> <https://www.eufic.org/en/vitamins-and-minerals/article/folate-foods-functions-how-much-do-you-need-more>

<sup>15</sup> <https://www.lifeextension.com/magazine/2018/9/folate-improves-brain-function>

<sup>16</sup> Fenech, M. (2010). Folate, DNA damage and the aging brain. *Mechanisms of Ageing and Development*, 131(4), 236–241. <https://doi.org/10.1016/j.mad.2010.02.004>

## 2.5 Iron

Iron is one of the most abundant chemical elements in the earth's crust and plays a crucial role in our health. In the case of iron, we can find and ingest two different forms: haem-iron and non-haem iron.

### 2.5.1 Folate functions and reference dose

Iron is the most abundant transition metal in the human brain, an essential cofactor for energy production, myelination and neurotransmitter metabolism. As mentioned, this element is crucial for normal neurophysiological function due to its role in oxidative metabolism and is a cofactor. However, in the case of iron, all the mechanisms in which it participates and its distribution in the different brain regions are still very recent and complex topics simultaneously. In this way, it is essential to have a balance of iron in the brain, as both deficiency and excess can have serious adverse consequences for the nervous system.

Overall, the dietary reference value for iron also varies by age, sex and life stage. For healthy adults, the reference value is 11 mg per day<sup>17</sup>.

### 2.5.2 Food rich in Iron

We find iron in many food products, but it can come in two forms: haem iron, found in animal products, and non-haem iron, found mainly in plants. Iron-rich foods include meat, fish, cereals and beans, nuts, egg yolks, dark green vegetables and potatoes<sup>17</sup>.



Iron is also present in dairy products and fruits, but generally, the content is much lower. As for the absorption factor, several studies show that our body absorbs the haem-iron form better than the non-haem iron.

Recently, it was observed that vitamin C can allow a greater absorption of the non-haem iron form by our body. In the figure... some examples are given of how we can introduce vitamin c to increase iron absorption<sup>18</sup>.

<sup>17</sup> <https://www.eufic.org/en/vitamins-and-minerals/article/iron-foods-functions-how-much-do-you-need-and-more>

<sup>18</sup> Connor, J., & Pinero, D. (2005). Iron and Brain Function. <https://doi.org/10.1201/9780203564554.ch14>

### 3 Conclusion

In conclusion, it is increasingly important to understand the molecular basis of the effects of the foods we consume daily on cognition and brain health. This whole process of knowledge will allow you to adjust your diet to increase the resistance of neurons and promote fitness and mental health.

This way, the vital role of all four-helix actors in this process is highlighted. Each has its know-how and instrumentation, so the entire process has outputs that improve the individual's health. In the case of the food industry, this actor will allow the consumer to have access to more elaborate products aimed at the health of our brains.