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Food sources of lutein and its effect on the human health: a brief review

Fontes alimentares de luteína e seu efeito na saúde humana: uma breve revisão

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ABSTRACT

Carotenoids are plant pigments found in plants, algae and some bacteria. The most important carotenoids for the body and most abundant in diets are lycopene, beta carotene, lutein and zeaxanthin, which need to be ingested because the body is not able to synthesize them. Lutein has antioxidant and photoprotective activities, and interacts with other antioxidants, potentiating the immune system and protecting cells from oxidative damage, playing a fundamental role for health. To analyze studies on the role of lutein in human health and to search for foods that are sources of lutein, a literature review was carried out in the year 2021, in databases such as PubMed, ScienceDirect and Scielo. The keywords used were: "lutein", "macular carotenoids", "food and lutein" and "lutein-containing foods". It was observed that vegetables of dark green leaves are foods with high lutein content, especially the capuchin leaf, an unconventional food plant-PANC. Furthermore, it can be concluded that when inserted in the human diet, lutein brings several health benefits, such as the reduction of macular and cardiovascular diseases, in addition to presenting neuro and photoprotective activities. It is expected that this brief review provides information for the inclusion of foods rich in lutein in the diet..

Keywords: Food; Carotenoids; Diet; Lutein; Health

RESUMO

Os carotenóides são pigmentos vegetais encontrados em plantas, algas e algumas bactérias. Os mais importantes para o organismo humano e mais abundantes na alimentação são o licopeno, betacaroteno, luteína e zeaxantina. Entretanto, estes compostos não são sintetizados pelo organismo humano, sendo necessária a ingestão de alimentos que contenham esses pigmentos. A Luteína apresenta ação antioxidante, fotoprotetora e interage com outros antioxidantes, potencializando o sistema imunológico e protegendo as células de danos oxidativos, desempenhando papel fundamental à saúde. O objetivo deste trabalho foi realizar uma breve revisão para analisar estudos sobre o papel da luteína na saúde humana e pesquisar alimentos que são fontes deste composto. Para tanto, foi realizada uma revisão bibliográfica no ano de 2021, nas bases de dados como PubMed, ScienceDirect e Scielo. As palavras-chaves utilizadas foram "lutein", "macular carotenoids", "food and lutein" e "lutein- containing foods". Observou-se que as verduras de folhas verdes escuras são alimentos com alto teor de luteína, em especial a folha da capuchinha, uma planta alimentícia não convencional-PANC. Através desta revisão pode-se concluir que quando inserida na dieta humana, a luteína traz diversos benefícios para a saúde, como a redução de doenças maculares e cardíacas, além de apresentar atividades neuro e fotoprotetoras. Espera-se que as informações apresentadas, sirvam de referência para a inclusão de alimentos ricos em luteína na alimentação.

Palavras-chave: Alimentos; Carotenoides; Dieta alimentar; Luteína; Saúde, PANC

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INTRODUCTION

Carotenoids are natural pigments produced by plants, algae and bacteria, which may have yellow, orange or red coloration, except for two specific colorless carotenoids, i.e. phytoedon and phytopofle (SAUER, LI AND BERNSTEIN, 2019). Currently, over 700 carotenoid structures have been identified, which can be used by food, pharmaceutical and cosmetic industries, among others (MESQUITA, TEIXEIRA AND SERVULO, 2017).

Organic pigments commonly found in fruit and vegetables have several beneficial properties for the human body, such as pro-vitamin A activity, in addition to being antioxidant, anti-inflammatory and anticarcynogenous (LI et al., 2021). Xanthophylls include lutein, zeaxanthin and meso-zeaxanthin, which are carotenoids present in the human retina exerting a powerful and beneficial effect on preserving eye healthcare (MARES, 2016; MITRA, 2021).

Xanthophylls are yellow/orange and are present in eggs, fruit and vegetables, especially those of dark green leaves, such as cabbage, spinach and mustard, although their characteristic color is masked by chlorophyll green (LI et al., 2021). These carotenoids are commonly added to chicken feed in order to intensify the yellow color of egg yolk, therefore contributing to increase the concentration of these compounds in eggs (KIJLSTRA, et al., 2012). Studies reveal that fat intake increases lutein bioavailability in the body, given the fact that egg has fat and lutein absorption is favored by its consumption (KIJLSTRA, et al., 2012; MARES, 2016).

Since they are carotenoids exclusively found in the neural retina and lens, lutein and zeaxanthin protect them from damage caused by light. As a result, several studies evaluate the potential benefits of ingesting foods containing lutein and zeaxanthin so as to control age-related macular disease (AMD) and cataract (SAUER, LI AND BERNSTEIN, 2019). It is estimated that these carotenoids absorb 40 to 90% of incident blue light, thus protecting the retina. Furthermore, xanthophylls protect against oxidative stress and inflammation, which are factors affecting eye diseases (MARES, 2016).

Lutein and zeaxanthin concentration, as well as that of other carotenoids, vary according to the type of food, in addition to its absorption in the body (LI, et al., 2021). Thus, this literature review aims to investigate foods containing lutein and zeaxanthin and their contribution to human health.

METHODOLOGY

A literature review of scientific articles was carried out using three databases: PubMed, ScienceDirect and Scielo. The sought keywords were: "lutein", "macular carotenoids", "food and lutein" and "lutein-containing foods", both in Portuguese and English. The search was carried out during the months of November and December, 2021.

The eligibility criterion of scientific articles was based on studies correlating lutein and foods containing this carotenoid, in addition to their relationship with human health. Furthermore, studies from the latest ten years were selected and a catalogue having Brazilian sources of carotenoids was also used, but it was the only work found for 2008.

Initially, 45 articles in Portuguese, English and Spanish were selected, and afterwards those that best addressed the subject of interest were picked out. Therefore, while this article was being compiled, the authors selected 20 more up-to-date studies whose contents were directly related to the proposed theme. Foods mentioned by more than one author were inserted and the lowest and highest values were found for the aforementioned compounds in order to draw Table 1 which shows their respective contents of lutein and zeaxanthin.

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RESULTS AND DISCUSSION

. LUTEIN

Lutein belongs to a group of carotenoids called xanthophylls, which are oxygenated derivatives of carotenes (SAUER, LI AND BERNSTEIN, 2019; BECERA et al., 2020). It is found in esterified and non-esterified forms with fatty acids, and its free form (not esterified) is the most commonly found. On the other hand, the human body cannot synthesize lutein on its own , therefore food intake is necessary for such a purpose (LOPEZ, et al., 2020). Absorption in the human body occurs through the gastrointestinal tract via enterocyte uptake (KIJLSTRA, et al., 2012). Its bioavailability following consumption, however, depends on its rate of degradation. Nanodelivery systems with improved

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efficacy and stability are currently being developed to increase the bioavailability of lutein (BHAT, 2020).

However, lutein is one of the main carotenoids found in food, and it is a chemical compound derived from alpha-carotene dihydromethy (GAVAZZA et al., 2019). Thus, it has important biological and functional activities for the human organism, i.e. once the individual follows a healthy diet (CABRAL et al., 2017).

A dietary intake of fat is of paramount importance for lutein absorption, as it promotes solubilization of lutein esters and, concomitantly, favors the release and activity of esterases and lipases (KIJLSTRA, et al., 2012). Lutein is transported through the bloodstream to different tissues and it accumulates in the retina so as to act as an antioxidant and filter blue light (LOPEZ, et al., 2020). Unlike other well-known carotenoids, such as β-carotene and β-cryptoxanthene, lutein and zeaxanthin have no pro-vitamin A activity, but it does not undermine its benefits to human health.

According to Mares (2016), some of its studied benefits stand out, such as: light absorption, i.e. lutein intake is associated with damaged retinal protection and reduces light dispersion by absorbing 40 to 90% of incident light; protection against oxidative stress, as well as other carotenoids which are also potential antioxidants; protection against inflammation, it prevents an increase in cytokines caused by oxidation and positive regulation of the expression of inflammation-related genes; prevention of heart disease and some types of cancer, in addition to age-related macular disease (AMD) and cataract (LI, et al., 2020).

4. LUTEIN- FOOD SOURCES

Lutein has become a natural dye found in widely used foods due to its intense yellow staining (BECERA et al., 2020). A flower of the genus Tagetes has petals containing high lutein content representing about 90% of its color, which makes it the main commercial source of lutein. In addition, microalgae is also worthy of attention, as they have high lutein content and biomass productivity, therefore it is an alternative source of such a compound (BECERRA et al., 2020).

An excellent source of lutein is egg yolk due to the fact that it contains fat which in turn favors its absorption by the body (BECERRA et al., 2020). A calendula flower (tagetes erecta) is considered one of the main sources of lutein (BECERRA et al., 2020, ZMITEK et al., 2020). Other foods, such as fruit and vegetables, are also excellent sources of lutein, and some of which are presented in table 1.

Table 1 shows that capuchin is the food containing the highest lutein content (13600 μg/100g), and Rodrigues-Amaya, Kimura and Amaya-Farfan (2008) describe that the value found refers to its leaf. However, the flower also has high lutein contents. Capuchin is a flower considered an unconventional food plant (PANC), as it has coloration ranging from light yellow to red. In addition to lutein, capuchin is rich in anthocyanins and vitamin C and its beneficial health effects have been widely studied in recent years (SOUZA et al., 2020).

Dark green leaf such as spinach, taioba and cabbage also have high lutein contents, i.e. close to the value found for capuchin. Li et al. 2021 reported that a daily intake of 100 g of dark green leafy vegetables is associated with reduced risk of mortality, heart disease and stroke. In addition, other foods such as pumpkin, corn, olive oil also have considerable lutein content.

It is worth mentioning that a balanced healthy diet allows maintaining a good intake of lutein. A proper consumption of these foods promotes beneficial health effects due to their strong antioxidant power, in addition to protecting the eye from ultra violet radiation (BECERRA et al., 2020). In a study conducted by Zmitek et al. (2020), it was observed that a daily intake of 20 mg of lutein improved the skin's photoprotective activity.

It is noteworthy that attention must be devoted to food processing, since lutein is an unstable compound that can be affected by a change in temperature, light, pH and the presence of oxygen. Some forms of processing, such as bleaching, storage mode and temperature can also affect lutein content in food (BECERRA et al., 2020). Furthermore, the source and food matrix also affect bioavailability.

5. LUTEIN CORRELATION WITH FOOD AND HEALTH BENEFITS

There is a growing number of studies on carotenoids emphasizing the importance of these substances for human tissues. Moreover, these compounds stand out due to their strong antioxidant potential, as well as other benefits that vary according to the type of carotenoid (BECERRA et al., 2020).

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Tabela 1. Lutein and zeaxanthen content in different foods.

Food	Lutein (µg/100g)	Zeaxanthin (µg/100g)	Luteine and Zeaxanthin (µg/100g)	Reference
Avocado	314		270 - 300	Beltrán *et al.* (2012); Johnson (2014); Eisenhauer *et al.* (2017).
Pumpkin	460 - 4700		1014 - 2249	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Eisenhauer *et al.* (2017); Aparício *et al.* (2018).
Cooked chard	1960			Beltrán *et al.* (2012); Aparício *et al.* (2018).
Acerola cherry	160			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Raw watercress	6800		10713	Aparício *et al.* (2018).
Raw lettuce	340 - 4780		2313 - 2894,74	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Beltrán *et al.* (2012); Abdel-Aal *et al.* (2013); Johnson (2014); Eisenhauer *et al.* (2017).
Cooked artichoke	275,00			Beltrán *et al.* (2012).
Leek (raw)	36,8 - 76			Beltrán *et al.* (2012); Abdel-Aal *et al.* (2013).
Chicory (*Cichorium intybus*)	5700			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Cooked asparagus	738 - 991		771	Beltrán *et al.* (2012); Eisenhauer *et al.* (2017).
Virgin olive oil	599 - 934			Beltrán *et al.* (2012); Aparício *et al.* (2018).
Cooked broccolis	710 - 3500		1079 - 2179,5	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Beltrán *et al.* (2012); Abdel-Aal *et al.* (2013); Johnson (2014); Eisenhauer *et al.* (2017).
Raw broccolis	1108			Beltrán *et al.* (2012); Aparício *et al.* (2018).
Nasturtium (*Tropaeolum majus*), leaf	13600			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Cashew	40-560			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Camu camu (*Myrciaria dubia*)	380	30		Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Pigweed (*Amaranthus viridis*)	11900			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Khaki			834	Aparício et *al.* (2018).
Carrots	250 - 510			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Beltrán *et al.*(2012); Abdel-Aal *et al.* (2013).
Corn chips	61,1	92,5		Abdel-Aal *et al.* (2013).
Cilantro (*Coriandrum sativum*)	7400			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Cooked kale	5200 - 8884		15798 - 18246	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Johnson (2014); Eisenhauer *et al.* (2017).

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Food	Lutein (µg/100g)	Zeaxanthin (µg/100g)	Luteine and Zeaxanthin (µg/100g)	Reference
Cooked Brussels sprouts	468 -		1541 - 1282,05	Beltrán *et al.* (2012); Johnson (2014); Eisenhauer *et al.* (2017).
Peas	1910		1375,0 - 2593	Abdel-Aal *et al.* (2013); Johnson (2014); Eisenhauer *et al.* (2017); Aparício *et al.* (2018).
Escarola Escarole, slightly processed	4300			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Cooked spinach	6422 - 12640	564	6422 - 11308	Beltrán *et al.* (2012); Johnson (2014); Eisenhauer *et al.* (2017); Aparício *et al.* (2018).
Raw spinach	4229 - 7900	377	12197 - 11842,1	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Beltrán *et al.* (2012); Abdel-Aal *et al.* (2013); Johnson (2014); Eisenhauer *et al.* (2017).
Cooked Green Beans	306	0	564 - 1619	Eisenhauer *et al.* (2017).
Orange	20-250		129	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Eisenhauer *et al.* (2017).
Marjoram (*Origanum majorana*)	4400			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008)
Basil (*Ocimum basilicum*)	3000			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008)
Corn	202 - 2190	106,15	684 - 1866,67	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Beltrán *et al.* (2012); Abdel-Aal *et al.* (2013); Johnson (2014); Eisenhauer *et al.* (2017); Aparício *et al.* (2018).
Turnip			8440	Aparício *et al.* (2018).
Nectarine (*Prunus persica* var. nectarina)	110	160		Rodrigues-Amaya, Kimura e Amaya-Farfan (2008)
Whole boiled egg	237	216	200 - 353	Johnson (2014); Eisenhauer *et al.* (2017).
Raw whole egg	288	279	620 - 504	Beltrán *et al.* (2012); Eisenhauer *et al.* (2017).
Boiled egg yolk	645	587		Eisenhauer *et al.* (2017).
Raw egg yolk	384 - 1320	762	1094 - 2980	Abdel-Aal *et al.* (2013); Eisenhauer *et al.* (2017); Aparício *et al.* (2018).
Raw orange chili pepper	208	1665		Eisenhauer *et al.* (2017).
Green chili pepper	880			Abdel-Aal *et al.* (2013).
Red chili pepper	250 - 8510	590 - 13500		Abdel-Aal *et al.* (2013).
Green (*Capsicum annuum*) bell pepper	770 - 341			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Beltrán *et al.* (2012).
Yellow bell pepper	780			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Red bell pepper	750			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Pistachio	730,85		1404	Abdel-Aal *et al.* (2013); Eisenhauer *et al.* (2017).

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Food	Lutein (µg/100g)	Zeaxanthin (µg/100g)	Luteine and Zeaxanthin (µg/100g)	Reference
Rocket leaves	6300 - 8061			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Aparício *et al.* (2018).
Salsa (*Petroselinum crispum*)	4326 - 10600		5562	Rodrigues-Amaya, Kimura e Amaya-Farfan (2008); Abdel-Aal *et al.* (2013); Eisenhauer *et al.* (2017).
Sow thistle (*Sonchus oleraceus*)	8700			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008)
Taioba (*Xanthosoma sp*)	10400			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008)
Tomato	44 - 54		94	Beltrán *et al.* (2012); Eisenhauer *et al.* (2017).
Thyme (*Thymus vulgaris*)	1800			Rodrigues-Amaya, Kimura e Amaya-Farfan (2008).
Durum wheat	540	50		Abdel-Aal *et al.* (2013).
Einkorn wheat	740	90		Abdel-Aal *et al.* (2013).
Khorasan Wheat	550	70		Abdel-Aal *et al.* (2013).

Given the fact that it is considered having an antioxidant potential, some studies address the neuroprotective effect of lutein. Mitra et al. (2021) reports that different studies conducted in vivo and in vitro have revealed that lutein was effective in reducing the risk of neural retinal diseases, and also concerning diabetic retinopathy. Li et al. (2021) and Becerra et al. (2020) state that a lutein intake was inversely associated with heart disease, stroke and amyotrophic lateral sclerosis.

Studies addressing the correlation between lutein intake and ophthalmologic effects markedly stand out. Lutein and zeaxanthin accumulate in the macula, thus acting as blue light filters. Individuals aged over 65 years are prone to suffer from degenerative diseases affecting this region of the eye, and ingesting lutein foods reduces the risks of developing these diseases (BECERRA et al. 2020). The presence of these compounds in the eyes of children aged up to two years old has also been documented. Furthermore, the presence of these carotenoids is of paramount importance, since a newborn is under development and are vulnerable to blue light and oxidative damage (LONG, KUCHAN AND MACKEY, 2019).

Lutein and zeaxanthin are the two main carotenoids present in breast milk, in addition to being responsible for the visual and cognitive development of babies, as they represent about 66 to 77% of the total concentration of carotenoids in the brain (BECERRA et al., 2020). However, the concentration of these carotenoids varies according to maternal dietary intake. In a study evaluating the presence of lutein in different regions of the brain in infants allowed observing that this carotenoid was also present in an important region responsible for memory and learning processes (LONG, KUCHAN AND MACKEY, 2019).

An intake of these foods in a short period of time is associated with higher levels of serum lutein concentrations in the body. Thereby, there is no standard dietary intake for non-pro-vitamin A carotenoids, but there are intake suggestions based on minimizing chronic diseases. Thus, based on epidemiological studies, it is recommended to add a daily dietary intake ranging from 6 to 10 mg of lutein (RANARD et al., 2017). However, lutein consumption is very low in some countries, i.e. between 0.48 to 2 mg/day (RANARD et al., 2017; LOPEZ et al., 2020).

Cabral et al., (2017) evaluated individual food intake of carotenoids and vitamin A in overweight and obese individuals in different populations and observed a predilection for dark green fruits and vegetables containing lutein. This component provides greater quality of life and health for people as regards food composition.

CONCLUSION

Based on analyzed studies, it is found that lutein is widely found in vegetables, fruit and egg. Furthermore, it is observed that capuchin leaf, an unconventional food plant, has higher lutein content, in addition to dark green leafy vegetables that are also foods containing a higher content of this carotenoid, even if its coloration is masked by chlorophyll green. Furthermore, it is noted that, when inserted in food, lutein offers several health benefits, such as a reduction of macular, cardiovascular diseases, in addition to acting as neuroprotectors and having a photoprotective activity.

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