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REVIEW

Chia (*Salvia hispanica* L.) Seed Germination: a Brief Review

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Abstract

Chia (*Salvia hispanica* L.) is a seed native to northern Mexico and southern Guatemala that has started to be consumed in recent years in other regions of the world owing to its nutritional and functional properties. Germination of chia seeds seems to be able to further improve these properties, and it has been the subject of some studies. In general, germination has proven to be a simple and inexpensive process capable of improving the content of phenolic compounds and the antioxidant capacity of foods, as well as reducing antinutritional factors that interfere with nutrient absorption. A particular characteristic of chia seeds is that they produce mucilage when they are hydrated. For this reason, the germination conditions of the seed need to be adapted. The nutritional guidelines of some countries, such as Brazil, Germany and Sweden, recommend that the diet of the population should be more plant-based, thus encouraging the consumption of foods with a high content of bioactive compounds and nutrients, *e.g.*, germinated seeds. This review briefly explored the germination conditions of chia seeds as well as the changes in phytonutrient content and antinutritional factors after their germination process. The main information available in the literature is that germination of chia seeds can increase the contents of protein, fiber, and total phenolic compounds. As a conclusion, germination of chia seeds is favorable for increasing their health benefits and nutritional value. However, chia germination parameters should be adjusted and microbiological risks should be properly evaluated.

Keywords Germination process · Plant-based diet · Phenolic compounds · Antioxidant activity · Antinutritional factors

Introduction

Salvia hispanica L., popularly known as chia, is an ancient herbaceous plant of the Lamiaceae family, native to Southern Mexico and Northern Guatemala [1, 2], which has recently been commercialized as a crop in South America [3]. Chia seed was recognized as a novel food ingredient by the European Parliament in the 1990s [4] owing to its health benefits and has been associated to lower incidence of non-communicable chronic diseases, *e.g.*, cardiovascular disease, obesity, hypertension, diabetes, and cancer [5–7]. The health benefits of chia seed are attributed to its nutrition and functional properties since it is a source of fat, protein, dietary fiber, mineral [8–15]. Table 1 shows data on the nutritional composition of chia found in the scientific literature.

Regarding lipids, chia seeds are considered a food source with a high content of omega-3 and omega-6 fatty acids [20]. A recent scientific report examined 16 transcriptomes obtained from seeds of eight different cultivated and wild accessions of *S. hispanica*, representative of the biodiversity of this crop [20]. The study found that domestication of chia could be associated with the accumulation of storage lipids in the cultivated accessions and that genes responsible for the biosynthesis and degradation of triacylglycerols and fatty acids showed differences in expression between cultivated and wild accessions. In addition, the study provided evidence that the expression of transcripts related to lipid metabolism in chia seeds may be affected by different growth conditions [20].

Chia seeds are also a rich source of protein, making them a very attractive source for human nutrition and health, with much higher levels than in other crops such as oats, wheat, and rice [20]. In a study to identify the protein fractions of commercial chia varieties, it was found that the

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Table 1 Centesimal composition and total phenolic content of chia seeds (ungerminated) observed in the scientific literature

Component	Hernández-Pérez et al.* [16]	Marineli et al.* [17]	Segura-Campos et al. [11]	Fernandes et al.* [12]	Monroy-Torres et al. [13]	Beltran-Orozco et al. [18]	Gómez-Favela et al.*, ** [19]
Moisture (g/100 g)	4.50 ± 0.00	5.82 ± 0.04	6.32	5.74 ± 0.17	6.25		
Lipids (g/100 g)	32.50 ± 2.70	30.22 ± 0.08	34.88	35.68 ± 0.61	33.00	37.98 ± 2.79	33.70 ± 0.16
Protein (g/100 g)	22.70 ± 0.70	25.32 ± 0.21	23.99	19.55 ± 0.25	18.65	20.66 ± 0.10	18.48 ± 0.76
Ash (g/100 g)	3.70 ± 0.30	4.07 ± 0.02	4.32	4.93 ± 0.03	4.35	5.06 ± 0.02	3.20 ± 0.30
Total dietary fiber (g/100 g)	33.50 ± 2.70	37.50 ± 1.07	35.85	17.18 ± 0.04****	28.38	16.60 ± 0.36****	42.52 ± 0.43
Soluble dietary fiber (g/100 g)	8.20 ± 0.80	2.43 ± 0.30	–	–	–	–	3.99 ± 0.043
Insoluble dietary fiber (g/100 g)	25.40 ± 2.20	35.07 ± 0.90	–	–	–	–	38.53 ± 0.47
Carbohydrates (g/100 g)	3.10	34.57 ± 0.26	–	22.66	9.37	–	44.62 ± 0.4
Total phenolic content (mg GAE/g)	0.78 ± 0.04–0.97 ± 0.03***	0.94 ± 0.06	–	–	–	0.98 ± 0.03	–

- Analysis not performed

*Values are the mean ± standard deviation

**Ungerminated chia flour

***Range of four varieties of commercial chia seeds

****Crude fiber determination

concentration of globulins was the highest, followed by the protein fractions albumin, glutelin, and prolamin [16].

Chia seed consumption has also been reported for its high antioxidant potential [7, 21]. Several studies have shown the capacity of chia to scavenge free radicals and reduce oxidative stress [11, 22–24]. Phenolics composition is an important factor that is responsible for the antioxidant activity of chia seeds [25]. Another important characteristic of chia seeds, which is responsible for satiety during intake and for their high potential as a functional ingredient to be added in foods, is the content of mucilage, which forms a thick layer when soaked in water (gel) [26, 27].

Chia can be consumed as whole seeds or in the form of flour, mucilage (gel) and oil, alone (*in natura*), added to other foods (yogurts, fruits, salads, and soups) or as ingredients of preparations (breads, cakes, whole grain bars, and beverages) [28]. Adding chia to foods improves their physicochemical and sensory characteristics as well as increases their nutritional content and health properties [22, 29]. There has been recent research on germinated chia seeds because their germination seems to be able to increase the nutritional and nutraceutical values of foods [30, 31].

Germination is a simple process in which water is added to the seeds until they have developed the embryonic axis. It is a process that does not require soil neither controlled light, temperature, and humidity conditions; in addition, it is inexpensive and can be carried out in a domestic environment [32]. Although simple, germination requires careful monitoring to provide further insights into the changes that occur during the process, with a view to determining the optimal conditions that result in a safe and quality product [33]. Sprout is the advanced stage of seed germination and, according to the European Parliament, it is "the product obtained from the germination of seeds and their development in water or another medium, harvested before the development of true leaves and which is intended to be eaten whole, including the seed" [34, 35].

A wide range of sprouts have been studied for their high nutritional value and therapeutic properties and are increasingly present in the diet of people who seek a close relationship between diet, health, and the environment [36]. Germination is an effective green food development strategy to increase the phytonutrient content in seeds because it reactivates their metabolism, which leads to catabolism as well as macronutrient degradation and stimulates the synthesis of secondary metabolites that have health benefits [33, 37, 38]. Germination is able to induce enzymes to break down carbohydrates, lipids, and proteins in basic methods, and stimulates proteases involved in protein destruction, thus improving nutrient bioavailability [33].

Although there are still few studies, the literature reports that germination of chia seeds results in increased protein content and quality, and increased total phenolic compounds and antioxidant capacity [31]. More recently, Cabrera-Santos et al. [39] explored lipid profile changes during chia seed germination and showed an increase in fatty acid content, depending on the phase and temperature of germination. Chia sprouts can be consumed *in natura* by being added to salads, soups, and sandwiches, or be used to improve the nutritional and functional value of food products [40, 41].

The addition of sprouted chia to food products has not been widely explored in the scientific literature. Argüelles-López et al. [40] developed a functional beverage based on chia and amaranth processed by germination and extrusion, and they evaluated its nutritional, antioxidant and antihypertensive properties. To this end, two functional beverages were developed from flour mixtures: Mixture 1 (70% extruded amaranth flour +30% sprouted chia flour) and Mixture 2 (70% sprouted amaranth flour +30% sprouted chia flour). In the sensory evaluation performed with panelists, the beverages had high acceptability with average values of 83–85. The authors concluded that the beverages had a high content of high-quality protein and dietary fiber, with low energy content and high sensory acceptability. In addition, the beverages had high antioxidant and antihypertensive potential and may be a good alternative to beverages with high calories and low nutritional value, which predominate in a consumer market with significant trends towards overweight and chronic degenerative diseases [40].

The use of germinated chia as a cooking ingredient can be a good strategy to increase the nutritional value of food products. Moreover, the addition of chia sprouts in culinary preparations can reduce the risk of foodborne diseases, since the consumption of sprouts, which are usually raw, is associated with several foodborne outbreaks, and cooking them is able to reduce their microbial load [42]. Harvey et al. [41] reported an international outbreak of multiple *Salmonella* serotype infections in 2013–2014, linked to sprouted chia seed powder. Ninety-four people were found to be infected with outbreak strains from 16 states, in which 21% were hospitalized. The authors reported that although chia seed powder is a new outbreak vehicle, sprouted seeds are recognized as an important cause of foodborne illnesses [41].

In addition, it should be noted that the promotion of habitual consumption of chia sprout may be an important action in the context of plant-based diets, which are well-recognized for provide physical and environmental health benefits [36, 43]. Considering that chia sprouts have been increasingly studied for their nutritional and functional potential, this review explores the germination conditions of chia seeds, and the changes in the content of phytonutrients and antinutritional factors after germination. The literature search was carried out using scientific databases comprising Scopus, Web of Science, PubMed, using the following keywords: "chia", "chia sprout", "*S. hispanica* L.", "sprout", "germination" and "seeds". The articles found about chia sprouts were published between 2017 and 2021.

Optimizing the Chia Germination Process

Germination is often considered to be a critical stage in the life cycle of plants, as it is highly sensitive to environmental factors such as temperature, light, water availability, and gaseous environment [39, 44, 45]. It is worth noting that chia seeds release mucilage during the imbibition phase [39]. It has been suggested that mucilage inhibits germination under excessively humid conditions by preventing the diffusion of oxygen to the embryo [46]. To date, few studies in the scientific literature have shown the optimal conditions for sanitization process, light and temperature [39, 47]. Most studies have established germination conditions based on preliminary tests in the laboratory and adopted the strategy of using germination paper and spraying water on the seeds on a daily basis [18, 30, 31]. Table 2 shows the objectives, germination conditions, and the main results found in the studies with germinated chia. It should be noted that the germination conditions were different, as well as the origin of the chia seed in some studies.

Sanitization

As a pre-germination step of any seeds, measures should be adopted to decrease their microbial load, such as sanitizing the seeds prior to the germination process, since germination presents optimal conditions for microbial development [42]. In a study conducted by Abdel-Aty et al. [31], chia seeds were sanitized with sodium hypochlorite, while Beltran-Orozco et al. [18] previously hydrated chia seeds and then washed them with liquid detergent, whereas ethanol was used to sanitize chia seeds in another study [30].

Light

Light intensity, quality, and duration significantly affect plant growth and development through morphogenesis, photosynthetic apparatus function, and metabolic pathways [47, 49]. Mlinari et al. [47] suggested that lighting has a positive effect on the antioxidant potential of chia seeds, as light conditions can enhance the synthesis of different antioxidants. In the studies found in

Table 2 Summary of studies conducted with germinated chia seeds reported in the scientific literature

Reference	Objective	Origin of chia	Germination conditions					Main results
			Sanitization	Place	Temperature	Time	Light	
Abdel-Aty et al. [31]	To evaluate the impact of the germination process on the phenolic profile, antioxidant, and the enzymatic activities	Egypt	0.07% sodium hypochlorite solution at room temperature for 5 min	Plastic tray containing moistened tissue paper	Room temperature (25–30 C)	1 to 10 days	Dark	↑ Total phenolic and flavonoid contents of chia seeds until 7-day sprouts ↓ total phenolic content between day 7 and 10 Detection of 12 phenolic acids and 5 flavonoids ↑ total antioxidant activity
Beltrán-Orozco et al.) [18]	To evaluate the effect of germination on protein, fat, fiber, ash, tryptophan, vitamin C, total phenolic compounds and total flavonoids, protein digestibility and antioxidant activity	Mexico	The seeds were placed in water for 10 min for hydration and then washed with liquid detergent.	Plastic trays containing filter paper sheet	Up to 30 °C	0, 1, 2, 3 and 4 days	Dark	Germination for 2 days: ↑ protein content Germination for 4 days ↑ contents of fiber, tryptophan, total phenolics and flavonoids ↑ Vitamin C ↑ Antioxidant capacity ↓ protein digestibility
Gomez-Favela et al. [19]	To investigate the antioxidant activity, phenolic compounds, GABA, essential amino acids, and dietary fiber of germinated chia seeds.	Mexico	–	Placed on plates with absorbent paper previously moistened with sodium hypochlorite solution and placed in a germination chamber	21 °C	57 h	12/12 h light and dark	↑ protein content ↑ total dietary fiber content ↑ insoluble fiber ↓ soluble dietary fiber by
Pajak et al. [30]	To investigate the effect of germination on antioxidant properties, phenolic compounds, and mineral composition.	Austria	Ethanol 96%	Spread on sterile stackable trays and sprayed twice a day	22 ± 2 °C	7 days	12/12 h light and dark.	↑phenolic compounds ↑ antioxidant activity. > amount of caffeic acid

Table 2 (continued)

Reference	Objective	Origin of chia	Germination conditions					Main results
			Sanitization	Place	Temperature	Time	Light	
Stefanello et al. [48]	To evaluate the influence of different salts on the germination of chia seeds.	Argentina	–	Placed on plastic boxes and kept in chambers	20 °C	7 and 14 days	8/16 h light and dark.	↓ germination in the presence of salts (NaCl, KCl, CaCl2 and MgCl2)
Cabrera-Santos et al. [39]	To explore fatty acid changes during chia seed imbibition, to establish a correlation between fatty acid behavior, temperature, and germination	Mexico	–	Placed inside woven mesh cotton bags, in Petri dishes and kept inside germination chambers 25 seeds were sown on agar medium in Petri dishes.	10, 20, and 30 °C	1 to 14 days	12/12 h light and dark.	↑germination rates at 30 °C ↑ fatty acid concentration after 3 h of imbibition ↓ correlation between linoleic and linolenic acid at 20 °C Formation of three isomers of trans linolenic acid at 30 °C

the scientific literature, there is no consensus on light exposure during the chia germination process, with some studies adopting 12/12 h in light and dark [19, 30], while others performed germination only in the dark [18, 31]; still, others used different light/dark ratio [48].

Temperature

Temperature is the main controlling factor in germination and its effect has been related to the seeds' water uptake, level of latency, rate of seed deterioration, and length of time during which germination takes place [39, 45]. As with the other parameters mentioned above, there is no consensus on the ideal temperature for chia germination. Abdel-Aty et al. [31] germinated chia seeds at room temperature (25–30 °C). These values were close to those described by Gomez-Favela et al. [19] (20–35 °C) and by Beltran-Orozco et al. [18] (up to 30 °C). Lower temperatures were used by Stefanello et al. [48] and Pajak et al. [30]: 20 and 22 ± 2 °C, respectively.

One study determined the best combination of process variables for producing optimized sprouted chia flour and found the optimal combinations of bioprocess variables (21 °C/157 h; 33 °C/126 h) to produce two flours with higher protein, lipid, phenolic compound and antioxidant activity contents. Only the flour made with chia germinated at 21 °C for 157 h was considered as adequate, because the samples germinated at 32 °C for 126 h tended to have fungal growth and a small number of germinated seeds [19].

Nutritional Value of Germinated Chia

In general, almost all nutrients in sprouted grains are more available, and several antioxidants occur in higher concentrations; for this reason, sprouts can be considered as "functional foods" [50]. Some changes in phenolic compounds and nutritional composition were found in germinated chia (Fig. 1). Table 3 shows data on the nutritional composition of chia sprouts found in the scientific literature. These changes will be reported in more detail below.

Phenolic Compounds

Studies have shown that dietary intake of bioactive components, such as phenolic compounds in chia seeds, is associated with reduced risk of cardiovascular disease and hepatoprotective effects, as well as protection against plasma oxidative stress and obesity-related diseases [17, 51]. Abdel-Aty et al. [31] evaluated the impact of germination on the antioxidant and antibacterial properties of

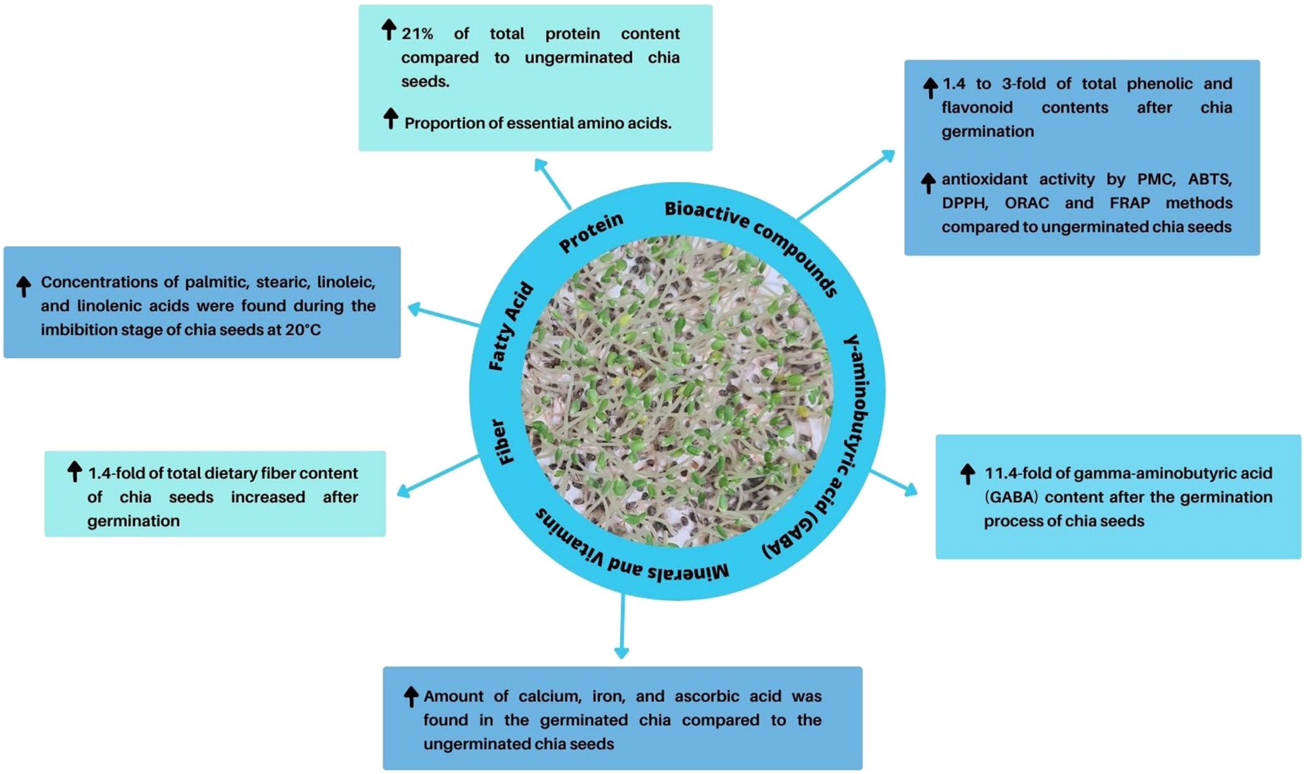

Fig. 1 Main changes in the nutritional composition and phenolic compounds in chia sprouts reported in the scientific literature

Table 3 Centesimal composition and total phenolic content of chia sprouts found in the scientific literature

Component	Abdel-Aty et al.* [31]			Beltran-Orozco et al.* [18]				Gómez-Favela et al.*, ** [19]	Pająk et al. [30]
	Time of germination (day)								
	1	7	10	1	2	3	4	6.5	7
Lipids (g/100 g)	–	–	–	41.65 ± 0.88^{c}	42.16 ± 0.31^{d}	38.44 ± 0.79^{b}	30.98 ± 0.04^{a}	15.06 ± 0.60	–
Protein (g/100 g)	–	–	–	22.10 ± 0.47^{a}	23.24 ± 0.07^{b}	22.16 ± 0.10^{a}	21.24 ± 0.02^{a}	22.34 ± 0.51	–
Ash (g/100 g)	–	–	–	5.01 ± 0.01^{a}	5.02 ± 0.03^{a}	5.04 ± 0.04^{a}	5.12 ± 0.04^{a}	5.10 ± 0.20	–
Total dietary fiber (g/100 g)	–	–	–	18.66 ± 0.02^{a} ***	21.14 ± 0.52^{b} ***	22.30 ± 0.70b^{c} ***	24.25 ± 0.09^{c} ***	43.96 ± 0.05	–
Carbohydrates (g/100 g)	–	–	–	–	–	–	–	57.5 ± 0.60	–
Total phenolic content (mg GAE/100 g)	430.00 ± 21^{a}	900.00 ± 42^{b}	680.00 ± 29^{c}	148.60 ± 0.70^{a}	165.40 ± 7.33^{b}	191.10 ± 3.50^{c}	293.60 ± 1.30^{d}	612.00 ± 7.90	440.00

Different letters in the same row mean significant differences in the study

- Analysis not performed

*Values are expressed as mean ± standard deviation

**Ungerminated chia flour

***Crude fiber determination

sprouted chia seeds. The results showed that total phenolic and flavonoid contents had a 6.4- and 11.5-fold increase until day 7 of chia seed germination, respectively. After this germination period until day 10, there was a decrease in total phenolic and flavonoid contents, which may have been due to the conversion of some free phenolic compounds to bound phenolic compounds or to the ones used for cell wall synthesis. Furthermore, the results also suggested that the antibacterial activity of chia seeds was enhanced after germination, which may have been due to an increase in the concentrations of all identified phenolic compounds or to the production of new ones [31].

Gomez-Favela et al. [19] produced germinated chia flour and found a total phenolic content of 3.38 mg GAE/g after 155 h of seed germination at 21 °C. In another study, the value of total phenolic content increased 3-fold after the fourth day of germination. Moreover, 30% of the total phenolic content was represented by total flavonoid content and its content increased 197% after 4 days of germination [18]. The results were similar to those of Pajak et al. [30], who found an increase in phenolic compounds from 0.92 to 4.40 mg GAE g-1 in germinated chia when compared to ungerminated chia seeds.

Table 3 shows that the values found for total phenolic compounds in the studies were different from each other. This may have occurred because of the different germination conditions and origins of the study seeds [31].

Protein Content

The protein content of chia seeds is about 17%, higher than the protein content in all other cereals [2]. According to Beltran-Orozco et al. [18], the germination process increased the protein content by 13% during the initial 48 h of the germination process, but there was a decrease after that time. This subsequent decline in protein after 2 days of germination may have been due to its use for energy or for the synthesis of other components required for plant growth. Furthermore, germination induced an increase in the proportion of essential amino acids and resulted in an approximately 100% increase in tryptophan content after 4 days of chia seed germination [18].

Another study found a 20.9% increase in protein content after 156 h of germination at 21 °C [19]. In addition, the essential amino acid content of chia seeds increased significantly after this germination process, and there was also a 4.8% increase in protein digestibility *in vitro* [19]. This behavior differs from those found by Beltran-Orozco et al. [18], since *in vitro* protein digestibility decreased as germination progressed, possibly owing to the parallel increase in fiber and phenolic compounds.

Gamma-Aminobutyric Acid (GABA)

In a study using germinated chia seed flour, GABA content in chia seeds was evaluated before and after the germination process. The results showed that GABA content in chia seeds was 9.51 mg and 117.66 mg/100 g dry weight before and after the germination process, respectively [19]. Therefore, the germination of chia seeds showed a significant ($p < 0.05$) 11.4-fold increase in GABA content. This increase may have been due to decarboxylation of L-glutamic acid and catalyzation by glutamate decarboxylase (GAD) during seed germination. This is a positive result, because GABA has anti-diabetic, anti-hypercholesterolemia, antihypertensive, anti-inflammatory and antidepressant properties, and antiproliferative effects against cancer cells [52].

Dietary fiber Content

Dietary fiber intake can reduce the risk of diseases such as diabetes, obesity, coronary heart disease, hypertension, stroke, and gastrointestinal disorders [53]. Total fiber content increased by approximately 46% after 4 days of chia seed germination [18]. In another study, the total dietary fiber content of chia seeds after germination (157 h) increased by 3.39%, with insoluble fiber increasing by 5.14% and soluble dietary fiber decreasing by 13.53%. According to the authors, this effect may have been due to the loss of mucilage when the seeds come into contact with the hydration solution early in the germination process [19]. It is worth noting that the values found for dietary fiber were very different between these studies, since one analyzed total dietary fiber while the other, crude fiber (Table 3).

Lipid Content and Fatty Acid Profiles

Chia seeds stand out for their lipid profile, showing approximately 25–40% of their total weight in lipids, with 50–57% being linolenic acids and 17–26% being linoleic acids [39]. The lipid content of chia seed meal after germination at 21 °C for 157 h had a significant ($p < 0.05$) decline from 33.7 ± 0.16 to 15.06 ± 0.60 g/100 g dw [19]. Another study found an increase in the amount of lipids after chia germination for 48 h and a significant reduction after germination for 96 h compared to ungerminated chia (Table 3) [18]. The reduction in seed oil content during germination can be attributed to the use of energy for metabolic activity, such as synthesis of DNA, RNA, enzymes, structural proteins, and other [54].

Regarding lipid profile, a study investigated the changes in fatty acids during hydration of chia seeds at 10, 20 and 30 °C to determine the correlation between fatty acids, temperature and germination. The results showed that the highest concentrations of palmitic, stearic, linoleic and linolenic acids were found at 20 °C [39]. It should be noted that no studies were found in the scientific literature that evaluated changes in the profile of fatty acids after chia germination.

Antinutritional Factors Versus Mineral and Vitamin Contents

There is evidence to indicate that germinated foods are superior in nutrients, such as minerals, compared to their ungerminated counterparts owing to the activation of endogenous enzymes that degrade the antinutritional factor, e.g., trypsin inhibitors in legumes, tannins in legumes and cereals and phytates in cereals [55, 56]. Antinutritional factors may occur naturally in plants as part of their protection against attacks by herbivores, insects, and pathogens or as a means of survival under adverse growing conditions [57]. The presence of antinutritional factors in food can restrict the digestion of proteins and bioavailability of different minerals [58]. For better understanding, the terms bioaccessibility and bioavailability should be distinguished. Bioaccessibility is the fraction of compounds that is released from the food matrix during digestion and becomes available for absorption in the intestine, while bioavailability refers to the fraction of compounds that is absorbed, distributed through the circulatory system, and subject to metabolism and elimination [59].

During germination, there is a frequent increase in mineral content as a result of the hydrolysis of phytic acid, owing to an increase in phytate enzymatic activity [30]. Phytic acid is an antinutritional factor that acts as a powerful chelating agent, thus reducing the bioavailability of minerals that form insoluble complexes [30].

Few studies have aimed to verify the content of minerals in chia before and after germination. Pajak et al. [30] evaluated the content of sodium, potassium, calcium, magnesium, iron, manganese, copper, and zinc in chia seeds and in 7-day germinated chia. The results showed that there was a significant increase in the amount of calcium and iron in germinated chia compared to ungerminated chia seeds [30].

This is in agreement with the study by Calvo-Lerma et al. [60], who also analyzed the calcium content in chia seeds and in germinated chia. The results showed that there was a significant increase in calcium content in the 10-day germinated chia sample [60].

Another study evaluated the ascorbic acid content in chia seeds and in 4-day germinated chia. The authors found that the ungerminated chia seeds had no detectable ascorbic acid, but germination produced an increase of this vitamin as of the second day and continued to increase significantly over the next 2 days [18]. This increase is related to the activity of GLDH (L-galactonoclactone dehydrogenase), a key enzyme in ascorbic acid biosynthesis, which increases significantly during germination, reactivating vitamin C biosynthesis [61].

It is worth noting that the studies mentioned above did not evaluate the reduction of antinutritional factors, but only compared nutrient content before and after chia seed germination. Considering the lack of studies on this topic, it is expected that future studies will be developed to evaluate the behavior of the antinutritional factors at different germination times of chia seeds.

Conclusions and Perspectives

Germinating chia seeds can increase their health benefits and nutritional value. However, the seeds' own mucilage can inhibit the germination process. Therefore, the germination parameters of chia need to be adjusted. Few studies were found in the scientific literature that evaluated the optimal germination conditions of chia seeds at different periods, as well as the impact of germination on the nutritional value of these seeds. More studies are needed to evaluate the reduction of antinutritional factors in germinated chia seeds and the consequent increased bioavailability of nutrients, as well as to evaluate the fatty acid profile of chia during germination. In addition, *in vivo* and *in vitro* studies should be conducted to verify the benefits of consuming sprouted chia, as well as if there is a chance of toxicity.

The consumption of a more plant-based diet is increasing worldwide, and sprouted seeds may be a promising dietary option, and they may thus favor a higher intake of phenolic compounds, minerals, gamma-aminobutyric acid (GABA), fiber, omega-3 fatty acid, and others.

Authors' Contributions R.M. had the idea for the article. V.S. performed the literature search and data analysis. R.M., L.Z., V.S. and A.A. wrote the main manuscript text. V.S. prepared Table 2 and Fig. 1. R.M. prepared Tables 1 and 3. All authors drafted and/or critically revised the work.

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Data Availability Data is available upon request.

Declarations

Ethics Statement Not applicable.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

Conflict of Interest The authors declare no conflict of interest.

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