proceedings

Proceedings

Nutritional Composition and Uses of Chia (*Salvia hispanica*) in Guatemala †

Elsa Julieta Salazar de Ariza *, Ana Ruth Belloso Archila, Ingrid Odete Sanabria Solchaga and Sandra Beatriz Morales Pérez

Department of Chemical and Pharmaceutical, School of Nutrition, Universidad de San Carlos de Guatemala, Cdad. de Guatemala 01012, Guatemala; anabelloso@gmail.com (A.R.B.A.); odette_2865@hotmail.com (I.O.S.S.); sanbmor@gmail.com (S.B.M.P.)

* Correspondence: julietasalazar10@gmail.com

† Presented at the 2nd International Conference of Ia ValSe-Food Network, Lisbon, Portugal, 21–22 October 2019.

Published: 10 September 2020

Abstract: *Salvia hispanica* L. (chia) is a seed native to Mexico and Central America; in Guatemala it is known as "chan". It is cultivated in small quantities and sold in neighborhood markets in different areas of the country. Little information exists on the nutritional composition of this seed, so chia samples were obtained in five regions of the country and studied for their macronutrients, minerals, and fatty acids, the form of consumption, and the adequate quantity to mix with water. We found an average of 22% for protein, 18.6% for fat, 67% for alpha-linoleic acid, 19% for raw fiber, and 9 mg/100 g of sodium, among other nutrients. The most frequent form of consumption is mixed with lemonade; the primary known benefits are to lose weight, improve digestion, and as a source of fiber; the adequate amount to mix with water is 0.8% of gel equivalent to 0.4% of seeds.

Keywords: alfa-linoleic acid; chia; consumers; *Salvia hispanica* L.

1. Introduction

Salvia hispanica L. is a seed native to Mexico and Central America; it has been known and cultivated in Guatemala since pre-Hispanic time [1,2], its common name is "chia", and traditionally, it has been sold in bulk in neighborhood markets, even though recently it has also been sold packaged and branded in supermarkets and gourmet stores. It is also found as an ingredient in processed food, which allows it to be advertised as a functional food. The chia seed has a high content of α-linoleic acid, protein, and dietary fiber, propertied which make it recommended for consumption as flour, as oil, or as a hydrolyzed protein [3].

Alvarado [4] quantified the macronutrients and fatty acids of the chia seed cultivated in the northern region of Guatemala, finding amounts of these nutrients similar to those reported by Bushway et al. [5], Ayerza and Coates [6] and Ixtaina [7].

The objective of the present study was to quantify the macronutrients, minerals, and fatty acids of *S. hispanica* sold in bulk in Guatemala, as well as to determine the form of consumption, the consumer benefits known by consumers, and the concentration of the gel that they consider suitable when mixed with water.

2. Materials and Methods

2.1. Sample Collection

The chia seeds were obtained in bulk in the markets of Cobán, Alta Verapaz (northern region), Atiquizaya, El Salvador (southern region), Jocotán, Chiquimula (eastern region), San Juan Ostuncalco (western region), Chimaltenango and San Agustín Acasaguastlán, El Progreso (central region).

2.2. Macronutrient, Minerals and Fatty Acids Quantification

Proximal analysis was used to determine the macronutrients. The humidity was determined in a convection oven at 60 °C, until it was a constant weight; the raw protein by the Kjeldhal method using Kjeltec Auto 1030 Analyzer equipment; the raw fiber by acid and alkaline digestion using Fibertec System I equipment; the fat by petroleum benzene extraction using Goldfish equipment, carbohydrates by difference, and energy by the Atwater factor. The minerals were determined by atomic absorption spectroscopy, using Perkin Elmer AAnalyst 100 equipment, except phosphorus, which was determined using a UV/VIS Lambda 11 colorimeter. The fatty acids were quantified using a GCMS-QP2020 gas chromatograph, with a 30-m-long DB-5MS column, an internal diameter of 0.25 mm, and a stationary phase thickness of 0.2 micrometers. The column temperature in the oven was 100.0 °C.

2.3. Preparation of Chia Gel Solutions

The gel was prepared by hydrating the chia seeds in water, at a 5:95 proportion, letting them stand for 24 h, and then separating the water and the gel by simple filtration. With the gel obtained, solutions were prepared at 0.4, 0.6, 0.8, and 1.6% in water, which were identified by three-digit codes, obtained from a random number table.

2.4. Sensory Study

We chose 50 young adults, students, and workers from the Universidad de San Carlos de Guatemala, who self-identified as chia consumers. In an appropriate room, they were presented with an ounce of each solution of gel in water, they were invited to taste each one and to qualify them as "lacking", "sufficient", or "a lot", which were respectively recorded as 1, 2, and 3; afterwards, they were asked two open questions: in what form have they consumed chia and what health benefits does it have. They were chia consumers.

2.5. Statistical Analysis

Macronutrient, mineral, and fatty acid content data were analyzed with descriptive statistics; the information about forms of consumption was analyzed by means of frequencies, and variance analysis was applied to the rating given to the chia gel solutions, through the Microsoft Excel 2010 statistical analysis.

3. Results and Discussion

3.1. Macronutrients, Minerals, and Fatty Acidsin S. hispanica L.

Table 1 shows the average content and standard deviation of macronutrients, minerals, and fatty acids of the chia samples collected from neighborhood markets from five regions of the country.

The chia is confirmed as a seed with high protein content, similar to the protein content of the bean (*Phaseolus vulgaris*), 20 to 22%, but with a digestibility of 29%, which is considerably lower than that of the bean, which is 79% [3,8]. In this study, 3% more protein was found than that reported by Alvarado [4], which is an acceptable variation, since values have been reported in the 18 to 24 g/100 g range [3,9].

The high content of alpha-linoleic acid in chia was also confirmed, representing 66% of total fatty acid of that oil seed, a similar concentration to that reported by Alvarado [4] and by Ixtaina [7].

As for fat, it is notable that a much lower value was found than the range reported by the aforementioned authors, which is between 29 and 34 g/100 g.

The mineral content is similar to the values found in the United States Department of Agriculture database [10], which highlights its low sodium content and its high content of calcium, potassium, and magnesium.

Table 1. Macronutrient, energy, mineral, and fatty acid content in *S. hispanica* L.

Nutrient	Average (n = 5)	SD
Macronutrients, g/100 g		
Water	5	0.7
Protein	22.1	0.7
Fat	18.7	2.7
Carbohydrates	31.8	2.7
Raw fiber	19	1.1
Energy, Kcal/100g	383	17
Minerals, mg/100 g		
Calcium	512	50
Phosphorus	156	27
Potassium	722	164
Magnesium	358	24
Sodium	9	1
Iron	5	2
Manganese	2.5	1.1
Copper	0.9	0.4
Zinc	4.7	0.5
Fatty acids, g/100 g		
α-linoleicacid	66.8	7.5
Linoleic acid	17.2	1.4
Palmitic acid	8.7	3.1
Stearic acid	4.8	1.1
Oleic acid	1.1	0.2

3.2. Forms of Consumption and Benefits of Consumption of S. hispanica

Table 2 shows the forms of chia consumption in lemonade and water. It is important to observe that all the forms of consumption refer to the raw, whole seed, which has a digestibility of 29%, which means that only 6.38% of the protein and 19% of the alpha-linoleic acid are used. This indicates the need to promote the production of chia flour and its use in different preparations, through which up to 80% digestibility can be reached [3]. Despite the aforementioned, consumption of raw chia seeds is still important due to their raw fiber and dietary fiber content, made of xylose, glucose, and glucoronic acid, which increases the feeling of satiety and thereby decreases energy consumption, and decreases obesity, cardiovascular diseases, and type 2 diabetes risk factors [9,11].

The following benefits were mentioned regarding the consumption of chia seeds: it helps weight loss, improves digestion as a fiber source, prevents constipation as a source of omega-3 fatty acids, controls blood lipids and glycaemia. This indicates that consumers have correct information on the benefits of whole raw chia seed consumption, with the exception of the benefit of being an omega-3 fatty acid source. On the other hand, although it was requested that they mention only the benefits of consumption, three of the 50 consumers spontaneously mentioned that there is a risk of appendicitis, due the possibility of seeds accumulation on it.

3.3. Adequate Quantity to Add to Water

Table 3 shows the rating given by the consumers about the solutions of water and chia seed gel. The consumers' opinion did not show significant differences ($p \geq 0.05$) for concentrations between 0.4 and 0.6%, indicating that they are lacking; the opinions were significantly different ($p \leq 0.05$) when rating solution with 0.8 and 1.6%, indicating that they were sufficient and a lot, respectively.

Table 2. Form of consumption and benefits mentioned by consumers of *S. hispanica* L. in Guatemala.

Form of Consumption	Frequency
In lemonade	33
Mixed with water	15
In prepared drinks or juices	14
In cookies	7
In smoothies	7
Mixed with yogurt	5

Table 3. Percentage of *S. hispanica* gel adequate for a drink according to consumers' tastes.

Percentage of Gel	Rating *
0.4	1.48
0.6	1.58
0.8	1.98
1.6	2.62

* 1 = lacking, 2 = sufficient, 3 = a lot.

Young Guatemalan adults, as residents of a tropical country, are in the habit of consuming water frequently throughout the day, so they carry a container of about a liter of water with them, to which they could add chia seeds. Taking into account that the chia seed doubles its volume due to gel formation when put in contact with water and left to stand for 2 h, 4 g of chia seeds could be added to a liter of water and consumed over the course of the day, which would allow the ingestion of 0.76 g of raw fiber and 1.26 g of dietary fiber, as well as 0.25 g of usable protein and 0.15 g of usable alpha-linoleic acid. The quantities are relatively small in relation to the recommended daily intake of nutrients, hence the need to promote chia consumption in the form of flour and through other preparations, in order to increase daily intake.

4. Conclusions

Chia (*Salvia hispanica* L.) has 22% protein, 18% fat, 31% carbohydrates, 19% raw fiber, and 67% alpha-linoleic acid, as well as 9 mg/100 g of sodium, 512 mg/100 g of calcium, 722 mg/100 g of potassium and 358 mg/100 g of magnesium. In Guatemala, it is consumed as a raw seed mixed with lemonade and the benefits it provides as a source of dietary fiber are recognized. The consumer considers it adequate to use 0.8% gel mixed with water, which is equivalent to 4 g of chia seeds.

Funding: This work was supported by grant IaValSe-Food-CYTED (119RT0567) and Universidad de San Carlos de Guatemala.

References

1. Ullah, R.; Nadeem, M.; Khalique, A.; Imran, M.; Mehmood, S.; Javid, A.; Hussain, J. Nutritional and therapeutic perspectives of Chia (*Salvia hispanica* L.): A review. *J. Food Sci. Tech.* **2015**, *53*, 1750–1758, doi:10.1007/s13197-015-1967-0.
2. Di Sapio, O.; Bueno, M.; Busilacchi, H.; Quiroga, M.; Severin, C. Caracterización Morfoanatómica de Hoja, Tallo, Fruto y Semilla de *Salvia hispanica* L. (Lamiaceae). *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas* **2012**, *11*, 249–268.
3. Monroy-Torres, R.; Mancilla-Escobar, M.L.; Gallaga-Solórzano, J.C.; Medina-Godoy, S.; Santiago-García, E.J. Protein Digestibility of chia seed (*Salvia hispanica* L). *Revista de Salud Pública y Nutrición* **2008**, *9*, 1–9.

4. Alvarado Rupflin, D.I. Caracterización de la semilla del chan (*Salvia hispanica* L.) y diseño de un producto funcional que la contiene como ingrediente. *Revista de la Universidad del Valle de Guatemala* **2011**, *23*, 43–49.
5. Bushway, A.; Belyea, P.R.; Bushway, R.J. Chia seed as a source of oil, polysaccharide and protein. *J. Food Sci.* **1981**, *46*, 1349–1356, doi:10.1111/j.1365-2621.1981.tb04171.
6. Ayerza, R.; Coates, W. Influence of environment on growing period and yield, protein, oil and alpha-linoleic content of three chia (*Salvia hispanica* L.) selections. *Ind. Crops Prod.* **2009**, *30*, 321–324, doi:10.1016/j.indcrop.2009.03.009.
7. Ixtaina, V.Y.; Martínez, M.L.; Spotorno, V.; Mateo, C.M.; Maestri, D.M.; Diehl, B.W.K.; Nolasco, S.M.; Tomás, M. Characterization of chia seed oil obtained by pressing and solvent extraction. *J. Food Comp. Anal.* **2011**, *24*, 166–174, doi:10.1016/j.jfca.2010.08.006.
8. Cárdenas Quintana, H.; Gómez Bravo, C.; Díaz Novoa, J.; Camarena Mayta, F. Evaluación de la calidad de la proteína de 4 variedades mejoradas de frijol. *Rev. Cuba. Aliment Nutr.* **2000**, *14*, 22–27.
9. Olivos-Lugo, B. L.; Valdivia-López, M. Á.; Tecante, A. Thermal and physicochemical properties and nutritional value of the protein fraction of Mexican chia seed (*Salvia hispanica* L.). *Food Sci. Technol. Int.* **2010**, *16*, 89–96. doi.org/10.1177/1082013209353087.
10. USDA-Database. Available online: https://ndb.nal.usda.gov./ndb/search/list (accessed on 19 May 2019).
11. Coelho, M.S.; Salas-Mellado, M.M. Revisão: Composição química, propriedades funcionais e aplicações tecnológicas da Chia (*Salviahispânica* L.) em alimentos. *Braz. J. Food Technol.* **2015**, *17*, 259, doi:10.1590/1981-6723.1814.