Multidisciplinary

Reintegration of chia (*Salvia hispanica* L.) in nutraceutical diet as a superfood worldwide

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Abstract
In the ethnic history, chia was the important crop worldwide, however, the prohibition of its use by almost 260 years led it almost disappeared, this mainly due that the tradition about their use as food and medicine was not transmitted in at least six generations, conducting that this crop remained forgotten for nearly 180 years. Today this marvelous crop has been rescued for a lot of scientists who's through of an arduous research work to bring it back to live and make it available for the nutritional balanced future generations around the world. Taking in account that in the next years its importance as food worldwide will be increased, will evident that chia crop is destined to be the Sleeping Beauty of all nutraceutical crops. Farmers can earn more profit by cultivating Chia seeds, for this it is necessary to keep awareness and readiness and remain in touch with agricultural institutions and universities. Intensive research work is further carrying out by the most recognized global companies of nutraceutical world where vertical integration of the chia into of new nutraceutical products like Nutrilite products "the best of nature, the best of science". There is no doubt that the importance of chia as a functional food on the world will continue achieving and the next generation of functional food, supplements and nutraceuticals products where the main active ingredient is PUFAs ω3 will have as raw material of the chia seed.

Keywords: salvia, nutraceutical, PUFAs, chia seed

Introduction

The history of *Salvia hispanica* L. is fascinating because for 5,500 years back this Chia was the third most important crop for European countries, in only 260 years it became a virtually unknown species that to reintegrate as food into the modern diet. It has had to adapt to situations that other crop would hardly survive. After the Spanish conquest, the first situation that chia faced was the prohibition of its use for 260 years (between 1550-1810) that Spanish imposed to the Aztecs nation that the existence of chia would depend as domestic specie. But it survived, is no surprise since over time other plant species have been able to survive to the prohibition and the latest example is marijuana (Cannabis sativa L.) in USA [1]. This fact indicates that the greater challenge that chia faced to subsist not was the prohibition, but the oblivion derived of this was, because the tradition of its use not was completely transmitted in at least six generations (estimated using 260 years of prohibition and 45 years as life expectancy). After the independence of Mexico, the prohibition about chia use disappeared; however, the damage that this fact caused was so big that after cultivating 30, 000 has of chia in 1550 (land area estimated considering an annual production of 15,000 ton and 500 kg of yield seed per hectare), this area decreased until a few hectares in 1810. Fortunately, chia crop was able to survive on the mountain's zones of Jalisco, Michoacán, Puebla and Jalisco [2] and in 1932 this specie began to regrowth and official records of the agricultural production in México presents that on this year were cultivated 38 has [3]. The farmers of acratic Jalisco played an important role for chia arrival as crop until the 90s decade, when after to prove their high nutritional value and agronomic adaptability, chia became the source more sustainable and cheaper to meet direct or indirectly the requirements of PUFAS ω3 on man [4-6]. At global level, the integration of the chia into the modern agriculture began in 1991 when researchers of Argentina and EUA started to study the chia crop under a research project known as ¨Western Argentina Regional Project¨. The results of this long-term study were so impressive that the implementation of the agronomic and industrial technology generated led to the land area cultivated with chia increased from 500 has in 1994 (only established in México) [4, 5] to 370, 000 has in 2014 (established in 13 countries) [7-9]. Currently this oilseed is cultivated on 14 countries and the analysis of the demand global of chia recently carried out by [7] indicates that on the next years the land area cultivated with chia will follow increasing, this first because the demand of PUFAS ω3 supplements is not completely cover [10], and in second place because chia is beginning to use as raw product to produce supplements and nutraceuticals where protein and fiber are the main targets [11, 12]. Based on the abovementioned, the objective of this work was to do an updated scientific review of the chia history as a crop in Mexico and all over the world and its importance as a source of PUFAs ω3 in the human diet.

Brief description of chia

Chia (Salvia hispanica L.) is a native plant of Central Mexico and North of Guatemala that belongs to Lamiaceae family [13], and where also are included peppermint (Mentha X piperita L.), holy basil (Ocimum basilicum L.), and sage (Salvia officinalis L.) [14]; these crops as well as chia are currently used as a

functional food and also to produce supplements and nutraceutical products [15-18]. The chia was classified by the Swedish botanist Carl Von Linneo in 1753, who named it Salvia (save or cure) hispanica (Spanish) that in Latin means Spanish plant to cure or save [19]; is evident that this name was wrongly given because although chia was collected by Löfling in Madrid [20], this specie is not native from Spain, but it was carried by Cristobal Colón from México to this country. However, 178 year later, demonstrated that effectively chia is no native from Spain, but its origin center is Mexico and America Central, is possible that considering that in the past its binomial name was a mistake, he did not named Salvia hispanica, but he named it as Salvia chia Fernald. On Nahua language, the Chian word (today named chia) means oily, so the Aztecs used the chia Word to refer to all spices of Salvia genus that their main characteristic is their high oil content (for example, Salvia hispanica L, Salvia polystachya O., Salvia tiliifolia V. y Salvia columbariae B.). Because the Spaniards were unaware of the botanical classification of plants used by the Nahua people, when they did their translations had the mistake for using the chia word chia to refer to the species of the genus Salvia and other edible plant species such as chan (Hyptis suaveolens L.) and amaranto (Amaranthus hybridus L.) [4].

This error is still committing, and even today there are some scientific reports where the chia term is used to refer to amaranth, chan and even to huauzontle (Chenopodium berlandieri Moq.), which is wrong, because the most appropriate is to use the chia term to refer only to species of the Salvia genus and in particular to the regular chia (Salvia hispanica L.) as in the past the Nahuas did.

Chia history as crop and food

Chia: ancient staple food (3500 BC-1550 AC)

Chia is an ancestral crop that was domesticated 3,500 years BC [4] and up until the arrival of the Spaniards along with corn, bean and amaranth was key in the Aztec diet of more than eleven millions of inhabitants. This affirmation is supported on records of Mendocino codex where is mentioned that Tenochtitlan, capital of Aztec empire consumed between four and fifteen thousand tons of chia seed per year [2], so in pre-Columbian times this crop was cropped on several locations of Mexico (such as the states of Guerrero, Morelos, Puebla, Michoacán. Estado de México, Jalisco, Nayarit and Sinaloa), Guatemala, Nicaragua and Honduras (Figure 1).

Chia was an important food source for the Aztecs, who during in the wars of conquest that lasted several days, their warriors as such as the informants who traveled great distances had as food source only small amounts of this oilseed [4]. But chia not only was used for the Aztecs, and in the Lienzo de Tlaxcala (Tlaxcaltecs war book) which is also known as Yaotlacuiloli, there are evidences that in 1531 chia was cultivated in the South of Sinaloa; at least so it reflects the picture painted by the Tlaxcaltecs warriors that accompanied to Nuño of Guzman and its Spanish warriors in the conquest of Chiyametlan (today Chametla) that in Nahua language means place where there is a lot of chia. The chia was also cultivated at Morelos State, and affirms that on 1537, Hernan Cortes gave to the San Lorenzo Chiamilpa town a title of land possession and a weapon shield that in the top part presents a vessel with chia seeds, this symbol was used to represent the Chiamilpan term that in Tlahuica language means field of chia. For the other side, reported that between 1500 and 1550 at Olinala and Temalacatzingo Guerrero chia was used as food, medicine and as well as on the crafts production which were part of the Azteca tribute and were sold to buy corn, gold and cocoa that paid to Aztecs tribute.

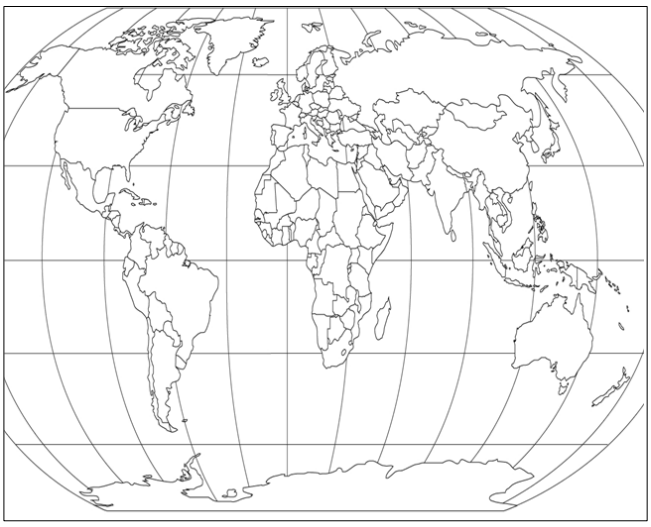

Fig 1: Historical widespread of chia crop around the world. The agricultural areas shaded in green, blue, yellow and red represent the area of chia cultivated on Early times (3500 BC-1000 AC) to Modern time (until this date).

Decline of chia as staple food of México (1550-1810)

After the Spanish colonization, chia production in Mexico was prohibited, because the competition that it exercised to plant species and animals introduced from Spain; but mainly due that this crop was widely venerated and used in religious rites by the Aztec population [13]. In more than 500 years in which the chia was prohibited, its cultivation became almost on the verge of extinction; and although this did not take place, all knowledge associated with its use as food, medicine, as well as the agronomical management and cultivars developed were forgotten and many of them were lost. The use of chia oil to make handicrafts was one of the few applications that were not forgotten, and in according with, this in part due that in Olinala Guerrero the Spaniards allowed to continue using the chia oil on the production of handicrafts to sell them as well as a way that they could pay tribute. The Spanish crown granted this privilege in recognition that the inhabitants of this town not presented resistance to evangelization. A very similar treatment Hernan Cortés gave to the San Lorenzo Chamilpa town who in award to their unconditional support during the construction of the Palacio de Cortés in 1537 in Cuernavaca, Morelos, he allowed them to produce chia.

Renaissance of chia as food (1810-1990)

The chia crop survived because various Nahua populations that were living in the mountains of Puebla, Guerrero, Morelos and Jalisco in México continued its clandestine production [2] and

although there are evidences that the NAO of china since late century XVII exported chia from México to another countries; the first official record related with their economic importance as crop in México appears in 1932 [3]. Later, at the 40s decade was published the first scientific proof of the high content of PUFAs ω3 exhibited in chia seed cultivated on México; however, because on this time the essentiality of UFAs ω3 on humans was unknown, the chia crop not happened to be an exotic crop used to prepare beverages and paints to decorate crafts. The key step to demonstrate the relevance of chia as food on the human nutrition occurred in 1975 when Dyerberg and its co-workers in Greenland found that PUFAs ω3 are essential for man and its intake at levels below of 2 g of PUFAs ω3 per day could result in the disease known as coronary arteriosclerosis. On basis of this finding, currently, nutritional guidelines of Canada, USA and Europe recommend at least twice a week to eat fish as part of a healthy diet to prevent cardiovascular diseases and patients with documented coronary artery disease should to consume 900–1000 mg of PUFAs ω3 per day.

Integration of chia as modern food around the world (1990-2010)

Chia crop arrived at twenty-first century without having incorporated the changes needed to adapt into modern production, this because chia did not travel on the same way its ancients mates such as corn, bean and tomato did; hence, it is not one of constituents of modern diets as the other are [4]. As a result the chia crop was not known to other countries, and its use was limited to the regions which adopted its use before arriving the Spaniards (Figure 1). However, the status of chia as crop and food source changed on the 1990 decade, because taking in count the finding, the study of chia as crop and vegetal source of PUFAs ω3, proteins and fiber were started [6] and in according with [5] on this time a team of researchers of USA and Argentina visited Acatic Jalisco, México to learn the basis of agronomic management of chia, and later they conducted the research project of long term named as ¨Western Argentina Regional Project¨. The main goals of this research project were to study the nutritional profile, adaptation and breeding, agronomic management, and marketing of chia on different agricultural regions of Argentina as well as other countries as Peru, Colombia, Bolivia and Ecuador [4]. The scientific results of this project have been published by Ricardo Ayerza, Wayne Coates and others Argentinian researchers during the last 22 years, and these findings have been key to promote the use, production and marketing of chia around the world; as result of this, currently the chia crop is produced in 14 countries around the world (Figure 1).

Importance of chia as crop, food and PUFAs ω3
chia as a source of PUFAs ω3

At the last six years, the status of chia on the global agriculture has changed very fast [7-9] and after to be a crop forgotten, today for their nutritional properties is subject to an intense study by agronomists, biologists, botanists, breeders, chemists, biochemists, nutritionists and doctors around the world [17]. From the nutritional view point, while in the food market there are several food sources to cover the requirement of PUFAs ω3 (Menhaden fish, salmon, algae and flax); none of them is safer, shipper, more sustainable and traceable than chia, this fact is related that it is the unique source that we can to eat directly, there is not restrictions on their consumption, and a daily intake between 25-50 grams of seed per day is sufficient to cover the PUFAs ω3 requirements in adults. Taking into account that chia is the source with higher content of PUFAs ω3 (58-64 % of total lipids), present high levels of protein (16-24 %) and lipids (31-35 %), and fiber (34-56 %), on the last six years the demand of chia on the world has increased linearly and during 2014 are established 367,000 has, being Argentina, Bolivia, Paraguay and Mexico the main four producer of this oilseed [7].

Chia as a crop on the world

Currently, the importance of chia as crop is so high that countries such as USA, Chile, Argentina and Italy where for the climatic conditions is very difficult to cultivate chia are evaluating different agronomic practices to adapt it on their agricultural zones The main problem facing these countries is because chia is a tropical specie of short day only grow properly in areas located between 20° 55’ N to 25° 05’ S; therefore at higher latitudes than 39o 11´ S (Choele Choel Argentina) and 32o 14´ N (Tucson Arizona, USA) the plant cannot produce seeds since it is killed by frost before flowers set [4], therefore when chia is cultivated outside of latitude range aforementioned, the seed yield and nutritional quality are quite low and many times the crop not produce seeds. In order to resolve this issue, researchers and agronomists of USA and Argentina have been using the plant breeding to develop cultivars able to flower in locations where the day duration longer than 12.5 hours, as result of this, these countries have some varieties of chia registered; the first one is the Hearthland variety, this cultivar was developed on the University of Lexington of Kentucky, USA by mutation with gamma radiation and currently this genotype is available on two presentations white and black seeds; the other three ones are Sahi Alba 911, Sahi Alba 912 and Sahi Alba 914, these cultivars were generated in Argentina by mass and individual selection. Mexico does not have weather restrictions that prevent the chia production, however this country also is conducting breeding on chia and currently there are several lines identified which in the future will be generated the first chia variety registered on the world. In all these countries (Argentina, USA and Mexico), the new varieties of chia were developed using as genetic source the Mexican Pinta variety that is a mixture of black and white seed in a ratio 9:1. The genetic improvement as a agronomic tool has helped to produce chia in Argentina, so in just five years their land area established with chia passed from 100 has on 2010 to 120,000 has on 2014. The seed yield in Argentina fluctuates between 1,200 and 150 kg per ha, but the national average is only 350 kg ha. For the contrary, in agricultural zones of USA the results have been less successful than Argentina and the land area established with chia has increased very little, and also the average seed yield is very low (only 290 kg of seed per ha). Chile, and Italy are trying to identify the best planting date

to produce chia, but the results are very encouraging and the seed yield in these countries are less than 400 kg ha. Only on agricultural regions located in tropical zone (between latitude 23o 30´N and 23o 30´S) such as Jalisco, México and Ghana, Africa is possible to obtain high yields of chia seed (1305-2605 kg per ha), especially under irrigation, the low yield commonly obtained in these countries are not related with the low temperatures, but are associated with water stress because almost land area planted with chia is established on summer season, this mainly related to the farmer and researchers still consider it exclusively of rainy season.

This belief could change on the next years, because recently have demonstrated that in Jalisco México is feasible to get two cycles per year, and in both two seasons to achieve high yields and seed quality. Mexico is the origin center of chia, for this reason, this specie grows properly under the soil and climatic conditions of this country, however if to compare their national seed yield (500 kg per ha) versus the yield determined by (1305 kg per ha), It is clear that currently the potential productive of chia in México not has been fully exploited, this in part because México has not implemented a research project to generate agronomical management technology in chia such as on the past Argentina did.

What else following with chia as a modern food?

The tendency of global consumption of chia on the last six years [7], and their use as raw material to produce supplements and nutraceutical are confirming the prediction done for [19], 129 year ago, this botanist predicted that a future this specie would be one important crop in the food industry. Currently, the potential use of chia on the human nutrition is so wide, that researchers of universities, publics research centers and private companies are working very hard to develop technology to include the chia as source of PUFAs ω3, protein and fiber in beverages, supplements, nutraceuticals and processed foods in the short term. In addition, in recent years, the PUFAs ω3 of chia also have been extensively evaluated for their cosmetic benefits and the preliminary results suggest that PUFAs ω3 of chia exhibit many biological functions in the skin such as prevention of transepidermal water loss, maintenance of the stratum corneum epidermal barrier, and disruption of melano-genesis in epidermal melanocytes. Intensive research work was further developed by Nutrilite, the most recognized company of nutraceuticals on the world where to vertically integrate the chia into of new nutraceutical products the work motto is: “the best of nature, the best of science”. There is no doubt that the importance of chia as a functional food on the world will continue achieving and the next generation of functional food, supplements and nutraceuticals products where the main active ingredient is PUFAs ω3 will have as raw material the chia seed, an ancestral crop of Mexico that although it was forgotten for more than 500 years, it has been rescued for a lot of scientists who’s through of an arduous research work to bring it back to live and make it available for the nutrition balanced future generations around the world. It should be noted that Chia is not the first time that science rescue one crop and between 1945 and 1960 in Canada a group of scientists saved the industry of boat lubricant oil extracted from rapeseed. At the end of the second world war, because the demand of oil lubricant gone, the rapeseed crop was destined to disappear, so the Government of Canada gave the task to its scientists to convert the rapeseed oil inedible (because its high content of erucic acid, eicosenoic acid, and glucosilates) into an edible oil, the results were great and the oil rapeseed was transformed to the margarine and canola oil that we know today.

Because canola was converted on the second most important crop of Canada; in recognition, in 1978 the Canadians decided to change its name and after to be named as rapeseed the new name coined was Canola. Is possible that on chia is living that occurred with Canola, so if in the past century canola was named the Cinderella of the Canada crops, chia after sleeping for more than 500 years in this century might be destined to be the Sleeping Beauty of functional crops on the world.

Now chia crop is also blooming in India

Actually, Chia seeds are known as ‘Super Food’ in foreign markets as well as in India, which is very beneficial for health. After America and China, now the crop of Chia seeds is blooming in many states of India including Rajasthan. In Barabanki district of Uttar Pradesh, farmers are now cultivating ‘Chia seeds’. Chia’s Advanced Germplasm are in the pipeline of investigations in Rajasthan also under the wisdom umbrella of Renowned Team of Breeders of Agriculture University, Jodhpur.

Remember, recently, in the ‘Mann Ki Baat’ program, PM Narendra Modi had mentioned Colonel Harish Chand, a progressive farmer of Barabanki, who cultivates Chia seeds. So, he represented everyone that If you still do not understand what is Chia seeds and how farmers will benefit from its cultivation, then you should read about its case study for higher income.

In this regard, Colonel Harish advises other farmers that they should do such farming, which can make maximum profit in less field and less expenditure and increase income according to the intention of the government (doubling of farmers income). Chia farming also earns more income at a lower cost, its seeds are also sold for up to a thousand rupees.

This person from barabanki, after cultivating chia, became a nazir for the farmers

To see the cultivation of Colonel Harish’s Chia Seeds, farmers come nearby and gather the necessary guidelines and information, so that they too can cultivate it. By the way, the area of Chia cultivation in India is increasing, apart from Barabanki, it is now being cultivated in many districts of UP, because it can earn profits in comparison to its cost. Colonel Harish has now become a visionary for the farmers of the state by cultivating Chia seeds.

Benefits of intake of chia seeds

Chia seeds are rich in omega-3 fatty acids. Apart from this, nutrients like calcium, fiber, protein and all the minerals are found in it. Taking Chia seeds gives the heart and body the power to fight against diseases. In this case, include it in your

diet, it can be taken with milk or water. It has the properties to protect against many types of diseases.

How to cultivate chia seeds

- Agricultural scientists say that it can be cultivated easily in all types of land.
- Its crop is better in light-brown soil.
- It does not require much of pesticides and cow dung manure is also very effective in it.
- About 4-5 kg of seed is required for one acre. After its yields 7 quintals per acre.
- If it is sown in the months of October and November, it gives good results.
- To avoid weed infestation of the crop, weeding the field with the help of hands first 2 times in the field.
- Plantation should also be done within 10-15 days of planting in the vacant places in the field.
- It takes 90-120 days to prepare its cultivation. Flowers are grown in the crop within 40-50 days of planting.
- They are prepared in between 25-30 days.
- Plants and earrings begin to turn yellow while preparing the crop.
- Crop is harvested and cleaned and cleaned and dried and sold in the market.
- Chia crop yields 600–700 kg per acre.
- It costs up to 30 thousand rupees per acre in farming.
- If 6 quintals are also cultivated, then it is sold for about 90 thousand rupees.
- In such a case, the farmer earns up to 60 thousand rupees in an acre.

Conclusions

In the ethnic history, chia was the important crop worldwide, however, the prohibition of its use by almost 260 years led it almost disappeared, this mainly due that the tradition about their use as food and medicine was no transmitted in at least six generations, conducting that this crop remained forgotten for nearly 180 years. Today this marvelous crop has been rescued for a lot of scientists who's through of an arduous research work to bring it back to live and make it available for the nutritional balanced future generations around the world. Taking in account that in the next years its importance as food worldwide will be increased, will evident that chia crop is destined to be the Sleeping Beauty of all nutraceutical crops. Farmers can earn more profit by cultivating Chia seeds, for this it is necessary to keep awareness and readiness and remain in touch with agricultural institutions and universities.

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