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Research Application Summary

Potential benefits of dietary Chia in the primary prevention of pardiovascular piseases: A review

Mihafu, F D.[1] & Kiage, B. N.[2]

[1]Department of Science and Business Management, Mbeya University of Science and Technology, P. O. Box 131, Mbeya, Tanzania
[2]Department of Human Nutritional Sciences, Jomo Kenyatta University of Agriculture and Technology, P.O. Box 62000 00200, Nairobi, Kenya
Corresponding Author: bettynyanchama@yahoo.com

Abstract

Cardiovascular diseases (CVDs) are mainly caused by atherosclerosis which occurs when artery walls become widened due to accumulation of fatty deposits, smooth muscle cells and fibrous connective tissues collectively termed plaque. Plaque may promote thrombosis within the artery which in turn narrows the lumen of arteries obstructing blood flow leading to heart attack and stroke. Low density lipoprotein cholesterol, decreased high density lipoprotein cholesterol, elevated triglycerides and excess calories are among the risk factors that can promote atherosclerosis in the body. Modern diets are mostly low in omega^{-3} fatty and high in omega^{-6} fatty acids and saturated fatty acids (SFA). Such imbalance is associated with increased risks of heart disease and support chronic inflammation. Chia seed (*Salvia hispanica* L.) is becoming the popular functional food as it is high in omega^{-3} fatty acid, -linolenic acid (ALA). Omega^{-3} fatty acids have been associated with potential physiological functions in human body. Additionally the seeds are rich in proteins, dietary fiber, minerals and phytochemicals such as myricetin, quercetin, kaempferol, chlorogenic acid and caffeic acid which exhibit cardio-protective, antioxidant and lipid-lowering properties. This review expounds the importance of chia seed in counteracting the CVDs risk factors as evidenced by various animal studies and human trials.

Keywords: *Atherosclerosis, Salvia hispanica,* omega^{-3} fatty acids, phytochemicals and risk factor

Résumé

Les maladies cardiovasculaires (MCV) sont principalement causées par l'athérosclérose qui se produit lorsque les parois des artères s'épaississent en raison de l'accumulation de dépôts graisseux, de cellules musculaires lisses et de tissus conjonctifs fibreux appelés collectivement plaque. La plaque peut favoriser la thrombose dans l'artère qui à son tour rétrécit le lumen des artères obstruant le flux sanguin conduisant à une crise cardiaque et à un accident vasculaire cérébral. Le cholestérol des lipoprotéines de basse densité, la diminution du cholestérol des lipoprotéines de haute densité, les triglycérides élevés et les

calories excédentaires sont parmi les facteurs de risque qui peuvent favoriser l'athérosclérose dans le corps. Les régimes alimentaires modernes sont pour la plupart pauvres en acides gras oméga-3, riches en oméga-6 et en acides gras saturés (AGS). Un tel déséquilibre est associé à des risques accrus de maladies cardiaques et favorise l'inflammation chronique. La graine de chia (*Salvia hispanica* L.) devient l'aliment fonctionnel populaire car riche en acides gras oméga-3, acide -linoléique. Les acides gras oméga-3 ont été associés à des fonctions physiologiques potentielles dans le corps humain. De plus, les graines sont riches en protéines, en fibres alimentaires, en minéraux et en composés phyto-chimiques tels que la myricétine, la quercétine, le kaempférol, l'acide chlorogénique et l'acide caféique qui présentent des propriétés cardio-protectrices, anti-oxydantes et hypo-lipidémiantes. Cette revue démontre l'importance des graines de chia dans la lutte contre les facteurs de risque de maladies cardiovasculaires, comme en témoignent diverses études animales et des essais sur l'homme.

Mots-clés: Athérosclérose, *Salvia hispanica*, acides gras oméga-3, phyto-chimiques et facteur de risque

Introduction

Cardiovascular diseases (CVDs) refer to a group of disorders of the heart and blood vessels that normally interferes with their normal functioning (WHO, 2017). The most common CVDs are caused by atherosclerosis which is sometimes called hardening of arteries. Atherosclerosis occurs when arterial walls become thickened due to accumulation of fatty deposits, smooth muscle cells and fibrous connective tissues collectively termed plaque (Rolfes *et al*., 2009; Coates and Ayerza, 2009). Plaque may promote thrombosis within the artery which in turn narrows the lumen of arteries. With time, the thrombus may enlarge and obstruct blood flow. Although some people are born with certain types of CVDs, most people develop CVDs as a result of poor lifestyle habits, such as eating unhealthy foods (foods high in saturated fats, sugar and salts), physical inactivity, tobacco use and excessive consumption of alcohols (Laslett *et al*., 2012; WHO, 2013).

In recent years, functional foods and other therapeutic lifestyles have been treated as components of healthy lifestyle changes. Several epidemiological and experimental studies recommend that changes in the composition of diet based on healthy foods are important in the prevention or improvement of numerous disorders of the heart and blood vessels (Chicco *et al*., 2009; WHO, 2017). Chia seeds (*Salvia hispanica*) a species of flowering plant native to Mexico and Guatemala, have attracted attention on health benefits as they are rich in omega -3 polyunsaturated fatty acids (PUFAs) particularly -linolenic acid (ALA). The seeds are also high in protein, fat/lipid, fiber, vitamins, minerals and phytochemicals (Ali *et al*., 2012; Segura-Campos *et al*., 2014). In 2013, The Chia Company (TCC) outsourced its production to farmer organizations in East Africa particularly Kenya and Tanzania. This has allowed TCC to become the world's largest producers of premium quality chia (Lardizabal, 2014). This review paper therefore highlights the current findings on the identified active ingredients and in vivo and human trials on the health benefit of chia seeds.

Methodological approach

A desk study was conducted to review the potential benefits of using chia seeds in preventing the

risk factors for cardiovascular diseases, especially its cardio-protective, anti-inflammatory, antioxidant and lipid lowering properties. Data were obtained from the published journal articles on chia seeds. The review is based on quantitative approaches that enhanced better understanding of the potential benefits of chia seeds on cardiovascular health. To achieve the general objective, the following research questions were basic: i) What is the impact of chia seeds on the modifiable cardiovascular risk factors? iii) Do animal studies and human trial enough to label chia as a functional food?

Results and discussion

The results presented in this paper represent a review of previous research work on potential benefits of using chia seeds.

Role of omega-3 rich diets in cardiovascular risk factors . Several functional foods have been reported to prevent the modifiable cardiovascular risk factors (table 1). Foods with high omega-3 PUFAs, dietary fiber and phytochemicals have been associated with lowering the rate of cardiovascular risks (Chicco *et al*., 2009; Gazem and Chandrashekariah, 2016). Possible mechanisms for the cardiovascular protective effects of omega-3 fatty acids are proposed to be; anti-inflammatory, antithrombotic, antiarrhythmic, raising HDL-C, lowering hypertension, hyperglycemia, hypertriglyceridemia and LDL-C (Simopoulos, 2004; Alissa and Ferns, 2012).

Current experimental studies have reported that, a tablespoon of chia seeds delivers 100 % daily value of omega-3 ALA, 25 % daily value of fiber and approximately 10% of calcium, magnesium and iron (Lardizabal, 2014). Since ALA can be converted to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (figure 1), then ALA from chia seeds can be substituted for fish and fish oil and become useful to people allergic to fish (Azcona et al., 2008; Gazem and Chandrashekariah, 2016).

Table 1. Risk factors for cardiovascular diseases

Major risk factors (not modifiable)	Major risk factors (modifiable)
Family history of premature heart disease	Hypertension
Increasing age	Low density lipoprotein cholesterol
Male gender	High density lipoprotein cholesterol
	Abdominal obesity
	Diabetes
	An 'atherogenic diet' (high in saturated fats and low in vegetables, fruits and whole grains)
	Physical inactivity
	Cigarette smoking
	Alcoholic overconsumption

Source: (Rolfes *et al.,* 2009; Alissa and Ferns, 2012, WHO, 2017)

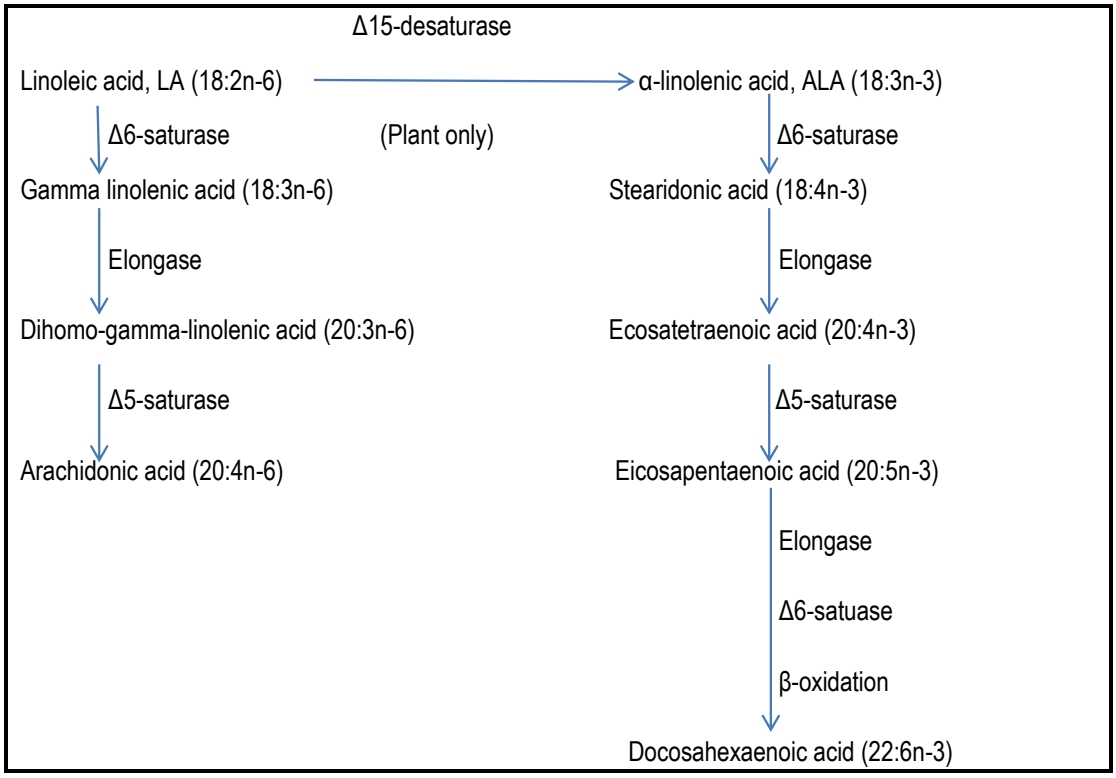

Figure 1. Conversion of -linolenic acid to EPA and DHA (Calder 2013)

Potential health benefits of chia seeds

Animal studies: Azcona *et al*. (2008) fed broilers with rapeseed, flaxseed, chia seed and chia meal and assessed the ability of such feed ingredients to increase the omega^{-3} fatty acid content of the meat. The results showed that, chia seed significantly reduced the saturated fatty acid (SFA) content of the white and dark meats compared with the control diet. Also it gave the highest increase of total n^{-3} PUFA, yielding 157% for dark meat and 200% increases for the white meat compared with the control. It was further reported that the ratio of omega^{-6} to omega^{-3} and that of SFA to omega-3 extremely improved in both types of meat of the broilers fed chia seed, chia meal and flaxseed.

Another study on the effects of chia seeds on fatty acid composition of the meat, internal fats, growth performance and sensory characteristics of meat, revealed the sound modification of fatty acid composition of the meat fat, but not of the internal fat. Also ALA content increased with increasing chia content of the diet (Coates and Ayerza, 2009).

Chicco *et al*. (2009) investigated the benefits of taking dietary chia seed rich in ALA and fiber against dyslipidemia and insulin resistance (IR). Rats were fed with sucrose rich diet (SRD) for 3 months to induce dyslipidemia and IR, after that the rats were divided into two groups and fed with SRD and SRD plus chia for another 2 months. The results were impressive as

dietary chia seed prevented the onset of dyslipidemia and IR in the rats whereas glycaemia did not change.

The study that explored the mechanisms underlying the altered lipid metabolism in the heart of dyslipemic insulin-resistant (IR) rats fed a sucrose-rich diet (SRD) and the effect of chia seeds to reverse cardiac lipotoxicity revealed that, the hearts of SRD-fed rats displayed lipotoxicity suggesting impaired myocardial lipid utilization. Dietary chia normalized blood pressure and reversed heart lipotoxicity and glucose oxidation in SRD group (Creus *et al*. 2016).

Human trials: The results on human trials have been summarized in Table 2

Table 2. Summarized findings on human trials

Mode of trial	Time	Formulation	Results
Randomized double blind trial on 11 health subjects	120 minutes	50 g white bread containing either 0, 7, 15 or 24 g of chia seeds	Reduced postprandial glycaemia
10 postmenopausal women	7 weeks	25 g of chia seed/day	PUFAs ALA and EPA contents raised with supplementation with milled chia seeds
Randomized trial with control	2 months	Beverage of 235 kcal that contain soy protein, nopal, chia seed and oat	-Triglycerides and blood glucose levels reduced -Body weight loss
Single blinded with 76 subjects	3 months	25g chia seeds in 250 mL water twice/day	-The plasma level of ALA increased -No significant results on weight loss and disease risk factors

Source: Human trials (Ali *et al.,* 2012)

Previous research findings highlight the presence of some bioactive compounds in chia seeds with potent antioxidant activity such as kaempferol, myricetin, quercetin, caffeic acid and chlorogenic acid (Gazem and Chandrashekariah, 2016; Ullah *et al*., 2016). Excellent source of n^{-3} ALA in chia makes it a promising natural food that can be substituted for fish and also used in nutraceutical products (Ali *et al*., 2012). It is possible that dietary ALA could exert similar physiological effects as in the case of EPA and DHA from dietary fish (Chicco *et al*., 2009).

Nitrayová *et al*. (2014) compared the contents of proteins, fats and amino acid of chia and flaxseeds. Results indicated high quality of these proteins as 37.87%, 33.76% and 35.18% for chia, brown and gold flax seed respectively. The ALA constituted on average 63.79% and 54.38% for chia and flaxseeds respectively. The study confirmed the high amount of ALA in chia and an outstanding quality of protein and fat in both chia and flaxseeds.

Findings obtained by Gazem and Chandrashekariah (2016) ascertained the available literature on the various therapeutic aspects of chia. Dietary chia provides an array of pharmacological, anti-inflammatory, lipid lowering and antioxidant properties. However protocols regarding extraction and effective dose need to be standardized in order to suit the human consumption globally. The study emphasized the understanding of the nature of bioactive compounds and fatty acids responsible for its biological activity in cell and animal models before using chia seeds as functional food.

Conclusion

Regular consumption of chia seeds has been associated with low risk of developing chronic diseases. An increased number of people suffering from cardiovascular diseases (CVDs) due to inactive lifestyle and poor diets have promoted the search for functional foods including chia seeds. However in vivo and human trials on the health benefit of chia seeds are still limited, also the development of standard dose that suit human consumption globally is questionable. The findings therefore highlight the need for further exploration of the efficacy of chia seeds on cardiovascular risk factors using animal models and human subjects.

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References

Ali, N. M., Yeap, S.K., Ho,W.Y., Beh, B.K.,T an, S.W. and Tan, S.G. 2012. The promising future of chia, *Salvia hispanica* L. Hindawi Publishing Corporation. *Journal of Biomedicine and Biotechnology* Volume 2012, Article ID 171956, 9 pages. doi:10.1155/2012/171956.

Alissa, E.M. and Ferns,G.A. 2012. Functional foods and nutraceuticals in the primary prevention of cardiovascular diseases. Hindawi Publishing Corporation, *Journal of Nutrition and Metabolism* Volume 2012, Article ID 569486, 16 pages. doi:10.1155/2012/569486.

Azcona, J.O., Schang, M.J., Garcia, P.T., Gallinger, C., Ayerza,R. Jr. and Coates, W. 2008. Omega^{-3} enriched broiler meat: The influence of dietary -linolenic-ω-3 fatty acid sources on growth, performance and meat fatty acid composition. *Canadian Journal of Animal Science* 88: 257-269.

Calder, P. C. 2013. Omega^{-3} polyunsaturated fatty acids and inflammatory processes: nutrition or pharmacology?. *British Journal of Clinical Pharmacology* 75: 645-62.

Chicco, A.G., D'Alessandro, M.E ., Hein, G. J., Oliva, M.E. and Lombardo, Y.B. 2009. Dietary chia seed (*Salvia hispanica* L.) rich in -linolenic acid improves adiposity and normalises

hypertriacylglycerolaemia and insulin resistance in dyslipaemic rats. *British Journal of Nutrition* 101: 41-50.

Coates, W. and Ayerza, R. 2009. Chia (*Salvia hispanica* L.) seed as an n-3 fatty acid source for finishing pigs: Effects on fatty acid composition and fat stability of the meat and internal fat, growth, performance and meat sensory characteristics. *Journal of Animal Science* 87: 3798-804.

Gazem, R.A.A and Chandrashekariah, S.A. 2016. Pharmacological properties of *Salvia hispanica* (Chia) Seeds: A review. *Journal of Critical Reviews* 3: 63-67.

Lardizabal, R.U. 2014. Salvia hispanica: Meeting rigorous post-harvest demands of rural farmers in Lempira with the introdcution of a high value crop, Van Hall Larenstein University of Applied Sciences.

Laslett, L.J., Alagona, P., Clark, B.A., Drozda, J.P., Saldivar, F., Wilson, S. R., Poe, C. and Hart, M. 2012. The Worldwide Environment of Cardiovascular Disease: Prevalence, Diagnosis, Therapy, and Policy Issues. *Journal of the American College of Cardiology* 60(25 Supp):S1-S49

Nitrayová, S., Brestensk, M., Heger, J., Patráš,P., Rafay, J. and Sirotkin, A. 2014. Amino acids and fatty acids profile of Chia (*Salvia hispanica* L.) and Flax (*Linum usitatissimum* L.) Seed. *Potravinarstvo® Scientific Journal for Food Industry* 8: 72-76.

Rolfes, S.R., Pinna, K. and Whitney, E. 2009. Understanding Normal and Clinical Nutrition. Yolanda Cossio: USA.

Segura-Campos, M.R., Ciau-Solís,N., Rosado-Rubio,G., Chel-Guerrero, L. and Betancur-Ancona, D. 2014. Physicochemical characterization of chia (*Salvia hispanica*) seed oil from Yucatán, México. *Agricultural Sciences* 5: 220-26.

Simopoulos, A.P. 2004. Omega^{-6}/Omega^{-3} Essential fatty acid ratio and chronic diseases. *Food Reviews International* 20: 77-90.

Ullah, R., Nadeem, M., Khalique, A., Imran, M., Mehmood, S., Javid, A. and Hussain, J. 2016. Nutritional and therapeutic perspectives of Chia (*Salvia hispanica* L.): A review. *Journal of Food Science and Technology* 53: 1750-58.

World Health Organisation (WHO). 2013. A Global Brief on Hypertension: Silent killer, global public health crisis. WHO, Geneva, Switzerland

World Health Organisation (WHO). 2017. Cardiovascular Diseases (CVDs): Fact Sheet. Geneva, Switzerland.