Review article

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The nutritional value and health properties of tahini and tahini-based products

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ABSTRACT

Tahini is an oily paste made from mechanically hulled, roasted and ground sesame, which is used as an ingredient in many traditional Middle Eastern recipes. It is rich in MUFAs, PUFAs, polyphenols, minerals and vitamins. Literature about the health effects of tahini consumption is limited since only two studies in human population and one study in animal model are available, so far. A 6-week supplementation with 28 g tahini in T2DM patients led to lower TG and hs-CRP and higher HDL-C levels. Additionally, consumption of 50 g tahini decreased plasma glucose and increased total phenolic content, urinary 8-iso-prostaglandin F2a and flow-mediated dilatation in healthy individuals postprandially. Moreover, in 40 male albino rats of Wistar strain, sesame butter decreased glucose and malondialdehyde and increased HDL-C and total antioxidant capacity compared to control. Hummus is a dip or spread made from boiled chickpeas, blended with tahini, lemon juice, olive oil, garlic and salt. It is rich in vitamins, minerals and different bioactive compounds including phytic acid, tannins, carotenoids, sterols, and other polyphenols. Hummus consumption has been positively related with weight management and glucose-insulin response. Halva is a low-moisture confectionery that contains tahini, sugar, citric acid and Saponaria officinalis root extract and its consumption has been found to ameliorate glycemic control. In conclusion, tahini could be beneficial regarding diabetes-induced inflammation, oxidative stress and endothelial function. Since more research is needed in order to confirm the aforementioned properties, tahini and tahini-based products seem to be a healthy choice, aiming at promoting healthy dietary patterns.

KEY WORDS: *Tahini, sesame, hummus, halva, glucose, HDL-C, triglycerides, diabetes, endothelial function*

INTRODUCTION

Sesame seed (Sesamum indicum L.), also known as beniseed, is one of the earliest human production and consumption oil crops in the family of Pedaliaceae[1]. It was first discovered in ancient sites in Pakistan and was distributed in India, China, and Malaysia[1,2]. Across the globe, the major producers of sesame include India, Sudan, Myanmar, China and Tanzania. Recently, the production of sesame seeds in African countries has increased and Tanzania has replaced India as the leading producer. According to the Food and Agriculture Organization of the United Nations, the global sesame production in 2017 was 5.899 million tons, of which 806,000 tons were produced in Tanzania and 733,000 tons in China[3].

Sesame seeds are composed of 50-52% of fatty acid

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glycerides, 17-19% of protein and 16-18% of carbohydrates (3.2% glucose, 2.6% fructose and 0.2% sucrose). More specifically, sesame contains in higher proportion unsaturated (mainly oleic, linoleic and linolenic) compared to saturated fatty acids (mainly palmitic and stearic acid). Regarding its protein content, sesame contains mainly arginine (140 mg), leucine (75 mg), methionine (36 mg), lysine (31 mg) and cysteine (25 mg). Additionally, it contains about 10.8% fiber, minerals, vitamins and phytosterols and both water-soluble glucosides, lignans, and fat-soluble lignans[4].

Tahini (tahina or tehineh) is a thick beige-colored oily paste made from mechanically hulled, roasted and ground sesame seeds and its name is derived from the Arabic language. In the literature, it is also called sesame paste, sesame butter, tahini butter and tahini dressing, depending on the type of sesame seeds used. It can also be prepared with unroasted seeds, a product called "raw tahini". Tahini is considered a condiment in many regions of the world mainly in the Middle Eastern region from the Levant countries including Syria, Lebanon, Palestine and Jordan while it is also used in cooking in South-East Asian, Central Asian and African countries. Over the past 3 decades, it has become a very popular ingredient, especially in vegetarian recipes for its additional flavor, when used[5]. Tahini is considered as a major ingredient in very famous Middle Eastern dishes such as hummus and baba ghanoush and many other hors d'oeuvre dishes[5].

Although the existing literature on tahini consumption and its possible effect on human health and disease is very limited, the purpose of this review is to aggregate all the available information about the health and medicinal properties of tahini and tahini-based products.

Origin, history and consumption

There is little data to trace the origin and the period when tahini was introduced in the region of Middle East. It has been suggested that tahini was firstly produced when sesame seeds were cultivated in the ancient Middle East. The original area for the first plantation of sesame is obscure but it seems likely to have first been brought into cultivation in Asia or India. Archeological records indicate that sesame has been known and used as a crop in Babylon and Assyria about 4,000 years ago. It was probably exported to Mesopotamia around 2500 BCE and was known in Akkadian and Sumerian. Prior to 600 BC, the Assyrians used sesame oil as food, lotion, and medication, primarily by the rich due to its cost and the difficulty of obtaining it. Hindus also used it in votive lamps and considered the oil sacred[5].

Little data is available about the daily intake of tahini in Middle East countries. Data from a survey in 500 Lebanese individuals showed that the consumption of tahini was approximately 171.1 g/day[6]. Dietary data from 130 women aged 19-30 years were extracted from a descriptive cross-sectional survey conducted between November 2016 and March 2017 in males and females (age range: 1-50 y; n=860) living in 4 urban areas in Egypt[7]. The results showed that the mean observed frequency of tahini consumption was 0.5 times/week[8].

Nutritional value

Chemical analysis values of tahini differ from one sesame cultivar to another while processing of the seeds may also affect its nutritional value.

Since tahini is the paste of sesame seeds, its components are similar to those of sesame. It contains mainly lipids, especially monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs). However, tahini is poor in omega 3 fatty acids or a-lipoic acid while it contains virtually no cholesterol[9].

Regarding its mineral content, tahini contains mainly calcium followed by potassium, magnesium and phosphorus. All other elements are present in comparatively low concentrations[10]. Tahini is also considered a good source of many vitamins such as B-complex vitamins, mainly niacin (B3), folic acid, thiamin (B1), pyridoxine (B6) and riboflavin (B2). However, tahini is poor in vitamin C, B12, retinol, vitamin D2, D3 and vitamin K[11]. According to Food Composition Databases of the United States Department of Agriculture, tahini's main nutrient components are presented in Table 1[11].

In one of the first studies about the nutritional value of tahini[12], the chemical composition of tahini (tehineh), from Saudi Arabia and other countries, was studied. Tahini was found to contain 24.7% protein, 58.9% fat, 2.3% fiber, 3.0% ash and <1.0% moisture. It also contained relatively high amounts of P (692 mg/100g), Mg (362 mg/100g), Fe (7.19

TABLE 1. Nutritional value of tahini (/100g)[11]

Nutrient	Amount
Energy (Kcal)	595
Protein (g)	17
Total fat (g)	53.76
Fatty acids, total saturated (g)	7.53
Fatty acids, total monounsaturated (g)	20.30
Fatty acids, total polyunsaturated (g)	23.56
Carbohydrates, by difference (g)	21.19
Total dietary fibers (g)	9.3
Water (g)	3.05

mg/100g), Cu (1.96 mg/100g), Mn (1.46 mg/100g) and Zn (7.82 mg/100g) and low amounts of Ca (61 mg/100g) and Se (0.05 mg/100g). Gas-liquid chromatography analysis of the oil revealed percentages of 42.4 for oleic, 39.7 for linoleic, 9.8 for palmitic and 6.4 for stearic acid[12].

In another study[13], researchers examined the nutritive value of tahini produced by dehulled sesame seeds roasted using different heat treatments. The different samples of tahini were found to contain 58.6-59.4% crude oil, 21.9-22.6% crude protein and <3% crude fiber and ash. Additionally, tahini samples were found to be good sources of essential amino acids, especially sulphur-containing amino acids, aromatic amino acids and tryptophan while lysine was the first limiting amino acid. Moreover, tahini is a good source of niacin while it contains relatively high amounts of Na, Mg, K, Cu, Zn and Fe and a low amount of Ca.

In the study of Borchani et al.[14], researchers examined the chemical characteristics of raw (intact) sesame seed and sesame paste. The results showed a high content of oil, protein and ash (52%, 24% and 5%, respectively). Regarding the fatty acid profile of both raw sesame and sesame paste, a predominance of oleic acid (41.68% and 41.94%, respectively) followed by linoleic acid (38.29% and 37.48%, respectively) was shown.

In a more recent study from China[15], researchers analyzed the nutritional value of nine different brands of sesame paste, from both white and black sesame varieties and significant differences were observed between the products ($p<0.05$). The fat content ranged from 51.80% to 61.56%, and the protein content varied between 16.08% and 18.97%. The crude fiber, total sugars, and total ash contents were in the range of 2.53-3.78%, 6.23-18.57% and 4.48-5.24%, respectively. These high variances in nutrient content of analyzed tahini samples may be attributed to different sources of sesame seeds, both from China and abroad (Sudan, Nigeria, Ethiopia, Myanmar)[15].

It is well known that sesame seeds have considerable amounts of lignans (up to 1.5%), including sesamin, episesamin, and sesamolin[16]. Lignans are a group of natural compounds which are defined as an oxidative coupling product of β-hydroxyphenylpropane and widely distributed as a minor component in the plant kingdom, especially in bark of wood. Sesamin and sesamolin have been known as major lignans, and sesaminol was later identified as another major lignan[17]. Given the lack of data about tahini's content, it is supposed that these micronutrients are present in sesame paste also in high amounts.

HEALTH EFFECTS

Tahini

Tahini and its effect on health outcomes has become an interesting topic for research in the last decade. At this point, there are only two studies in human population and one study in animal models that have examined the effect of tahini consumption on diabetes and dyslipidemia management.

The first study was designed to investigate the effects of tahini consumption on lipid profile and atherogenic lipid parameters as well as on glucose homeostasis parameters and serum high-sensitive reactive protein (hs-CRP) in, non-insulin dependent, patients with type 2 diabetes. Thirty six participants were randomly divided into two groups. The intervention group replaced part of their breakfast with 28g tahini and the control group continued their usual breakfast intake for 6 weeks, following a 2-week wash-out period. Both groups did not exceed an intake of 270 kcal during breakfast. The results of the study indicated no change in anthropometric measurements and blood pressure in both groups but significantly lower triglyceride levels (TG) and atherogenic index of plasma and a slight -but significant- increase in HDL levels after tahini consumption, supporting that sesame paste could have a beneficial effect in CVD risk factors in diabetic patients. No significant differences were observed in all the other lipid parameters[18].

Additionally, the supplementation of 28g tahini for 6 weeks was found to decrease serum hs-CRP levels by 21.1% ($p<0.05$) Fasting serum glucose , serum insulin, Sensitivity Index and Homeostatic Model Assessment of insulin resistance did not differ significantly[19]. Taking the results of the aforementioned study into account, the researchers concluded that tahini could be used as a functional food in order to diminish the diabetes-induced inflammation.

These favorable effects of tahini consumption on lipids and CRP could be attributed to its high antioxidant activity mainly due to its content in lignans and tocopherols.

In human, data about the effect of sesame seeds or sesame oil supplementation on lipid profile are inconsistent. However, despite some limitations of these studies, especially concerning the lack of control group, and the different doses that have been used, these results have mostly revealed a beneficial effect on lipids[20–22].

Sesame lignans may lower the cholesterol concentration in serum, especially in combination with tocopherol, due to the inhibition of absorption from the intestine and suppression of synthesis in the liver[23]. This synergistic effect has been observed in both animal and human studies[24].

The anti-inflammatory properties of tahini are also associated with bioactive components including lignans. Previous studies of sesame supplementation in humans did not show beneficial effects on CRP levels. However, studies in animal models have shown that sesamin and sesamolin could reduce the activity of p38 mitogen-activated protein kinase (MAPK)

TABLE 2. Characteristics of eligible studies.

Author (year)	Country	Study design	Population	Sample size	Study duration	Intervention group	Control group	Findings
Human Subjects								
Mirmiran et al., 2013	Iran	Parallel randomized double-blind controlled trial	T2DM patients (Non-insulin-dependent)	36 Group A (Tahini, n=20) Group B (control, n=16)	6 weeks	28g tahini during breakfast	Usual breakfast (bread & cheese ≃270 kcal)	Decrease by 15.3% in TG & by 39% in AIP & increase in HDL-C compared to control ($p<0.05$)
Bahadoran et al., 2015	Iran	Parallel randomized double-blind controlled trial	T2DM patients (Non-insulin-dependent)	36 Group A (Tahini, n=20) Group B (control, n=16)	6 weeks	28g tahini during breakfast	Usual breakfast (bread & cheese ≃270 kcal)	21.1% decrease in serum hs-CRP levels in tahini group ($p<0.05$)
Baxevanis et al., 2021	Greece	Single-arm postprandial study	Healthy male adults	20	4 hours	50g tahini	-	Lower FBG after 1h, 3 h and 4 h ($p<0.05$) Increase in TG levels after 3h ($p<0.05$) Increase in urinary 8-iso-prostaglandin F2α levels after 4h ($p<0.05$) Increase in total phenolic content after 1h ($p<0.05$)
Sakketou et al., 2021	Greece	Single-arm postprandial study	Healthy male adults	20	4 hours	50g tahini	-	Decrease in DBP and pulse rate and increase in FMD after 4h ($p<0.05$)
Animal models								
Haidari et al., 2016	Iran	Animal study	Male albino rats of Wistar strain	40 4 groups (10 rats per group)	6 weeks	Group 3: diabetic rats treated with sesame butter Group 4: diabetic rats treated with sesame oil	Group 1: non-diabetic control rats Group 2: diabetic rats	In Groups 3 & 4 lower levels of FBG and higher levels of HDL compared to Group 2 ($p<0.05$) In group 3 increase in TAC and decrease in MDA compared to Group 2 ($p<0.05$) In Group 4 decrease in TG levels compared to the Group 2 ($p<0.05$)

TG: triglycerides, AIP: atherogenic index of plasma, HDL: high density lipoprotein, LDL: low density lipoprotein, DBP: diastolic blood pressure, FMD: flow-mediated dilation, FBG: fasting blood glucose, hs-CRP: high-sensitive C reactive protein, HOMA-IR: Homeostatic Model Assessment of insulin resistance, TAC: total antioxidant capacity

and nuclear factor (NF)-kappaB[25]. Moreover, sesame lignans act as natural ligands for peroxisome proliferator-activated receptor gamma (PPAR-γ) *in vitro*[26] leading to substantial reduction of hs-CRP and other cardiovascular risk markers[27]. In a more recent study, 20 healthy men were recruited to examine the effect of tahini consumption on oxidative stress and cardiovascular risk indices. After a 12-h fast, and a 3-day wash-out period, blood and urine samples were collected. Blood pressure, endothelial function and arterial stiffness were also assessed at baseline (time 0). Subsequently, participants consumed 50g tahini and every hour for the next 4 hours blood and urine samples were collected while blood pressure, endothelial function and arterial stiffness were reassessed at the end of the trial. Plasma glucose was significantly lower at 1, 3 and 4 hours after tahini consumption compared to baseline ($p<0.05$). Furthermore, there was a slight increase

in total phenolic content ($p<0.05$) 4 hours postprandially and a significant increase in both serum TG ($p<0.05$) and urinary 8-iso-prostaglandin F2a levels ($p=0.016$) at the end of the trial[28]. Additionally, the consumption of 50g tahini was found to decrease diastolic blood pressure and pulse rate and increase TG levels and flow-mediated dilatation 4 hours postprandially[29]. All the aforementioned results suggest that the intake of 50g tahini as a part of a healthy diet could promote euglycemia, increase antioxidant capacity and improve not only lipid profile but also the endothelial function of healthy adult men.

In the study of Haidari et al.[30], 40 male albino rats of Wistar strain were randomly divided into 4 groups (i.e., non-diabetic control rats, diabetic (control) rats, diabetic rats treated with sesame butter (1.25 g/kg), and diabetic rats treated with sesame oil (0.5 g/kg)) for 6 weeks, in order to assess their lipid profile and oxidative stress biomarkers. Glucose levels significantly decreased in diabetic rats treated both with sesame butter and sesame oil and HDL levels were higher compared to diabetic control group ($p<0.05$). In addition, total antioxidant capacity increased and malondialdehyde decreased significantly in the diabetic rats treated with sesame butter ($p<0.05$). According to the researchers, sesame butter seems to improve glucose levels and lipid profile and also exerts antioxidative properties, suggesting a possible choice in the management of diabetes.

Tahini-Based Products

Hummus and halva are the most famous tahini-based products consumed in the Middle East and Mediterranean countries. The production of tahini (tahina) and halva (halawa) is described detailly in Figure 1[31].

Hummus

Hummus is a traditional food and one of the most popular in the Middle East countries, such as Syria, Lebanon and Jordan[32]. It is a dip or spread made from boiled chickpeas, blended with tahini, lemon juice or citric acid, olive oil, garlic and salt. Hummus, due to its chickpea content (about 20-25%)[32,33], is a nutritionally rich food and good source of energy, providing 166 kcal per 100g. It contains 14.29% carbohydrates, 7.9% protein, 6% dietary fiber, and 9.6% fat, mostly MUFAs and PUFAs. It is also rich in vitamins and minerals, including, folate, vitamin B6, calcium, potassium and magnesium. Apart from its rich vitamin and mineral content, different bioactive compounds including phytic acid, tannins, carotenoids, sterols, and other polyphenols such as isoflavones, are also present in significant amounts. However, it is worth mentioning that a variety of other forms of hummus (or bean-based dips labeled as hummus that do not follow the traditional hummus recipe) exist on the market; thus, the nutritional content of these products may differ significantly[33].

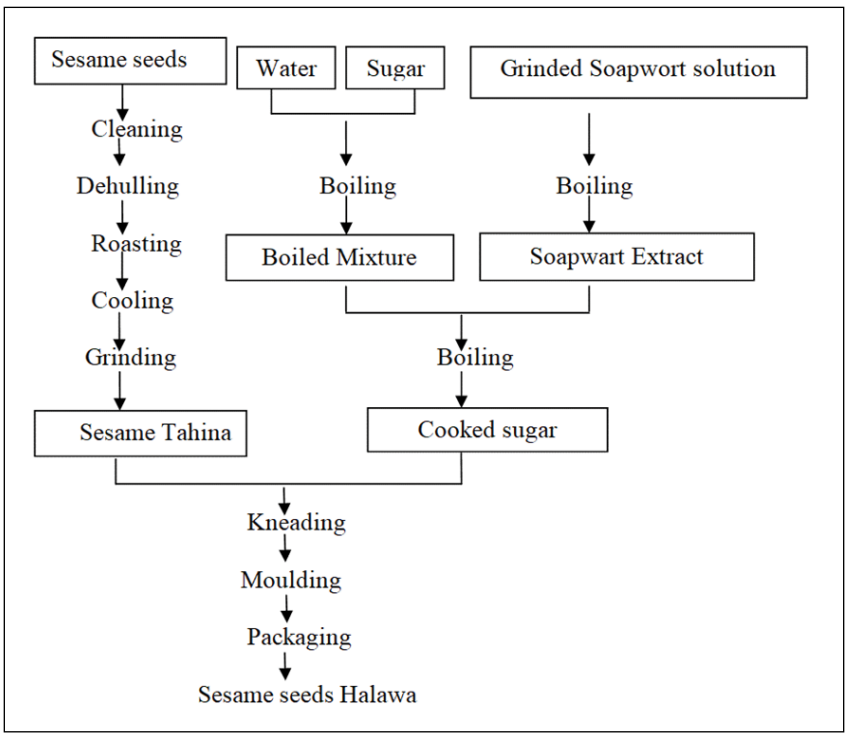

FIGURE 1. The procedure of production of tahini (tahina) and halva (halawa).[31]

Due to its unique recipe and nutrient density, hummus consumption has been associated with numerous health benefits. The available scientific literature supports that hummus consumption offers health benefits in terms of weight management[34–36] and glucose-insulin response[36,37]. However, due to the complexity of hummus as food, it is obscure if these effects are attributed to its content in tahini. However, it is hypothesized that tahini could add to hummus high nutritional value and exert its favorable properties. Additionally, according to Wallace et al. (2017), more clinical research is needed in order to clarify if hummus consumption results in additional benefits beyond improving nutrient profiles of meals, as for instance, slowing carbohydrate absorption and delaying gastric emptying[33].

Halva

Halva (known also as halvah, chalva, chalwa, halawa) is a low-moisture confectionery widely consumed in the Middle East and Mediterranean. It consists of tahini, sugar, citric acid and Saponaria officinalis (soapwort; Family Caryophyllaceae) root extract[38]. Production of halva on an industrial basis has been described in detail by Herda[39]. It is made by mixing tahini with a heated, acidified sugar syrup. The syrup contains a high concentration of glucose, citric or tartaric acid and soapwort root extract (Saponaria officinalis). The syrup is heated to 120-140°C prior to mixing with the tahini[38]. More specifically, halva is composed of 50% tahini, 25-35% sugar, 12-25% glucose and 1% additives, such as flour and whipping agents. In some varieties of halva nuts, cocoa, and other flavourings can be added before portioning and packaging[40]. Regarding its nutritional value, halva contains ≥24% fat, ≥8.5% protein, ≤55% sucrose, ≤2% fiber and ≤3% water[31]. An analysis of halva produced in a Greek facility indicated a water activityof 0.18 and pH of 6[38].

Similarly to other tahini-based products, it has been shown that halva consumption is also associated with significant health benefits in terms of glycemic control. Particularly, a randomized cross-over study of twelve healthy individuals designed to evaluate short-term effects of three traditional Greek mixed meals of legumes, trahana and halva on postprandial blood glucose responses, showed that all meals significantly produced lower postprandial glucose concentrations and lower glucose excursions, including halva, which led to a reduction by 49%, compared to the reference food (D-glucose)[41].

CONCLUSIONS

From ancient times, the relationship between nutrition and health has long been recognized and consumption of variety foods, mainly plant-based, has been shown to offer numerous health benefits for human health. Recently, sesame and its paste (tahini) have triggered the interest of researchers. Nevertheless, there is limited data about tahini consumption and its effect on human health. Only two studies in human population and one in animal models are available in the current literature. The results of these studies were quite optimistic in terms of favorable effects on oxidative stress and cardiovascular indices in both healthy individuals and patients with diabetes. Although the necessity to future research is crucial to confirm these conclusions, the incorporation of tahini and tahini-based products in our daily diet could be a healthy alternative to other foods/snacks with less desirable lipid profile, aiming at promoting healthy dietary patterns.

Conflict of Interest

The authors declare no conflict of interest.

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ΠΕΡΙΛΗΨΗ

Η διατροφική αξία και οι επιδράσεις στην υγεία του ταχινιού και των προϊόντων του

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**Ισότιμη συνεισφορά*

Το ταχίνι είναι μια λιπαρή πάστα από μηχανικά ξεφλουδισμένο, καβουρδισμένο και αλεσμένο σουσάμι, που χρησιμοποιείται ως συστατικό σε πολλές παραδοσιακές συνταγές της Μέσης Ανατολής. Είναι πλούσιο σε μονοακόρεστα και πολυακόρεστα λιπαρά οξέα, πολυφαινόλες, μέταλλα και βιταμίνες. Η βιβλιογραφία σχετικά με την επίδραση της κατανάλωσης ταχίνης στην υγεία είναι περιορισμένη αφού μέχρι στιγμής είναι διαθέσιμες μόνο δύο μελέτες σε ανθρώπινο πληθυσμό και μία μελέτη σε ζωικό πρότυπο. Η κατανάλωση 28 g ταχίνης για 6 εβδομάδες σε ασθενείς με ΣΔ2 οδήγησε σε χαμηλότερα επίπεδα TG και hs-CRP και υψηλότερα επίπεδα HDL-C. Επιπλέον, η κατανάλωση 50 g ταχίνης μείωσε τα επίπεδα γλυκόζης πλάσματος και αύξησε το ολικό φαινολικό περιεχόμενο, την 8-ισο-προσταγλανδίνη F2a στα ούρα και την ενδοθηλιοεξαρτώμενη αγγειοδιαστολή σε υγιή άτομα μεταγευματικά. Επιπλέον, σε 40 αρσενικούς αλμπίνους αρουραίους του στελέχους Wistar, το ταχίνι μείωσε τη γλυκόζη και τη μηλονική διαλδεΰδη και αύξησε την HDL-C και τη συνολική αντιοξειδωτική ικανότητα σε σύγκριση με την ομάδα ελέγχου.

Το χούμους είναι ένα άλειμμα από βρασμένα ρεβίθια, αναμεμειγμένα με ταχίνι, χυμό λεμονιού, ελαιόλαδο, σκόρδο και αλάτι. Είναι πλούσιο σε βιταμίνες, μέταλλα και διάφορες βιοδραστικές ενώσεις, όπως φυτικό οξύ, τανίνες, καροτενοειδή, στερόλες και άλλες πολυφαινόλες. Η κατανάλωση χούμους έχει συσχετιστεί θετικά με τη διαχείριση του βάρους και την απόκριση γλυκόζης-ινσουλίνης. Ο χαλβάς είναι ένα χαμηλής υγρασίας γλύκισμα που περιέχει ταχίνι, ζάχαρη, κιτρικό οξύ και εκχύλισμα ρίζας Saponaria officinalis και η κατανάλωσή του έχει βρεθεί ότι βελτιώνει τον γλυκαιμικό έλεγχο.

Συμπερασματικά, η κατανάλωση ταχίνης φαίνεται ότι είναι ευεργετική όσον αφορά τη φλεγμονή που προκαλείται από τον διαβήτη, το οξειδωτικό στρες και τη λειτουργία του ενδοθηλίου. Αν και απαιτείται περισσότερη έρευνα για να επιβεβαιωθούν οι προαναφερθείσες ιδιότητες, η ταχίνη και τα προϊόντα με βάση την ταχίνη φαίνεται να αποτελούν μια υγιεινή επιλογή, στοχεύοντας στην προώθηση περισσότερο υγιεινών διατροφικών προτύπων.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: *Ταχίνι, σουσάμι, χούμους, χαλβάς, γλυκόζη, HDL-χοληστερόλη, τριγλυκερίδια, διαβήτης, ενδοθηλιακή λειτουργία*

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