JOURNAL OF MEDICINAL FOOD
J Med Food 19 (4) 2016, 337–345

DOI: 10.1089/jmf.2015.0075

REVIEW

Effects of the Intake of Sesame Seeds (*Sesamum indicum* L.) and Derivatives on Oxidative Stress: A Systematic Review

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ABSTRACT This study is aimed at assessing the scientific evidence on the effect of the intake of sesame seeds and derivatives on oxidative stress of individuals with systemic hypertension, dyslipidemia, and type 2 diabetes mellitus. A systematic review was conducted in seven databases (Lilacs, PubMed, ISI Web of Knowledge, Cochrane Library, Scopus, Trip Database, and Scielo) from September 2013 to January 2014. Clinical trials on the intake of sesame seeds and derivatives assessing the outcomes related to oxidative stress were retrieved. The risk of bias in the results of the studies selected was assessed according to the criteria of the *Cochrane Handbook for Systematic Reviews of Interventions*. This review included seven clinical trials showing that the intake of sesame resulted in the increase in enzymatic and nonenzymatic antioxidants, as well as in a reduction in oxidative stress markers. This was mainly observed with the use of sesame oil for hypertensive individuals during 2 months and black sesame meal capsules for prehypertensive individuals during four weeks. Most studies involved a small number of participants, sample size being considered a limiting factor for this review. In addition, a significant heterogeneity was observed in the type of population studied and the type of sesame and derivatives used, as well as their amount. The follow-up time was considered a limiting factor, because it varied in the different studies. The high risk of randomization and blinding biases found in the studies assessed determines lower scientific evidence of the results. Despite the limitations and biases identified in this systematic review, sesame showed relevant effects on oxidative stress, suggesting it could increase the antioxidant capacity.

KEY WORDS: • ***antioxidants*** • ***cardiovascular disease*** • ***oxidative stress*** • ***risk factors*** • ***sesame oil*** • **sesamum**

INTRODUCTION

Sesame (*Sesamum indicum L.*) is mainly composed of fats, being considered a rich source of antioxidants.[1] Sesame belongs to the *Pedaliaceae* family,[2] and, of its nutrients with antioxidant function, vitamin E (alpha-tocopherol), and lignans, such as sesamin, sesamolin, and sesamol, stand out.[3–6] It ranks ninth among the worldwide oilseed crops.[7] Its major producers are India, China, Sudan, Ethiopia, Uganda, and Pakistan.[8] In Brazil, the top producing regions are the states of Goiás and Mato Grosso, the Triângulo Mineiro region in the state of Minas Gerais, and the Brazilian Northeastern region.[9]

Some studies have shown that sesame seeds can reduce oxidative stress by modifying the blood content of vitamin C (ascorbic acid) and vitamin E, and by modulating the concentration of antioxidant enzymes [superoxide dismutase (SOD), glutathione (GSH), glutathione peroxidase (GPx), catalase (CAT)], as well as of oxidative stress markers [thiobarbituric acid reactive substance (TBARS) and malondialdehyde (MDA)].[10–17]

Imbalance between the mechanisms of antioxidant defense and exposure to reactive oxygen species (ROS) induces oxidative stress,[18] and could trigger endothelial dysfunction, systemic hypertension,[19,20] dyslipidemia, and atherosclerosis.[21]

This systematic review is aimed at assessing the scientific evidence on the effect of the intake of sesame seeds and derivatives on oxidative stress (antioxidant defense system and oxidative stress markers) in individuals with systemic hypertension, dyslipidemia, and type 2 diabetes mellitus.

METHODS

This systematic review of studies retrieved from seven bibliographic sources of information was based on the recommendations of the Cochrane Collaboration.[22]

Manuscript received 24 June 2015. Revision accepted 5 February 2016.

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The research question asked in this systematic review of clinical trials was: ''What is the effect of the intake of sesame seeds and derivatives on oxidative stress?''

Two researchers were in charge of the search for articles and their selection, as well as the assessment of the risk of bias in the results of the articles selected in duplicate.

Search strategy

The following seven sources of information were used for the bibliographic research of this systematic review: Lilacs, PubMed, ISI Web of Knowledge, Cochrane Library, Scopus, Trip Database, and Scielo. The bibliographic search began in September 2013, and ended in January 2014. The languages of the articles sought were English, Portuguese, and Spanish.

In the site of the Virtual Health Library (BVS), the following keyword descriptors were initially sought in English, Portuguese, and Spanish: sesame, flour, risk, lipid profile, cardiovascular, seed, oil, sesame oil, and capsule. The following were identified: *Sesamum*, flour, risk factors, dyslipidemias, cardiovascular diseases, seeds, oils, sesame oil, and capsule.

In the next stage of the search strategy, the following keywords and their synonyms were sought in study titles and abstracts: *Sesamum brasiliensis*, *gergelim-do-Brasil*, sesame, flour, risk factors, dyslipidemias, cardiovascular diseases, and lipids.

The research was conducted in articles published in the last 15 years and the terms were used alone and/or combinations of them. There are no limits to the search in relation to the intervention time, country, and use of medicines. There were limits to the population with some kind of chronic disease.

Eligibility criteria

This review included clinical trials on the intake of sesame seeds and derivatives, which assessed the following outcomes related to oxidative stress: the antioxidant defense system, such as vitamin C, vitamin E, beta-carotene (vitamin A precursor), SOD, GSH, GPx and CAT; and oxidative stress markers, such as TBARS and MDA.

The inclusion criteria of this systematic review were: clinical trials written in English, Portuguese, and Spanish assessing the outcomes of interest, that is, the effect of the intake of sesame seeds and derivatives on oxidative stress and the participants must have a chronic disease such as hypertension, type 2 diabetes for example.

The exclusion criteria of this systematic review were: letter-type reports; interventions using sesame as an ingredient for cakes or cereal bars; articles with outcomes different from those of interest; and articles in idioms other than those of the inclusion criteria.

Assessment of the risk of bias

A bias is a systematic error or deviation from the truth, in results or inferences, and can lead to underestimation or overestimation of the true intervention effect.[22]

The risk of bias in the results of the studies selected in this review was assessed by two researchers according to the criteria of the *Cochrane Handbook for Systematic Reviews of Interventions*, version 5.1,[22] as follows: ''low risk,'' ''high risk,'' and ''unclear risk.'' This systematic review used a standard Cochrane Collaboration's ''risk of bias'' table with the following features of interest: random sequence generation (selection bias); allocation sequence concealment (selection bias); blinding of participants and personnel (performance bias); blinding of outcome assessment (detection bias); incomplete outcome data (attrition bias); and selective outcome reporting (reporting bias).

The inclusion and exclusion of the articles in this review were based on a consensus achieved by the two researchers. If in doubt, there is a third researcher who participated in the selection.

Data collection

The articles were systematically reviewed regarding the effect of the intake of sesame and its derivatives on the antioxidant defense system and oxidative stress markers in patients with systemic hypertension, dyslipidemia, and type 2 diabetes mellitus. The articles selected were organized in tables, and classified according to the populations studied and the outcomes ''antioxidant defense system'' and ''oxidative stress markers''. In the ''antioxidant defense system'' outcome, antioxidants, such as vitamin C, vitamin E, beta-carotene, SOD, GSH, GPx, and CAT, were assessed. In the ''oxidative stress markers'' outcome, TBARS and MDA were assessed. A meta-analysis could not be performed, because of the great heterogeneity of study designs, interventions, and populations.

RESULTS

Search for articles and data collection

Our search retrieved 3417 abstracts, of which 1432 were nonduplicate abstracts. At the end, seven articles with outcomes related to oxidative stress (antioxidant defense system and oxidative stress markers) were selected for this review.

Figure 1 depicts the flowchart of the search and selection of the articles for this review.

Characteristics of the studies

Of the 12 full articles assessed for eligibility with oxidative stress as an outcome, five were excluded from the systematic review due to heterogeneity, because they evaluated either healthy populations or different sesame presentations, which made data analysis difficult. Therefore, seven studies were selected for qualitative analysis.

Table 1 shows the major characteristics of the seven clinical trials retrieved, five of which were randomized,[10,11,14–16] two were placebo controlled,[13] and one, double-blind.[13] The sesame presentations in the seven clinical trials were as follows: sesame oil, four studies[10–12,14]; sesame flour, one[16];

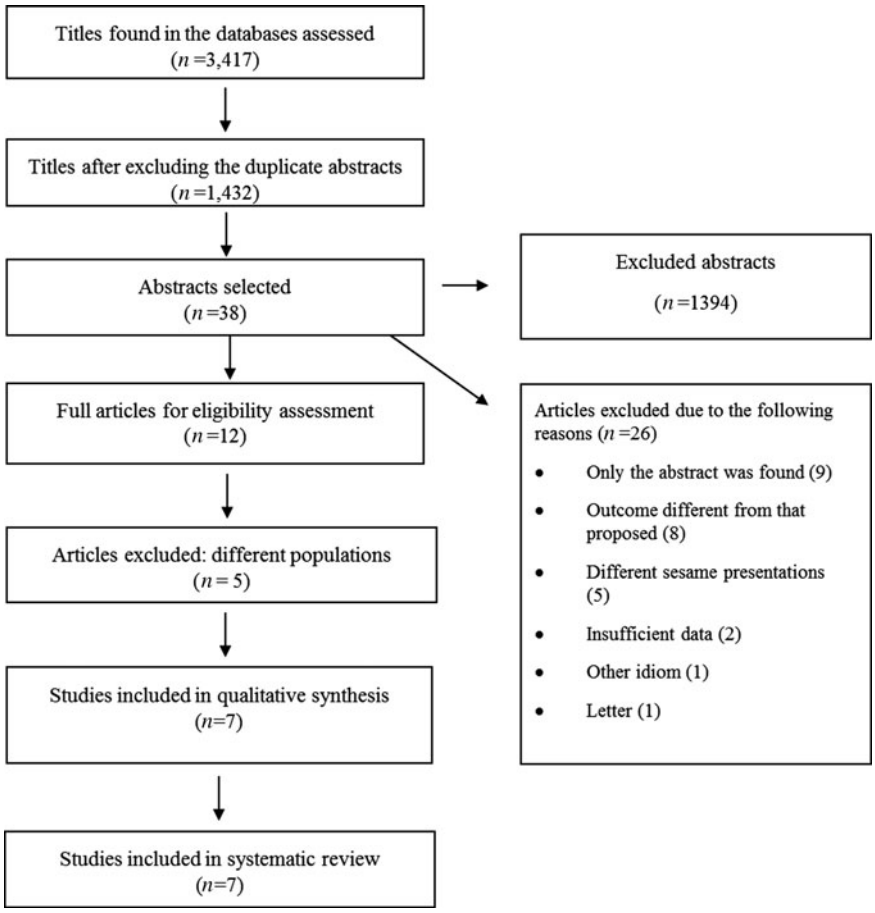

FIG. 1. Flowchart of the search and selection of the articles.

black sesame meal capsules, one[13]; and white sesame seeds, one.[15] Most studies used only sesame and its derivatives as dietary supplementation and instructed the participants to maintain their usual diets.[10–15] Only the clinical trial with hyperlipidemia individuals recommended a standard diet for two weeks (run-in).[16] Except for one study reporting on 530 participants,[10] the others included a small number of participants.[11–16]

Assessment of the risk of bias

Seven clinical trials assessing the outcome of interest were included for analysis of the risk of bias, by use of a ''risk of bias'' table (Table 2).

All studies had at least one item at high risk for bias. Of the seven studies, four were randomized, and three, non-randomized, generating high risk of selection bias. The four randomized clinical trials have not described the method used to generate the randomization sequence and to conceal the allocation sequence.

The lack of blinding was the most common cause of high risk of bias. Only one clinical trial was double-blind, but had no accurate information on the blinding process of participants and personnel, potentially producing biases against the effects of the intervention, generating a high risk for performance and detection biases.

All studies reported the results regarding all outcomes proposed, characterizing low risk for reporting bias.

The feature ''incomplete outcome data'' could not be observed in the articles selected. Therefore, the risk for attrition bias was unclear.

Effects of sesame on oxidative stress

The large majority of the articles selected has assessed the effects of sesame and its derivatives on the following antioxidant parameters: vitamin C[10–12]; vitamin E[11,12,14]; beta-carotene[10–12]; SOD[10–14]; GSH[9–11]; GPx[9–11,13]; and CAT.[10–12] The oxidative stress markers assessed were TBARS[10–13,15] and MDA.[13]

Of the seven articles, three have been performed on patients with systemic hypertension.[10–12] Those studies have used sesame oil (35 g), and reported an increase in seven antioxidants assessed, as well as a reduction in the oxidative stress marker, TBARS (Table 2). In addition, the articles with a 60-day intervention[10] have shown a greater increase in antioxidants, such as vitamin E (90.12% increase) and beta-carotene (112.99% increase), as compared with those with a 45-day intervention.[11,12]

One study with prehypertensive individuals and using black sesame meal capsules (18 capsules adding up to 7.56 g of sesame per day) has reported a 29.93% increase in vitamin E and a 33.33% reduction in MDA[13] (Table 2).

Table 1. General Characteristics of the Clinical Trials Included in the Systematic Review

Population profile	*Clinical trial (author, year)*	*Design/ Follow-up*	*Population (sex/age)*	*Sesame presentation*	*Intervention*	*Diet/Drugs*	*Statistics*	*Outcome of interest*
Type 2 diabetes	Sankar *et al.* 2011[14]	Interventional Parallel Randomized 60 days	28 (F) 32 (M) $n=36$ 50 ± 10 years 52 ± 9 years	Sesame oil	Sesame oil + glibenclamide ($n=20$): 35 g of oil for cooking or salad dressing +5 mg of glibenclamide (per day) Sesame oil ($n=18$): 35 g of oil for cooking or salad dressing (per day)	Usual diet. Hypoglycemic agent at the same dose for at least 4 weeks before the study	Paired Student's *t*-test ANOVA Newman–Keuls	Antioxidants
Hyperlipidemia	Alipoor *et al.* 2012[15]	Interventional Controlled Randomized	30 (F) 8 (M) $n=38$ 50–70 years	White sesame seed	Glibenclamide ($n=22$): 5 mg per day GI ($n=19$): 40 g of white sesame seed/60 days GC ($n=19$): drug treatment maintained (not cited in the study)	Usual diet. GI: exclude 240 kcal from the daily diet	*t*-test Paired *t*-test	Antioxidants and oxidative stress markers
Hyperlipidemia and one obese individual	Chen *et al.* 2005[16]	Interventional 10 weeks	15 (F) 6 (M) $n=21$ 50.9 ± 3.7 years	Sesame flour	I: 40 g of sesame flour/4 weeks R: standard diet/2 weeks WF: sesame flour withdrawn and back to usual diet/4 weeks	Instructed to maintain the dietary patterns according to the *National Cholesterol Education Program Step I diet* guidelines. Six individuals on lipid-lowering drugs.	Linear mixed effect model	Oxidative stress markers
Hypertension (mild to moderate)	Sankar *et al.* 2005[10]	Interventional Controlled Randomized 2 months	Middle age $n=530$	Sesame oil	GI: 35 g of oil per day/ 60 days Sesame oil ($n=356$) Sunflower oil ($n=87$) Groundnut oil ($n=47$) GC ($n=40$): Nifedipine + sunflower, sesame or groundnut oil, randomly/60 days	Usual diet: GI instructed to use their respective oils as exclusive oil for cooking or salad dressing. On treatment with nifedipine (20–30 mg/day)	ANOVA and Duncan	Antioxidants and oxidative stress markers

(*continued*)

Table 1. (Continued)

Population profile	*Clinical trial (author, year)*	*Design/ Follow-up*	*Population (sex/age)*	*Sesame presentation*	*Intervention*	*Diet/Drugs*	*Statistics*	*Outcome of interest*
Hypertension and diabetes (2–3 years)	Sankar *et al.* 2006[11]	Interventional Controlled Randomized 90 days	18 (F) 22 (M) $n=40$ 49–64 years	Sesame oil	I: 35 g of sesame oil for cooking or salad dressing/per day/ 45 days C: 35 g of palm tree oil or groundnut oil/45 days	Usual diet. Use of beta-blockers (atenolol 50–100 mg/day) and sulfonylurea (glibenclamide 10mg/day)	Student's *t*-test	Antioxidants and oxidative stress markers
Hypertension (mild to moderate)	Sankar *et al.* 2006[12]	Interventional Controlled 90 days	18 (F) 21 (M) $n=50$ 35–60 years	Sesame oil	I: 35 g of sesame oil/ 45 days (exclusively sesame oil) C: back to usual oil/ 45 days	Usual diet. Instructed to maintain the antihypertensive drugs. Use of diuretics and beta-blockers (hydrochlorothiazide or atenolol for 1 year)	Student's *t*-test	Antioxidants and oxidative stress markers
Prehypertension	Wichistrainoi, *et al.* 2011[13]	Placebo Controlled Double-blind 4 weeks	8 (F) 22 (M) $N=30$ 49.3 ± 7, 7 years 50.3 ± 5, 6 years	Black sesame meal capsule	GI ($n=15$): 18 black sesame capsules (0.42 g of sesame/capsule) per day/4 weeks GP ($n=15$): 18 capsules (same chemical composition, but without sesame) per day/4 weeks	Usual diet. Instructed to maintain the routine of physical exercises and not to consume vitamin or dietary supplements during the study. No drug that could affect blood pressure	ANCOVA–analysis of covariance Pearson correlation Paired Student's *t*-test	Antioxidants and oxidative stress markers

F, female; M, male; I, intervention; P, placebo; C, control; GI, intervention group; GP, placebo group; GC, control group; R, run-in; W, *washout*; WD, *washout* during the study; WF, *washout* at the end of the study; *n,* number of participants.

Table 2. Risk of Bias Table

Articles selected	*Random sequence generation*	*Allocation concealment*	*Blinding of participants and personnel*	*Blinding of outcome assessment*	*Incomplete outcome data*	*Selective reporting*
Chen *et al.*[16]	–	–	–	–	?	+
Sankar *et al.*[10]	?	?	–	–	?	+
Sankar *et al.*[11]	?	?	–	–	?	+
Sankar *et al.*[12]	–	–	–	–	?	+
Sankar*et al.*[14]	–	–	–	–	?	+
Wichitsranoi *et al.*[13]	–	–	+	?	?	+
Alipoor *et al.*[15]	?	?	–	–	?	+

Judgment of the authors of this systematic review for each entry in the ''risk of bias table'' for the seven articles included.
+, low risk; _ high risk; ?, unclear risk.

Regarding the dyslipidemic population, two studies assessing the effect of the intake of 40 g of sesame flour[16] and 40 g of white sesame seed[15] on oxidative stress have been identified. They have shown an increase in enzymatic antioxidants (SOD and GPx)[15] and in the antioxidant capacity,[21] as well as a reduction in oxidative stress markers [LDL TBARS and oxidized LDL (lag phase)][15] (Table 3).

One study with patients with type 2 diabetes on glibenclamide has shown that the association of glibenclamide with sesame oil is effective to increase the activities of SOD, CAT, and GPx, and the plasma levels of vitamins C and E and beta-carotene[14] (Table 4).

DISCUSSION

The systematic review of the seven articles selected identified a deficiency in the quality and availability of studies assessing the effects of sesame and its derivatives on oxidative stress. Most studies involved a small number of participants, sample size being considered a limiting factor for this review. In addition, a significant heterogeneity was observed in the type of population studied and the type of sesame and derivatives used, as well as their amount.

The follow-up time was another important factor to establish the most adequate duration of the intervention in the search for positive results to reduce oxidative stress in different populations. However, it was considered a limiting factor, because it varied in the different studies.

The high risk of randomization and blinding biases found in the studies assessed determines lower scientific evidence of the results. The random allocation of participants reduces the risk of bias in a study. The clear explanation of how blinding is performed, as well as of its type, can increase the scientific evidence of the study; in a double-blind trial, for example, both participants and authors ignore the type of intervention used.

The reduced number of articles assessing the effect of sesame in humans, as well as the significant heterogeneity of the studies selected concerning sesame presentation and population type made a meta-analysis impossible.

The antioxidant defense system is divided into the enzymatic and nonenzymatic antioxidant systems, the latter comprising a large diversity of antioxidants that can have either endogenous or exogenous (from food) origin.[21] The enzymatic system is composed by the enzymes SOD, CAT, and GPx, which act through preventive mechanisms, either preventing or controlling the formation of ROS.[23] The nonenzymatic system is formed by dietary antioxidant compounds, such as ascorbic acid, alpha-tocopherol, and beta-carotene, in addition to minerals, such as zinc, copper, selenium, and magnesium.[24]

The antioxidant defense system is known to inhibit or reduce the damage caused by ROS,[25] and antioxidants act either directly, neutralizing the action of ROS, or indirectly, participating in the enzymatic system.[21]

The studies using sesame oil[10–12,14] or black sesame meal capsules[13] have shown an increase in vitamin E levels, which is important to the antioxidant defense system.

Sometimes the acting capacity of antioxidants can be lower than the production of ROS, favoring the oxidation of biomolecules, generating metabolites known as oxidative stress markers, through the lipid peroxidation process.[26] The major oxidative stress markers are MDA and TBARS.[21,27] Sankar *et al.* have reported a beneficial effect on lipid peroxidation of hypertensive individuals, with a reduction in TBARS greater than 50% after using sesame oil for 2 months; this effect on oxidative stress was greater with sesame oil than with groundnut and sunflower oils.[10]

This lipid peroxidation process comprises a chain reaction of polyunsaturated fatty acids of cell membranes that generate free radicals, changing membrane permeability, fluidity, and integrity. The formation of ROS is known to be a physiological process; however, in excess, ROS can cause cell damage, predisposing to certain diseases, such as systemic hypertension and dyslipidemias.[26] Studies on sesame oil and reduced levels of oxidative stress markers[10–12,14] have reported a decrease in lipid peroxidation, suggesting that such fact could have resulted from the large availability of antioxidants in sesame oil.[28,29] In these studies, were offered to participants 35 g of sesame oil, and there was no difference in the amount supplemented. As regards clinical intervention time, the studies that offered sesame oil for 2 months[10] had better results than studies with 45 days of suplementation.[11,12] These findings suggest that the intervention time is critical to the achievement of better results in the populations studied.

Table 3. Effect of the Intake of Sesame on Enzymatic and Nonenzymatic Antioxidants and Oxidative Stress Markers of Individuals with Systemic Hypertension

Sesame presentation	*Clinical trial (author, year)*	*Antioxidants*							*Oxidative stress markers*	
		Vitamin C	*Vitamin E*	*β-carotene*	*SOD*	*GSH*	*GPx*	*CAT*	*TBARS*	*MDA*
Sesame oil	Sankar *et al.* 2005[10]	↑87.50% After 2 months ($P<.05$)	↑90.12% After 2 months ($P<.05$)	↑112.99% After 2 months ($P<.05$)	↑88.02% After 2 months ($P<.05$)	↑36.04% After 2 months ($P<.05$)	↑32.23% After 2 months ($P<.05$)	↑40.74% After 2 months ($P<.05$)	↑52.38% After 2 months ($P<.05$)	NA
	Sankar *et al.* 2006[11]	↑80.77% After 45 days	↑32.24% After 45 days	↑63.79% After 45 days	↑42.30% After 45 days	↑31.65% After 45 days	NA	↑26.09% After 45 days	↓32.16% After 45 days	NA
	Sankar *et al.* 2006[12]	↑20% After 45 days ($P<.001$)	↑25% After 45 days ($P<.001$)	↑40% After 45 days ($P<.001$)	↑56.67% After 45 days ($P<.001$)	↑83.33% After 45 days ($P<.001$)	↓12.50% After 45 days ($P<.001$)	↑33.52% After 45 days ($P<.001$)	↓43.33% after 45 days ($P<.001$)	NA
Black sesame meal capsule	Wichistrainoi *et al.* 2011[13]	NA	↑29.93% After 4 weeks ($P<.01$)	NA	NA	NA	NA	NA	NA	↓33.33% After 4 weeks ($P<.05$)

NA, not assessed; SOD, superoxide dismutase; GSH, glutathione, GPx, glutathione peroxidase; CAT, catalase; TBARS, thiobarbituric acid reactive substance; MDA, malondialdehyde.

Table 4. Effect of the Intake of Sesame on Enzymatic and Nonenzymatic Antioxidants and Oxidative Stress Markers of Individuals with Hyperlipidemia and Diabetes Mellitus Type 2

Sesame presentation	*Clinical trial (author, year)*	*Antioxidants*							*Oxidative stress markers*
		Vitamin C	*Vitamin E*	*β-carotene*	*SOD*	*GSH*	*GPx*	*CAT*	*TBARS*
White sesame seed	Alipoor *et al.* 2012[15]	NA	NA	NA	↑7.75%After 2 months ($P<.05$)	NA	↑5.14%After 2 months ($P<.05$)	NA	↓34.48%After 2 months ($P<.05$)
Sesame flour	Chen *et al.* 2005[16]	NA	NA	NA	NA	NA	NA	NA	LDL TBARS ↓19.4% (after 4 weeks $P<.05$)
Sesame oil	Sankar *et al.*[14] 2011	35–40% ($P<.001$)	40–50% ($P<.001$)	40–50% ($P<.001$)	40–50% ($P<.001$)	25–30% ($P<.001$)	35–40% ($P<.001$)	40–45% ($P<.001$)	NA

NA, not assessed.

Studies on sesame oil and reduced levels of oxidative stressmarkers[10–12,14] have reported a decrease in lipid peroxidation, suggesting that such fact could have resulted from the large availability of antioxidants in sesame oil.

Sesame has natural antioxidants such as tocopherol, phenolic compounds and specific lignans like sesamin, sesamolin, and sesamol that seem to improve the oxidative stress.[4] Sesamol is an excellent antioxidant and free radical scavenger.[30] Study with rats showed that the sesame seed lignan was more effective than flaxseed lignan in reducing breast tumor growth.[31]

Vitamin E, lipid soluble and present in membranes, is one of the antioxidants obtained through food, inhibits lipid peroxidation,[23] and relates to cardiac protection and to a reduction in the incidence of ischemic heart diseases, as reported in a study with rats.[31]

The clinical trials selected in this review reported that sesame intake was effective in reducing oxidative stress, showing, after the sesame intervention, an increase in both enzymatic and nonenzymatic antioxidants of the antioxidant defense system. It is worth noting that the studies on hypertensive populations showed the highest impact on health,[10–13] sesame oil being more frequently effective than other sesame derivatives. Sesame oil was effective in increasing both enzymatic and nonenzymatic antioxidants and oxidative stress markers in hypertensive[10–12] and type 2 diabetic populations.[14]

Endothelial damage can be one of the causes of atherosclerosis,[32,33] being considered the early event in vascular disease.[34] Other studies have reported that sesamin and sesamol seem to have antioxidant effects, inhibiting lipid peroxidation, in addition to contributing to a decrease in the endothelial dysfunction originating from ROS formation.[4,35] Studies performed in hypertensive rats have shown that sesamin and sesamolin can potentiate the effects of vitamin E, improving endothelial dysfunction, and having a large positive impact on cardiovascular health.[29,36] In two studies, Sankar *et al.* have reported an increase in vitamin E levels in individuals with hypertension and diabetes using sesame oil, showing the effects of sesamin and sesamolin already discussed.[11,14]

It is worth noting that all studies with sesame oil[10–12,14] have reported a reduction in oxidative stress, mainly an increase in vitamin E levels, a higher impact being shown in a study by Sankar *et al.*, in which patients with type 2 diabetes received 35g of sesame oil per day for 2 months.[14]

Despite the positive results found by using sesame oil, the active components involved in the effect on the antioxidant potential remain unclear.[14] Sankar *et al.* have reported that the combination of a hypoglycemic agent with sesame oil could be safe and effective in controlling glycemia, suggesting its intake to fight oxidative stress in patients with diabetes.[14]

The study by Wichitsranoi *et al.* has shown the antioxidant capacity of black sesame meal by increasing vitamin E levels in individuals with prehypertension.[13] The study has also suggested the beneficial effects of black sesame meal, contributing to reduce endothelial dysfunction caused by ROS, thus improving hypertension control by increasing the vasodilating factor (nitric oxide).[13,37] The antioxidant potential of black sesame has been observed in a study with a chemical composition of whole grains of white and black sesame.[1] The study has reported that black sesame had a higher antioxidant potential than cream sesame, due to the presence of compounds that can donate hydrogen and neutralize the excess of ROS, showing greater efficacy in the ability to eliminate the ROS, DPPH (2,2-diphenyl-1-picrylhydrazyl), and to reduce Fe^{3+}. In addition, black sesame had a larger number of phenolic compounds than white sesame.[1] In addition, black sesame was effective in reducing MDA levels,[13] considered a potential biomarker of oxidative damage.[38]

In conclusion, despite the limitations and biases of this systematic review, the studies assessed showed that sesame could have a significant effect on oxidative stress and the antioxidant defense system, being considered a food with an important antioxidant function in the different populations studied (individuals with dyslipidemia, diabetes, and hypertension), as well as in its different presentations (oil, seed flour, and capsule). However, better-controlled studies still lack to assess the positive effects on different populations.

There are few clinical trials assessing the effect of sesame on oxidative stress. The studies included in this review, mainly those with sesame oil and black sesame meal capsules administered to hypertensive and prehypertensive populations, respectively, showed an increase in enzymatic (SOD, GSH, GPx, and CAT) and nonenzymatic antioxidants (vitamin C, vitamin E, and beta-carotene), as well as a reduction in oxidative stress markers (TBARS and MDA).

Although several studies have reported that the exact mechanisms of oxidative stress reduction remain to be fully explained, this review showed that sesame can have a significant positive impact on the health of different populations.

ACKNOWLEDGMENTS

The authors thank Eliana Rosa da Fonseca for her support in this study. This article received support in the form of grants from FAPERJ, CAPES, and FAPERJ–APQ1.

AUTHOR DISCLOSURE STATEMENT

The authors declare no conflicts of interest.

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