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Effects of culinary herbs and spices on obesity: A systematic literature review of clinical trials

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ABSTRACT

The aim of this article was to systematically review literature on clinical trials investigating the effects of culinary herbs and spices on obesity in adults. Relevant articles were searched through the electronic databases using predefined search terms. Thirty commonly used herbs and spices for weight loss were selected based on the literature. Out of 33 intervention studies that were eligible for inclusion in the review, 24 studies reported statistically significant ($P < 0.05$) reductions in obesity indices either compared to baseline or to the placebo. Overall, eight herbs/spices were reported to be beneficial in regards to obesity in the eligible literature including basil (on BW and BMI), cardamom (on BW, BMI and WC), cinnamon (on BW, BMI, BFP and WC), coriander (on BMI), garlic (on BMI and WC), ginger (on BW, BMI, WC and HC), nigella (on BW, BMI, WC, BFP and HC) and turmeric (on BW, BMI, BFP and WC).

1. Background

Obesity is a chronic and serious disease that has emerged as a global epidemic in both developed and developing countries (Obesity, 2020). Obesity can be simply defined as a condition of abnormal or excessive fat accumulation that affects health adversely and may quantitatively be defined by a body mass index (BMI) greater than or equal to 30 (for adults) (WHO, 2020). BMI is the metric or the formula that is commonly used at present to delineate the anthropometric (height and weight) characteristics in adults and to assess obesity. The weight in kilograms divided by the square of the height in metres (kg/m^2) is termed as BMI (Obesity, 2020). According to WHO, the risk of comorbidities with respect to BMI is increased when 25.00–29.99; severe when 35.00–39.99 and very severe risk exists if the BMI is greater than or equal to 40 (Obesity, 2020). Increased BMI is a major risk factor for many non-communicable diseases including: type 2 diabetes, hypertension, coronary heart disease, stroke, osteoarthritis, gallbladder disease and some cancers (especially hormonally related cancers and large - bowel cancers). In addition, there are several other health problems associated with obesity such as respiratory difficulties, infertility, chronic musculoskeletal problems, skin problems and psychosocial problems (Obesity, 2020; WHO, 2020). Global obesity rates have risen dramatically and it has become a pressing issue and a significant public health concern. 603.7 million adults were obese in 2015 and the prevalence of obesity has doubled in more than 70 countries since 1980 with high BMI accounting for 4.0 million deaths worldwide (Afshin et al., 2017). More than 1.9 billion adults, 18 years and older, were overweight in 2016. Of these, over 650 million were people with obesity. In Australia, two in three (67%) adults were overweight or obese in 2017–18, out of which 31% were obese and in the year 2017–18, one in

Abbreviations: BW, Body Weight; BMI, Body Mass Index; HC, Hip Circumference; WC, Waist Circumference; WHR, Waist to Hip Ratio; BFP, Body Fat Percentage; SLM, Soft Lean Mass; LBM, Lean Body Mass; G, Grams; MG, Milligrams; KG, Kilograms; OB, Ocimum basilicum; PP, Plantago psyllium; M, Metres; Cms, Centimetres; BFM, Body Fat Mass; TBF, Total Body Fat; TUR, Turmeric; CHI, Chicory; GP, Garlic Powder; CSP, Coriander Seed Powder; RT, Resistance Training; GG, Ginger Group; PG, Placebo Group; CINAHL, Cumulative Index for Nursing and Allied Health Literature; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

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four children and adolescents aged 2–17 were overweight or obese (Overweight, 2020). All American adults are predicted to become overweight or obese by 2048 and costs could range from 860.7 to 956.9 billion US dollars, accounting for 1 in every 6 dollars spent on health care by 2030 (Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008). According to a recent analysis (Ademi et al., 2010), as obese patients use more cardiovascular drugs than non-obese patients, a person with a BMI $\geq$ 30 kg/m^2 is likely to spend approximately 50 AUD more in pharmaceutical costs per year than a person with a BMI $<$ 30 kg/m^2, independent of other risk factors (Ademi et al., 2010).

The four key strategies involved in obesity management are: prevention of weight gain; promotion of weight maintenance; management of obesity comorbidities and promotion of weight loss (Obesity, 2020). There are limited clinical treatment options available at present for persons with obesity who are trying to lose weight (Obesity drug outcome measures, 2020). Surgery, which is an invasive intervention seems to be effective for some people with severe obesity and not all for others (Obesity drug outcome measures, 2020). Postoperative anastomotic fistula, infection, deep vein thrombosis and long-term complications such as malnutrition and anaemia are the common surgical complications (Ikramuddin et al., 2016; Park & Kim, 2016). Prescription medicines currently available for obesity treatment include: Phentermine, Tetrahydrolipostatin, Ephedrine and Caffeine (Obesity, 2020). However, weight loss medication comes with its own set of side effects (Obesity drug outcome measures, 2020). Therefore, FDA evaluators and advisors are cautious over the approval of new obesity drug (Obesity drug outcome measures, 2020). Obesity is preventable (WHO, 2020) and the major modifiable factors underlying excessive weight gain are dietary factors and physical activity patterns that, if corrected, can prevent obesity (Obesity, 2020). A recent report (Obesity drug outcome measures, 2020) suggests there is a great need for additional treatment options for use in conjunction with lifestyle interventions, according to clinicians and patients (Obesity drug outcome measures, 2020).

Taking into account the shortcomings of western medicine (conventional medicine), a nutritional based approach and dietary constituents with anti-obesity potential could be considered to tackle obesity. Herbs and spices have both culinary and medicinal uses with a traditional history (Opara & Chohan, 2014). Culinary herbs and spices are significant dietary contributors of polyphenols and exert antioxidant and anti-inflammatory effects (Opara & Chohan, 2014). Although there is limited data available on the weight loss effects of culinary herbs and spices, there is anecdotal evidence of their potential value. Hence, more research is required to evaluate the efficacy of herbs and spices on obesity.

Therefore, the aim of this review was to systematically review literature on clinical trials investigating the effects of culinary herbs and spices in natural dried or fresh form on obesity in adults when consumed as a supplement and not as part of regular dietary intake.

2. Methods

This review protocol was registered with Prospero, the international prospective register of systematic reviews on 12th July 2020 and the registration number is CRD42020189666. (https://www.crd.york.ac.uk/prospero/). The protocol of this review was based on the guidelines of the PRISMA framework or Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). (*Appendix 1*)

2.1. Selection of herbs and spices

Thirty herbs and spices commonly used in household cooking were selected for inclusion in this review. These herbs and spices included: anise, basil, black pepper, caraway, cardamom, chili pepper, cinnamon, clove, coriander, cumin, dill, fennel, fenugreek, garlic, ginger, hibiscus, lemongrass, marjoram, nigella, nutmeg, oregano, parsley, peppermint, rosemary, saffron, sage, spearmint, tarragon, thyme and turmeric

Table 1
List of herbs with their botanical names and part used -

Sl. No.	Common name of the herb/ spice	Botanical name(s)	Part used	Herb/ Spice
1	Anise	Pimpinella anisum	Fruit	Spice
2	Basil	Ocimum basilicum	Leaf	Herb
3	Black pepper	Piper nigrum	Fruit	Spice
4	Caraway	Carum carvi	Fruit	Spice
5	Cardamom	Elettaria cardamomum	Seed/Fruit	Spice
6	Chili pepper	Capsicum annuum, Capsicum baccatum, Capsicum chinense, Capsicum frutescens, Capsicum pubescens	Fruit	Spice
7	Cinnamon	Cinnamomum zeylanicum (syn. Cinnamomum verum)	Inner bark	Spice
8	Clove	Syzygium aromaticum	Flower bud	Spice
9	Coriander	Coriandrum sativum	Leaf/Fruit	Herb/ Spice
10	Cumin	Cuminum cyminum	Fruit	Spice
11	Dill	Anethum graveolens	Leaf/Fruit	Herb/ Spice
12	Fennel	Foeniculum vulgare	Fruit	Spice
13	Fenugreek	Trigonella foenum - graecum	Leaf/Seed	Herb/ spice
14	Garlic	Allium sativum	Bulb	Spice
15	Ginger	Zingiber officinale	Rhizome	Spice
16	Hibiscus	Hibiscus sabdariffa	Flower	Herb
17	Lemongrass	Cymbopogon citratus	Leaf	Herb
18	Marjoram	Origanum majorana	Leaf	Herb
19	Nigella	Nigella sativa	Seed	Spice
20	Nutmeg	Myristica fragrans	Seed without shell	Spice
21	Oregano	Origanum vulgare	Leaf	Herb
22	Parsley	Petroselinum crispum	Leaf	Herb
23	Peppermint	Mentha × piperita	Leaf	Herb
24	Rosemary	Rosmarinus officinalis	Leaf	Herb
25	Saffron	Crocus sativus	Stigma (parts of pistil)	Spice
26	Sage	Salvia officinalis	Leaf	Herb
27	Spearmint	Mentha spicata	Leaf	Herb
28	Tarragon	Artemisia dracunculus	Leaf	Herb
29	Thyme	Thymus vulgaris	Leaf	Herb
30	Turmeric	Curcuma longa	Rhizome	Spice

[Table 1 - adapted from Vázquez-Fresno et al. (2019) and European Spice Association (ESA) (2019). Out of 30, 25 herbs and spices were selected based on the reports by Vázquez-Fresno et al. (2019) on the estimated consumption volume in North America and Europe and an additional five culinary herbs and spices (cardamom, coriander, garlic, hibiscus and nigella) that are commonly used by people for weight loss were also included for the review based on previous reviews which suggested these herbs and spices to have some anti-obesity effects (Hasani-Ranjbar, Jouyandeh, & Abdollahi, 2013; Jungbauer & Medjakovic, 2012; Mofrad, Milajerdi, Koohdani, Surkan, & Azadbakht, 2019; Mohtashami & Entezari, 2016; Mousavi et al., 2018; Sheba & Ilakkia, 2016; Shekarchizadeh-Esfahani, Arab, Ghaedi, Hadi, & Jalili, 2020).

2.2. Primary literature search strategy

Scientific literature was searched across five databases: PubMed, Ovid, Scopus, Cochrane and CINAHL, using a combination of grouped search terms. The search terms were finalized by three reviewers.

The following key terms were used in the search:

"anise" OR "Pimpinella anisum" OR "basil" OR "Ocimum basilicum" OR "black pepper" OR "Piper nigrum" OR "caraway" OR "Carum carvi" OR "chili pepper" OR "Capsicum annuum" OR "Capsicum baccatum" OR "Capsicum chinense" OR "Capsicum frutescens" OR "Capsicum pubescens" OR "cinnamon" OR

"Cinnamomum" OR "clove" OR "Syzygium aromaticum" OR "cumin" OR "Cuminum cyminum" OR "turmeric" OR "Curcuma longa" OR "dill" OR "Anethum graveolens" OR "fennel" OR "Foeniculum vulgare" OR "fenugreek" OR "Trigonella foenum-graecum" OR "ginger" OR "Zingiber officinale" OR "lemon-grass" OR "Cymbopogon" OR "marjoram" OR "Origanum majorana" OR "nutmeg" OR "Myristica fragrans" OR "oregano" OR "Origanum vulgare" OR "parsley" OR "Petroselinum crispum" OR "peppermint" OR "Mentha × piperita" OR "rose-mary" OR "Rosmarinus officinalis" OR "saffron" OR "Crocus sativus" OR "sage" OR "Salvia officinalis" OR "spearmint" OR "Mentha spicata" OR "tarragon" OR "Artemisia dracunculus" OR "thyme" OR "Thymus vulgaris" OR "Cardamom" OR "Elet-taria cardamomum" OR "Nigella" OR "Nigella sativa" OR "Garlic" OR "Allium sativum" OR "Hibiscus" OR "Hibiscus sabdariffa" OR "Coriander" OR "Coriandrum sativum" AND (obesity) or (adiposity) or ("body fat") or ("body composition") or ("body mass index") or ("weight loss") or ("bmi") AND "clinical trial*" OR "clinical study*" OR "randomized controlled trial*" OR "controlled clinical trial*"

The key terms used in this search strategy included both common names and botanical names for specific herbs and spices. The default search fields for each of the databases were [All Fields] for PubMed and Ovid, [Article Title/ Abstract/ Keywords] for Scopus, [all text] for Cochrane and [Expanders-apply equivalent subjects] for CINAHL respectively.

The literature search was limited to full-text papers written in the English language, with studies conducted in humans only and no restrictions being applied to the publication dates. The last search was conducted on September 23rd, 2019. Initially, articles were screened based on their titles and abstracts. If found eligible then full text screening was conducted. The articles were deemed eligible based on the inclusion and exclusion criteria mentioned below and the eligibility of the included articles was evaluated in Covidence by two researchers independently after importing all articles into Covidence.

2.3. Inclusion criteria

Papers written in English and published in full text were included in this review. Human studies with an intervention exploring the effect of natural dried or fresh forms of a culinary herb or spice on obesity indices on adults (18 years or older) were included in the review. Studies that investigated a combination of herbs were only considered if the intervention had individual arms for each of the herbs or spices and hence provided individual results.

2.4. Exclusion criteria

Papers were excluded if they were based on *in vitro* or animal studies, if the intervention study used the herb or spice in other forms such as extracts, oils, teas, beverages and juices, if the intervention was delivered with adjuvants, if it was a dual intervention without indicating the results for herb/spice group separately, if intervention included herbs/spices with any other ingredient that was not a herb or spice, (for example soybean bread fortified with turmeric or ginger). Studies on pregnant or breastfeeding women were excluded due to variation in obesity indices associated with these life stages.

2.5. PICO for systematic literature review

As shown below in Table 2, the participants in the included studies were adults (not pregnant and not breastfeeding) and these studies consisted of human intervention studies using herbs or spices in natural dried or fresh form. The comparisons of outcomes were made to the control or placebo group in these studies and the outcomes were based on the obesity indices BW, BMI, BFP, WC and HC.

Table 2
PICO.

Criteria	Description
Participants	Adults, not pregnant, not breastfeeding
Intervention (s)	Human intervention studies using herbs or spices in natural dried or fresh form
Comparison (s)	Comparison to the control or placebo group
Outcome(s)	Obesity indices including BW, BMI, BFP, WC and HC

2.6. Data extraction

After the identification of eligible papers, the following data were extracted from the included studies based on the predefined form: first author's name, publication year, country, study design, inclusion criteria, exclusion criteria, sample size, intervention dosage and form, placebo, duration of the study and results. Microsoft Excel was used to collate the extracted data.

2.7. Risk of bias in individual studies

The quality and risk of bias for each of the included studies were assessed using ADA quality criteria checklist for primary research (Academy of Nutrition and Dietetics) which consists of 14 questions. The study was eligible for designation with a (+) positive - if it had clearly addressed the issues of inclusion/exclusion, bias, generalizability, and data collection and analysis, a (−) negative was designated if these issues were not adequately addressed and (∅) neutral - if the report was neither exceptionally strong nor exceptionally weak (American Dietetic Association, 2008). None of the articles were excluded based on the scoring outcomes.

2.8. Summary measures

The effect of supplementation with culinary herbs or spices was examined on the following outcomes: BW (kg); BMI (kg/m^2); WC (cm); HC (cm); BF (%). A 'P' value < 0.05 was considered statistically significant.

2.9. Categorization of outcomes based on study results

Based on the final study results, the studies were categorized into two groups based on their impact on anthropometric parameters when compared to baseline or placebo group (Fig. 1):

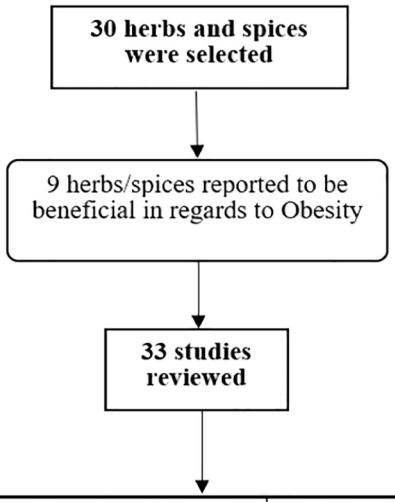
1. Significant (statistically) - Studies that showed a significant impact on obesity indices.
2. Non Significant (statistically) - Studies that had little or no impact on obesity indices.

3. Results

3.1. Search results and study selection

A total of 2318 studies were retrieved and imported from the electronic databases into Covidence where duplicates were removed and each of the studies were assessed on the above inclusion and exclusion criteria. 1791 studies were obtained after removing the duplicates.

Initially, the articles were screened as per the titles and abstracts followed by screening of the retrieved full text. Articles were included according to the inclusion and exclusion criteria and reasons for exclusion were recorded for the excluded articles. 1713 studies were excluded and the remaining 78 studies were included for the full text screening.



Herbs/Spices	Total number of studies	Significant result	Non-Significant result
Basil	1	1	0
Cardamom	3	2	1
Cinnamon	8	6	2
Fenugreek	1	0	1
Coriander and Garlic	1	1	0
Garlic	1	1	0
Ginger	7	4	3
Nigella	6	4	2
Turmeric	4	4	0
Nigella and Turmeric	1	1	0

Fig. 1. Categorization of the study results.

Out of 78 papers included for full-text screening, 45 studies were further excluded based on the exclusion criteria. The conflicts were resolved by two researchers and 33 final articles were selected to be included in this systematic review (Fig. 2).

3.2. *Fig. 2 – Search result flow chart showing number of studies extracted from various database*

After assessing the retrieved literature on the inclusion and exclusion criteria, 33 papers were identified as suitable for consideration in the current review (Adab et al., 2019; Aghasi et al., 2019; Akbarian, Asgary, Feizi, Iraj, & Askari, 2016; Akilen, Tsiami, Devendra, & Robinson, 2010; Amin, Islam, Anila, & Gilani, 2015; Atashak, Peeri, Azarbayjani, Stannard, & Haghighi, 2011; Atashak, Peeri, Jafari, & Azarbayjani, 2011; Badar et al., 2017; Borzoei, Rafraf, & Asghari-Jafarabadi, 2018; Choudhary, Jani, & Sharma, 2018; Daneshi-Maskooni et al., 2018; Datau et al., 2010; Ebrahimzadeh Attari et al., 2015, 2016; El Gayar, Aboromia, Ibrahim, & Abdel Hafiz, 2019; Fatemeh et al., 2017; Fatima, Niaz, Suhail, & Murad, 2018; Gupta Jain, Puri, Misra, Gulati, & Mani, 2017; Hajimonfarednejad et al., 2018; Hussain, Tunio, Akhtar, & Shaikh, 2017; Mirfeizi et al., 2016; Mohammadzadeh Honarvar et al., 2019; Navekar, Rafraf, Ghaffari, Asghari-Jafarabadi, & Khoshbaten, 2017; Qidwai, Hamza, Qureshi, & Gilani, 2009; Sharma, Sharma, Agrawal, Agrawal, & Singhal, 2012; Vafa et al., 2012; Yousefi et al., 2017; Zare, Nadjarzadeh, Zarshenas, Shams, & Heydari, 2019; Zeb et al., 2018). Two of the 33 studies had investigated a combination of herbs but also provided individual herb or spice results (Amin et al., 2015; Zeb et al., 2018). After considering this, numbers of eligible studies for each herb and spice included: one study on basil, three on cardamom, eight on cinnamon, one on coriander, one on fenugreek, two on garlic, seven on ginger, seven on nigella and five on turmeric. No eligible studies were found for remaining herbs and spices including: anise, black pepper, caraway, chili pepper, clove, cumin, dill, fennel, hibiscus, lemongrass, marjoram, nutmeg, oregano, parsley, peppermint, spearmint, rosemary, saffron, sage, tarragon and thyme.

24 of the 33 studies showed significant reductions in obesity indices and included the herbs/spices – basil (one of one study), cardamom (two of three studies), cinnamon (six of eight studies), coriander and garlic (one combined with individual arms), garlic (one of one study), ginger (four of seven studies), nigella (four of six studies), turmeric (four of four studies) and nigella and turmeric (a combined study with individual arms).

3.3. *Study characteristics*

Table 3 displays the overall characteristics of the studies included in the review. Selected studies were published between 2009 and 2019.

3.4. *Location and sample size*

Geographic locations included Iran (n = 21) (22,23,24,25,27,29,30,32,33,34,37,38,40,42,43,47,48,50,51,52,53], UK (n = 1) (Akilen et al., 2010), Pakistan (n = 5) (21,36,41,45,49], India (n = 3) (26,28,35], Egypt (n = 1) (El Gayar et al., 2019), Saudi (n = 1) (Badar et al., 2017), Indonesia (n = 1) (Datau et al., 2010). There were 33 articles in the final analysis with the sample sizes ranging from 32 to 250, with a total of 2655 participants and targeted adults aged between 18 and 80 years. Five studies recruited only men (Amin et al., 2015;

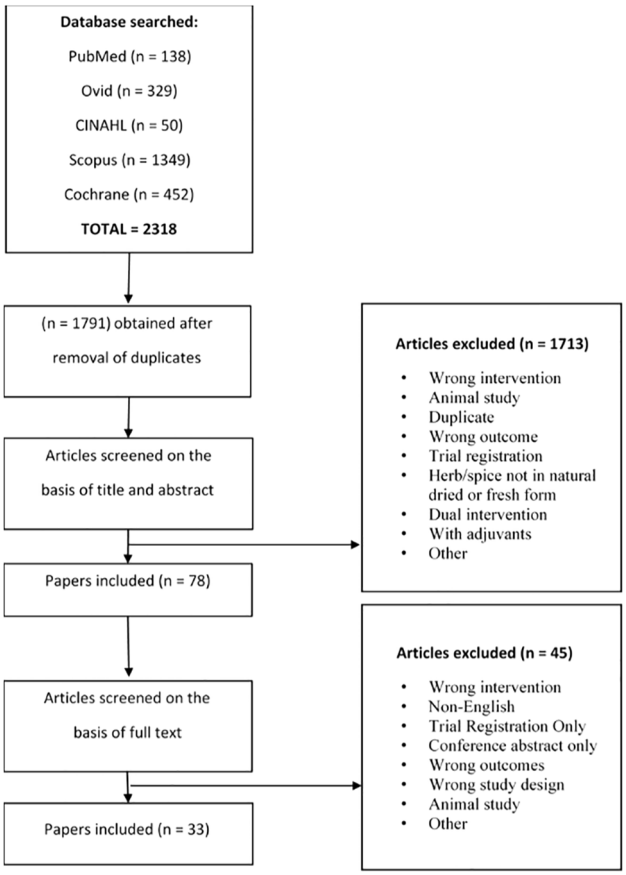


Fig. 2. Search result flow chart showing number of studies extracted from various database.

Atashak et al., 2011a, 2011b; Datau et al., 2010; Sharma et al., 2012) and four studies were done on women (Borzoei et al., 2018; Ebrahimzadeh Attari et al., 2015, 2016; Hajimonfarednejad et al., 2018) and the remainder of the studies recruited both men and women.

3.5. Study designs

All 33 studies had different study designs including single blind randomized four arm parallel trial (Akbarian et al., 2016), single blind randomized placebo controlled clinical trial (El Gayar et al., 2019; Fatima et al., 2018; Zeb et al., 2018), single blind non randomized clinical trial (Badar et al., 2017), double blind randomized controlled trials (n = 21) (Adab et al., 2019; Amin et al., 2015; Atashak et al., 2011a, 2011b; Borzoei et al., 2018; Daneshi-Maskooni et al., 2018; Ebrahimzadeh Attari et al., 2015, 2016; Fatemeh et al., 2017; Gupta Jain et al., 2017; Hajimonfarednejad et al., 2018; Mohammadzadeh Honarvar et al., 2019; Navekar et al., 2017; Qidwai et al., 2009; Sharma et al., 2012; Vafa et al., 2012; Yousefi et al., 2017), double blind randomized placebo controlled parallel trial (Aghasi et al., 2019), double blind randomized placebo controlled clinical trial with two parallel groups (Akilen et al., 2010), triple blind placebo controlled randomized clinical trial using a parallel design (Zare et al., 2019), triple blind randomized controlled trial (Mirfeizi et al., 2016), random study (Choudhary et al., 2018), randomized clinical trial (Hussain et al., 2017) and an experimental clinical test double blinded with placebo control, pre-test and post-test design (randomly divided) (Datau et al., 2010).

3.6. Intervention form and dosage

Basil (Plantago psyllium and Ocimum basilicum) was given as an intervention with a dose of 10 g/day (Akbarian et al., 2016); cardamom was used in capsule form containing whole green cardamom with a dose of 3 g/day with meal (Aghasi et al., 2019; Daneshi-Maskooni et al., 2018; Fatemeh et al., 2017), cinnamon in the form of capsule having cinnamon bark powder with a dose of 1 g/day (Mirfeizi et al., 2016; Zare et al., 2019), 1.5 g/day (Borzoei et al., 2018; Hajimonfarednejad et al., 2018), 2 g/day (Akilen et al., 2010), 3 g/day (Gupta Jain et al., 2017; Sharma et al., 2012; Vafa et al., 2012) and 6 g/day (Sharma et al., 2012); and fenugreek as seed powder with 8 g/day (Yousefi et al., 2017). The study investigating garlic used a dosage of 100 mg/kg body weight of crushed raw garlic two times per day (Choudhary et al., 2018) and the study investigating garlic and coriander together used 2 g garlic powder and 2 g coriander seed powder per day (Zeb et al., 2018). The studies that investigated ginger used ginger rhizome powder either in tablet form with 2 g/day (Ebrahimzadeh Attari, Asghari Jafarabadi, Zemestani, & Ostadrahimi, 2015; Ebrahimzadeh Attari, Ostadrahimi, Asghari Jafarabadi, Mehralizadeh, & Mahluji, 2016), capsule form with 1.8 g/day (El Gayar et al., 2019) or 4 g/day (Atashak et al., 2011a, 2011b) or 2 g/day (Mohammadzadeh Honarvar et al., 2019) and ginger's pasted powder of 5 g/day (Fatima et al., 2018). Nigella seeds (Badar et al., 2017) or seed powder (Farhangi, Dehghan, & Tajmiri, 2018; Farhangi, Dehghan, Tajmiri, & Abbasi, 2016; Hussain et al., 2017; Qidwai et al., 2009) was used either as is or in capsule form with a dose of 2 g/day (Badar et al., 2017; Farhangi et al., 2016, 2018; Hussain et al., 2017; Qidwai et al., 2009) or 3 g/day (Datau et al., 2010). There was a study that assessed the effect of turmeric and nigella together that used 1.5 g black seeds per day and 2.4 g turmeric per day (Amin et al., 2015). Finally, the studies pertaining to turmeric intervention used rhizome of turmeric dried and grounded into a powder or crushed (Ghaffari et al., 2019; Ghaffari, Rafraf, Navekar, & Asghari-Jafarabadi, 2018) and delivered in the form of a capsule, with 2100 mg/day (Adab et al., 2019), or 3 g/day (Ghaffari et al., 2018, 2019; Navekar et al., 2017).

3.7. Intervention period

The duration of the intervention varied from 4 weeks to one year. One study had an intervention period of 4 weeks (Choudhary et al., 2018), one study had an intervention period of 6 weeks (Qidwai et al., 2009), eight studies had an intervention period of 8 weeks (Adab et al., 2019; Amin et al., 2015; Borzoei et al., 2018; El Gayar et al., 2019; Farhangi et al., 2016, 2018; Vafa et al., 2012; Yousefi et al., 2017), four studies had an intervention period of 10 weeks (Aghasi et al., 2019; Atashak et al., 2011a, 2011b; Mohammadzadeh Honarvar et al., 2019), eight studies had an intervention period of 12 weeks: (Akbarian et al., 2016; Akilen et al., 2010; Ebrahimzadeh Attari et al., 2015, 2016; Hajimonfarednejad et al., 2018; Navekar et al., 2017), another one for 16 weeks (Gupta Jain et al., 2017), one study took the intervention for 60 days (Zeb et al., 2018), one study had an intervention period of 2 months (Fatemeh et al., 2017), seven studies had an intervention period of 3 months (Daneshi-Maskooni et al., 2018; Datau et al., 2010; Fatima et al., 2018; Hussain et al., 2017; Mirfeizi et al., 2016; Sharma et al., 2012; Zare et al., 2019) and the other study had an intervention period of 1 year (Badar et al., 2017).

3.8. Risk of bias within studies

The quality assessment was done using the ADA quality checklist (American Dietetic Association, 2008). Out of 33 eligible studies, 31 studies were rated positive while the other two studies (Badar et al., 2017; Choudhary et al., 2018) received a neutral rating which indicates that the studies were neither exceptionally strong nor exceptionally weak. (*Appendix 2*). The main source of bias for these two studies was the study design, method of assigning subjects/patients to groups, not properly blinding and lack of description regarding the intervention regimen and outcomes.

Table 3
displays the overall characteristics of the studies included in the review.

Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
Evaluate the clinical efficacy of the co-administration of turmeric and black seeds (Kalonji) in metabolic syndrome **21**	**TURMERIC + NIGELLA**	Faridah amin, 2015, Pakistan	Double - blind randomized controlled trial 250	• Male residents of Hijrat colony • WC > 90 cm along with a total of three or more features of MetS. • Not on any regular medications. • Pre-diabetes (FBG -between 100 and 125 mg/dl) • LDL -cholesterol 130 mg/dl − 160 mg/dl and/or triglyceride level of 150–200 mg/dl) or • Pre-hypertension (systolic BP of 130–139 mmHg and a diastolic BP of 85–89 mmHg)	• Patients with known diabetes, hypertension or coronary heart disease • Patients taking herbal supplements and patients on medications for hyperlipidemia or obesity. • Debilitated patients or on regular medications for chronic diseases like steroids, immune-suppressants and warfarin.	Black seeds powder – 500 mg (1 + 1 + 1) = 1.5 g/day and Turmeric rhizome powder – 800 mg (1 + 1 + 1) = 2.4 g/day 8 weeks	Ispaghul husk	• At 4 weeks, compared to baseline, black seed and turmeric alone showed improvement in BMI, WC and BF%. • At 8 weeks, combination group with 60% dose of the individual herbs, showed an improvement in all parameters from baseline. • Combination group showed a significant reduction in HC (P = 0.001), BF% (P= 0.008), BW (P < 0.001), TG (P = 0.02) and CRP (P < 0.001) when compared to black seeds group.
To investigate the effect of Plantago psyllium and Ocimum basilicum seeds on anthropometric measures in non alcoholic fatty liver patients - A comparative study **22**	**BASIL**	Shahab-Aldin Akbarian, 2016, Iran	Four - arm parallel randomized single - blind trial 120	• Men and women •Age - between 27 and 74 years with fatty liver	• Individuals with steady using of fibre supplements, insulin injection and drugs such as corticosteroid, anticonvulsant and antiepileptic. • Pregnant, lactating, hemochromato-sis and cirrhosis patients.	Seeds packed in 2.5 g pack. Because patients should pour the seeds into a glass of water, they were not blinded. OB 10 g/day; PP 10 g/day 12 weeks	–	• Compared to baseline, BW (P = 0.02), BMI (P = 0.01), and MBF (P = 0.04) in OB group were significantly reduced. • BW (P = 0.00), BMI (P = 0.01), SLM and LBM (P = 0.01) were lowered in PP group. • This study illustrates a 10 g increasing of PP, OB, or mix of them have no effects on weight, BMI, BFP, or SLM during 12 weeks when compared to placebo.
To investigate the beneficial effects of green cardamom on serum SIRT1, glycemic indices and triglyceride levels in patients with type 2 diabetes mellitus **23**	**CARDAMOM**	Mohadeseh Aghasi, 2019, Iran	In a parallel, double - blind randomized placebo controlled clinical trial 83	• Patients with T2DM • Aged between 30 and 60 years • BMI between 25 and 34.9 kg/m^2 • Haemoglobin A1c (HbA1c) value>7% that were treated with a stable dose of oral anti-diabetic drugs • Diagnosis of T2DM for at least 2 years	• Being on insulin therapy or need insulin based on expert opinion. • Pregnancy or lactating • Known disorders such as disorders that are related to the bowel function, severe hepatic, renal (dialysis), inflammatory and thyroid diseases. • Intake of some medications like warfarin, fibrates [peroxisome proliferator-activated receptor (PPAR-αligand)],	Cardamom seed powder, 3 g/ day; Each capsule contained 0.5 g of whole green cardamom powder 10 weeks	Rusk powder	• No significant differences in BMI and WC were observed between the two groups at the baseline. • There were no between group differences in BMI and WC after 10 weeks of intervention.

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Table 3 (*continued*)

Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
					thiazolidinediones (PPAR-γligand) and antidepressant agents. • Change in diet during the past 3 months. • Smoking or alcohol intake in the past month at least once a week. • Intake of herbals, antioxidant, multivitamin/ mineral supplements at least once a week in the past 3 months. • Changes in the type and dosage of hypoglycemic agents during the study. • If they consumed<90% of their supplements.			
Access whether green cardamom increases Sirtuin-1 and reduces inflammation in overweight or obese patients with non-alcoholic fatty liver disease **24**	**CARDAMOM**	Milad Daneshi-Maskooni,2018, Iran	Double - blind randomized placebo controlled clinical trial 87	• Having NAFLD • 30–60 years old • BMI − 25 ≤ 35 kg/m^2	• History of alcohol usage during the past 12 months. • Inability to cooperate. • Conditions influencing the liver. • Secondary NAFLD • Disability • Uncontrolled hypertension (>140/90 mmHg) • Pregnancy or lactation • Professional athlete • Intake of ursodeoxychol-ic acid, antihypertensi-ve, statins, probiotics, drugs interacting with cardamom, antioxidant, multivitamin - mineral supplements during the past 3 months • Weight loss in past 3 months • Taking<90% of the study's supplements	Whole green cardamom, two 500 mg capsules three times per day with meals 3 months	Toast flour	• Within cardamom group, BW, BMI decreased significantly (P < 0.05). • The decrease of weight and BMI were not significant in comparison with placebo.
To evaluate the effect of cardamom supplementation on anthropometric measurements in overweight and obese prediabetic women **25**	**CARDAMOM**	Yaghooblou Fatemeh, 2017, Iran	Double - blind randomized placebo controlled clinical trial 80	• FBS: 100–125 mg/dl • HbA1C: 5.7–6.4% • 2-h blood glucose: 140–199 mg/dl • Age: 30–70 years • Diagnosis duration of pre-diabetes at least 2 weeks and at most 2 months • BMI: 25–39.9 kg/ m^2 • Having at least one of the following criteria: 300 > TG	• BMI < 25 or ≥ 40 kg/m^2 • Following a specific diet for the previous 3 months • Being a professional athlete • Having allergy to cardamom • Pregnancy and lactation • Nutritional supplement and multi vitamin-mineral consumption at least two times a week in the last month	Whole green cardamom, 3 g/day 2 months	Rusk powder	• The cardamom supplementation significantly decreased WC values (P = 0.03). • There were no significant differences between intervention and control groups in mean weight and BMI.

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
				> 150 mg/dl, TC > 200 mg/dl, 160 > LDL - C > 100 mg/dl, HDL - C < 50 mg/dl • Willingness to participate in the study	• Medical history of GI ulcers, kidney or gall stones • Medical history of coronary heart diseases, cancer and multiple sclerosis • Consumption of blood lipid, glucose and blood pressure lowering drugs, hormonal, thyroid, nervous and heart diseases medications • Having blood pressure > 130/80 mmHg			
To investigate the effect of cinnamon supplementation on glycaemic control and lipid profile in type 2 diabetes mellitus **26**	**CINNAMON**	Pushpanjali Sharma, Shilpi Sharma, 2012, India	Double - blind randomized placebo controlled study 150	• Central obese men • Blood pressure has not exceeded hypertension stage I, normal or impaired fasting blood sugar	• Patients suffering from liver disease, arthritis pulmonary tuberculosis, malabsorption or alcoholism • Patients taking insulin, lipid lowering drugs, anti-hypertensive agents or weight reduction drugs • Consumption of non dietary cinnamon supplements • HbA1c < 6.0%	Cinnamon bark powder, 2 groups: 1st group, 1 gm cinnamon capsule after breakfast, lunch and dinner; total 3 gm/day and another group 2 gm capsule each time, total 6 gm/day. 3 months	–	• The mean BMI in both dose groups (3 gm and 6 gm) decreased slightly but no significant difference was found.
Access whether cinnamon improves metabolic factors without detectable effects on adiponectin in women with polycystic ovary syndrome **27**	**CINNAMON**	Azam Borzoei, 2018, Iran	Double - blind randomized controlled clinical trial 84	• 84 women with PCOS • Aged 20 to 38 years • BMI between 25 and 40 kg/m^2	• Thyroid disorders, hyper-prolactinemia, diabetes mellitus, pregnancy, lactation, liver or kidney diseases, Cushing syndrome, cardiovascular diseases, seizure, cerebro-vascular disorder and hypertension. • Use of medications such as insulin sensitizers, insulin, B -blockers, cholesterol-lowering drugs and dietary supplements • Smoking • Current treatment of infertility • Inhaled corticosteroid use • Following a specific diet • Consistent use of any culinary herbs and spices • Regular exercise (>2 weeks) • Allergic to cinnamon	Cinnamon bark powder, 3 cinnamon capsules (each one contained 500 mg cinnamon), 1.5 g/day 8 weeks	Wheat flour	• Significant difference was found in BW ($P < 0.05$) and BMI ($P = 0.002$) of subjects in cinnamon group after intervention compared to baseline values ($P < 0.05$). Changes in weight and BMI were not significant in control group. Changes in BMI were not significant between two groups at the end of the study.
To evaluate the effect of oral cinnamon intervention on metabolic profile and body	**CINNAMON**	Sonal Gupta Jain, 2017, India	Double - blind randomized control trial 116	• Abdominal obesity (WC: men > 90 cm; women > 80 cm) • High serum triglycerides (TGs	• Those suffering from uncontrolled hypertension (an average SBP ≥ 140 mmHg or DBP ≥ 90 mmHg)	Cinnamon bark powder, 3 g/day. 2 capsules three times/day	Wheat flour	• The cinnamon intervention resulted in a significantly higher decrease in BW (0.001), WC (P =

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
composition of Asian Indians with metabolic syndrome				≥ 150 mg/dL), low HDL - C (men < 40 mg/dL; women < 50 mg/ dL)	• Serum triglycerides > 400 mg/dL) •Hypo-thyroidism •Hyper-thyroidism	16 weeks		0.002), BMI (P = 0.001), WHR and BFP (P = 0.011) as compared to the placebo group.
28				• Dysglycemia (FBG ≥ 100 mg/dL) • Hypertension (≥130/≥ 85 mmHg) • Only subjects who were stable • If on medication for high blood pressure with no change in dosage over the past 3 months	• Suffering from other chronic diseases and metabolic complications such as CVD, diabetes, renal disease, myocardial infarction and other endocrinal disorders, any debilitating disease such as tuberculosis, HIV etc. • Those on medication of lipid lowering or hypo-glycaemic drugs			
To evaluate the effects of cinnamon consumption on glycaemic status, lipid profile and body composition in type 2 diabetic patients	**CINNAMON**	Mohammadreza Vafa, 2012, Iran	Double - blind randomized placebo controlled clinical trial	• Non insulin dependent type 2 diabetes	• Cholesterol > 240 mg/dl, triglycerides > 400 mg/dl	Cinnamon bark powder, each capsule contained 500 mg product. Two capsules at each main meal (breakfast, lunch and dinner) for eight weeks; 3 g/day	Wheat flour	• BW (P = 0.017) and BMI (P = 0.010) in both groups were significantly reduced after the intervention compared with baseline. • Fat body mass significantly reduced in cinnamon group (P = 0.047) but not in placebo group. • BMI decreased by 1.54% and fat body mass decreased by 1.36%). But these reductions were not significant compare to placebo group.
29			44	• Aged between 30 and 65 years • HbA1c between 6 and 8% • FBG levels between 126 and 160 mg/dl	• Smoking and alcohol consumption • Pregnancy and lactation • Allergic to cinnamon • Liver or renal or thyroid diseases • Haemolytic anaemia	8 weeks		
To investigate the efficacy of cinnamon in patients with type II diabetes mellitus: a randomized controlled clinical trial	**CINNAMON**	Roghayeh Zare, 2018, Iran	Triple - blind placebo controlled randomized clinical trial using a parallel design	• Patients with type II diabetes based on American Diabetes Association (ADA) criteria	• Allergic to cinnamon • Changed their treatment during the study	Cinnamon bark powder, 500 mg caps twice daily	Starch	• There was a significant decrease in BMI (P < 0.001), total body fat (P < 0.001) and visceral fat (P < 0.001) in cinnamon group.
30			140	• Age -between 30 and 80 years (male and female) • Lack of comorbid uncontrolled disease • BMI between 18.5 and 40 • Fasting plasma glucose between 126 and 250 mg/dl and only taking oral hypo-glycaemic agents for diabetes.	• Consumed<80% of the prescribed capsules.	3 months		• These changes were significantly more in the cinnamon group compared to those observed in the placebo group.
To access the glycated haemoglobin and blood pressure-lowering effect of cinnamon in multi-ethnic Type 2 diabetic patients in the UK	**CINNAMON**	R. Akilen, 2010, UK	Double - blind randomized placebo controlled clinical trial with two parallel groups	• 18 years of age or older • Diagnosed with Type 2 diabetes on two consecutive FPG measurements of>7 mmol/l and HbA1c ‡ 7%; being	• Patients treated with insulin therapy • Pregnant or lactating women • Already taking cinnamon or other herbal supplements with the potential use	Cinnamon bark powder, 2 g/day (500 mg × 4)	Starch	• At post-intervention, BW, WC and BMI in the cinnamon group were significantly (P < 0.05) low compared with baseline.
			58			12 weeks		

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
31				treated with oral hypo-glycaemic agents.	to control blood glucose levels • Patients with severe health conditions such as cardiovascular disease, liver disease, kidney disease and cancer.			• However, the changes in BW, BMI and WC in the cinnamon group were not significantly ($P > 0.05$) different from the placebo group.
To evaluate the Insulin resistance improvement by cinnamon powder in polycystic ovary syndrome **32**	**CINNAMON**	Mahdie Hajimonfarednejad, 2018, Iran	Double - blind randomized placebo controlled clinical trial 66	• Age:18–45 years meeting the Rotterdam Criteria for PCOS • Willingness to sign the informed consent • BMI - equal or>18	• Pregnancy or lactation • Being under treatment for infertility • Diagnosis of hyper -prolactinemia, thyroid disorders, hypertension, and diabetes mellitus. • Patients who were on insulin-sensitizing agents or hormonal treatment involving estrogen or progesterone or any drug inducing insulin resistance including corticosteroids within the past 3 months prior to the study • History of allergy to cinnamon or its by - products.	Cinnamon bark powder, The patients were instructed to use their prescribed medication (i.e., 500 mg cinnamon capsules or placebo) 3 times per day, after a meal with a standard treatment regimen (10 mg medroxy-progesterone tablet, from the 15th day of menstruation cycle for 10 days) 12 weeks	Starch + cinnamon	•Reduction in all anthropometric factors like BW, BMI, and WC. However, these changes were not statistically significant.
Investigate the effects of herbal medicines to control diabetes mellitus type 2 **33**	**CINNAMON**	Mani mirfeizi,2016, Iran	Triple - blinded randomized clinical trial 105	• Presence of T2DM, HbA1c > 7% • Fasting blood glucose (FBG) ≥ 140 mg/dL despite the use of commonly prescribed combinations of oral blood glucose-lowering agents (e.g. sulfonylurea derivatives, biguanides and/or thiazolidines [α-glucosidase inhibitors)	• The treatment of T2DM with insulin therapy with specific dietary and exercise regimens • The use of herbal medications • Smoking • Any alcohol consumption • Pregnancy or lactation • Allergies to cinnamon or Caucasian whortleberry • Serious pathology such as liver, renal, or thyroid disease.	Cinnamon bark powder, 1000 mg/day, 500 mg capsules twice per day 3 months	2nd group: Caucasian whortleberry, 3rd group: placebo	• Only BMI was significantly reduced in the cinnamon group compared with baseline ($P = 0.001$) and control group ($P = 0.02$). • The degree of weight loss was<5% – 10% total body weight.
To investigate the effects of fenugreek which is a therapeutic complement for patients with borderline hyperlipidaemia **34**	**FENUGREEK**	Yousefi, E, 2017, Iran	Double - blind randomised placebo controlled clinical trial 56	• Age – 18 to 65 years • One of the following factors: LDL > 135 mg and 200 mg/dl; triglyceride (TG) > 150 mg/dl	• Having underlying diseases such as diabetes, ischaemic heart disease (IHD), hypertension, metabolic syndrome, peripheral vascular disease or history of coronary artery disease • Patients who used anti - hyperlipidemic agents and/or steroids • Cigarette • Alcohol • Patients with LDL level ≥ 190 mg/dl	Fenugreek seed powder, 8 g sachet with lunch 8 weeks	Starch	• After 8 weeks, no significant difference in BMI when compared to baseline or placebo.

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
					• Patients who may undergo unpleasant complications during the study including headache, vertigo, nausea and fenugreek intolerance.			
To evaluate the efficacy of raw crushed garlic (Allium sativum L.) on components of metabolic syndrome **35**	**GARLIC**	Prema Ram Choudhary, 2018, India	Random study 40	• Age − 30 to 70 years • Newly diagnosed metabolic syndrome	• Patients with a history of malignancy • Alcoholism • Congestive cardiac failure and liver disease • Women who were pregnant • Using any medication (i.e., aspirin, metformin, steroid or non steroid)	Raw crushed garlic, 100 mg/ kg body weight, two times per day with standard diet. 4 weeks	–	• Abdominal obesity or WC significantly decreased ($P < 0.05$) after garlic consumption. • BMI levels decreased after garlic consumption, but these changes were not significant ($P > 0.05$).
To investigate the impact of garlic and coriander seed powder supplementation on body mass index, lipid profile and blood pressure of hyperlipidemic patients **36**	**GARLIC AND CORIANDER**	Falak Zeb, 2018, Pakistan	Single - blind randomized placebo controlled intervention 80	• Aged 40–80 years • Presence of hyperlipidaemia with CVDs • Total cholesterol > 200 mg/dl and serum triglycerides > 150 mg/dl	• Suffering from gastro - intestinal problems • Pregnant and lactating women	Garlic powder and coriander seed powder, GP, CSP, GP + CSP = 2 g/day. 60 days (includes 20 days of follow up period)	–	• All the supplements significantly ($P < 0.05$) influenced the BMI of the patients. • Among the supplements, GP had the highest influenced on BMI • All the parameters decreased with supplementation except HDL, which increased with the consumption of supplements.
To evaluate the changes of serum adipocytokines and body weight following Zingiber officinale supplementation in obese women **37**	**GINGER**	Vahideh Ebrahim-zadeh Attari, 2016, Iran	Double - blind randomized placebo controlled design 80	• Healthy obese women • Age: 18–45 years • BMI of 30–40 kg/ m^2	• Clinically diagnosed diabetes mellitus, cardiovascular disease, gallstone, hypo or hyper thyroidism • Deep depression • Pregnancy • Breast feeding • Menopause • Being on a weight-lowering diet • Taking medications that could influence weight • Smoking • Subjects with high physical activity • Taking nutritional supplements • Hyper-sensitive to ginger	Ginger rhizome powder made into tablet containing 1 g ginger powder in each, 2 tabs/day. 12 weeks	Corn starch	• Consumption of ginger for 12 weeks significantly reduced BMI ($P = 0.019$) as compared to the placebo. • BMI significantly decreased in ginger group ($P < 0.0001$).
To evaluate the effect of Zingiber officinale supplementation on obesity management with respect to the uncoupling protein 1 −3826A > G and ss3-adrenergic receptor	**GINGER**	Vahideh Ebrahim-zadeh Attari, 2015, Iran	Double - blind randomized placebo controlled clinical trial 80	• 80 eligible healthy obese women • Aged 18–45 years • Body mass index (BMI) of 30–40 kg/ m^2	• Clinically diagnosed diabetes mellitus, cardiovascular disease, gallstone, hypo or hyper thyroidism • Deep depression • Pregnancy • Breast feeding • Menopause	Ginger rhizome powder, tab of 1 g ginger powder in each, two 1 g tab/day. 12 weeks	Corn starch	• Significantly reduced the BW ($P = 0.023$), BMI ($P = 0.019$), WC ($P = 0.011$), HC ($P = 0.003$) and WHR ($P = 0.012$) as compared with the placebo, while there was no significant difference in the

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
Trp64Arg polymorphism **38**					• Being on a weight-lowering diet • Taking medications that could influence weight • Smoking • Subjects with high physical activity • Taking nutritional supplements • Hypersensitive to ginger			changes of body composition and total energy and macronutrients intake between groups. • However, body fat mass and fat free mass did not change by intervention.
To evaluate the effects of ginger powder supplementation on glycaemic status and lipid profile in newly diagnosed obese patients with type 2 diabetes mellitus **39**	**GINGER**	Mohamed Hesham El Gayar, 2019, Egypt	Single - blind randomized placebo controlled clinical trial 80	• Patients newly diagnosed with type 2 diabetes mellitus • HbA1c level < 9%, BMI $\geq$ 30 kg/m^2 • No pregnancy or lactation • No autoimmune disorder • No cardiac or renal diseases • No thyroid, chronic inflammatory diseases, or peptic ulcer • No regular consumption of ginger or other herbal drugs • No hyper-sensitivity to ginger • No consumption of lipid lowering drugs or oral contraceptive pills • No consumption of any supplements 2 months before starting the study, also received metformin as one 850-mg tablet twice a day with meals for a duration of 8 weeks.	• Diabetes duration>6 months • HbA1c level $\geq$ 9% • BMI < 30 kg/m^2 • Insulin therapy, any injectable or oral antidiabetic medication other than metformin • Any acute illnesses at the baseline or during the study • Smoking • Consumption of<80% of the capsules • Any sensitivity due to ginger consumption reported by the patient or noticed after the outset of the study • Consumption of vitamin, mineral or other nutritional supplements • Consumption of alcohol or narcotic drugs.	Ginger rhizome powder, three capsules daily; each capsule containing 600 mg of ginger powder (total daily dose of 1.8 g). 8 weeks	Wheat flour	• A highly significant statistical reduction in BMI (mean change in GG vs PG -0.54 ± 0.43 vs -0.03 ± 0.25 respectively, P < 0.001).
To investigate the effects of ginger supplementation and resistance training on lipid profiles and body composition in obese men **40**	**GINGER**	Sirvan Atashak, 2011, Iran	Double - blind randomized placebo controlled trial 32	• Men, BMI $\geq$ 30 • Aged 18 to 30 years • No participation in regular physical activity • No current chronic health problems • Non-smokers • No cardiovascular, metabolic or respiratory disease and • No consumption of any antilipidemic supplements or drugs	Not mentioned	Ginger rhizome powder, 4 capsules of ginger rhizome powder four times a day (Each capsule contained 250 mg of ginger root powder. 10 weeks	Maltodextrin	• In comparison with baseline values, BFP, fat mass, WC and WHR decreased in the groups GIRT and PLRT (P < 0.05) independently of GI and PL groups after 10 weeks. It remained unchanged in PL and GI groups.

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
				within the past 6 months.				
To evaluate if ginger pasted-powder prevents dyslipidaemia and body weight **41**	**GINGER**	Ajaz Fatima, 2018, Pakistan	Single - blind placebo controlled study 65	• Hyper-lipidemic (primary as well as secondary) patients • Age: 25–60 years.	• Chain smokers • Regular alcohol users • Patients suffering from any liver, kidney and gastro-intestinal illnesses	Ginger's pasted powder, 5 g/day 3 months	Grinded wheat	• BW reduction was non-significant when analysed statistically ($P > 0.05$).
To evaluate the obesity-related cardiovascular risk factors after long- term resistance training and ginger supplementation **42**	**GINGER**	Sirvan Atashak, 2011, Iran	Double - blind randomized placebo controlled trial 32	• Obese men BMI >= 30 kg/m^2 • Aged 18–30 years • No participation in regular physical activity • No current chronic health problems • Non smokers • No cardiovascular, metabolic or respiratory disease • No consumption of any antioxidant supplements or drugs within past 6 months	Not mentioned	Ginger rhizome powder, 4 capsules, 4 times a day, each capsule of 250 mg. 10 weeks	Maltodextrin	• In comparison with baseline values BFP, fat mass, WC and WHR decreased in the groups RTGI and RTPL ($P < 0.05$) independently of GI and PL groups after 10 weeks. • Mean BMI remained unchanged in all groups.
To investigate the effect of an oral ginger supplementation on NF-kappa B concentration in peripheral blood mononuclear cells and anthropomorphic data of patients with type 2 diabetes **43**	**GINGER**	Niyaz Mohammadzadeh Honarvar, 2019, Iran	Double - blind randomized placebo controlled clinical trial 48	• Suffering from type 2 diabetes for 1–10 years • Adults aged 30 – 60 years in both genders • BMI: 18.5–35 kg/m^2 • Not receiving insulin and treated with glucose lowering medications	• If they consume<90% of capsules in intervention and placebo groups • If they report any situation such as pregnancy, lactating • Alcohol consumption • Cigarette smoking • Insulin therapy •Hospitali-zation with any cause • Ginger consumption during the intervention • Change in medication type or dosage • Change in the diet and physical activity levels • Patients with type 2 diabetes	4 capsules of 500 mg of dried ginger powder (two with their lunch and two with the dinner). 10 weeks	Wheat powder	• Ginger supplement significantly decreased HC (107.07 ± 6.05–106.59 ± 5.98, $P = 0.027$). Also, affected BMI and WC ($P < 0.1$). • The difference between supplement and placebo groups was not statistically significant
To investigate the effect of Nigella sativa supplementation over a one-year period on lipid levels, blood pressure and heart rate in type-2 diabetic patients receiving oral hypoglycemic agents **44**	**NIGELLA** **NIGELLA**	Ahmed Badar, 2017, Saudi Arabia	Single - blind, non randomized clinical trial 57	• Poorly controlled type 2 diabetes (determined by two readings of HbA1c of>7% taken three months apart) • 18–60 years of age • Regular use of standardized oral medications [glibenclamide, metformin or rosiglitazone]	• HbA1c in excess of 9% • Insulin therapy • BMI in excess of 40 kg/m^2 • Triglyceride (TG) >400 mg/dL • Any other reason for deranged lipids • Major cardiovascular disease, hepatic disorder, renal disorder •Pregnancy/ lactation	Nigella sativa seeds, 2 g/day in 2 divided dosages; (Bio extract [Pvt] Ltd, Sri Lanka) were provided in the form of 500 mg oral capsules. 1 year	Activated charcoal	• BMI was not significantly different in any of the two groups, therefore the intergroup and intragroup differences were non-significant.

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
To evaluate the effects of Nigella sativa on various parameters in patients of non-alcoholic fatty liver disease **45**		Mazhar Hussain, 2017, Pakistan	Randomized controlled trial 70	• Age: 20 – 45 years • BMI $\geq$ 25 • Presence of fatty liver grading 0–3 on abdominal ultrasound • Mild to moderate elevation of amino-transferases level	• Positive test for HBsAg, Anti HCV and HIV • Hereditary defects of iron, copper and alpha-1 antitrypsin deficiency • Evidence of advanced liver disease in the form of very high level of amino-transferases and highly abnormal ultrasound • Secondary causes of NAFLD such as hypo-thyroidism, hypo-gonadism, short bowel syndrome, pancreato-duodenal resection • Drugs which cause fatty liver such as corticosteroid, antiviral (nucleoside analogue), tetracycline, methotrexate, tamoxifen and amiodarone • Patients who were taking any drug for NAFLD	Nigella seed powder, at a dose of 1 g twice a day. 3 months	Micro crystalline cellulose	• BW decreased significantly from 86 $\pm$ 13.8 to 76 $\pm$ 12.6 kg vs placebo 84.5 $\pm$ 14.4 to 82.8 $\pm$ 12.82 (P = 0.041). • There was notable reduction in BMI value from 29.06 $\pm$ 4.6 to 26.25 $\pm$ 6.2 kg/m^2 vs placebo 28.18 $\pm$ 3.8 to 27.67 $\pm$ 4.2 kg/m^2 (P = 0.012).
To investigate the efficacy of Nigella sativa on serum free testosterone and metabolic disturbances in central obese male **46**	**NIGELLA**	E.A. Datau, 2010, Indonesia	An experimental clinical test double blinded with placebo control, pre-test and post - test design (randomly divided) 39	• Central obese men • Blood pressure not exceeding hypertension stage I • Normal or impaired fasting blood sugar	• Those using drugs, supplement or traditional medicine • Alcohol consumption during the last 1 month • Doing moderate or severe intensity of sports • Having liver and or kidney disturbances (creatinine level>1.5 mg/dL, liver function (SGOT and or SGPT) three times more than normal, and reverse albumin/globulin ratio • Type 2 diabetes mellitus and or gouty arthritis • Blood pressure more than stage I • Refusing informed consent • Not following the procedures • Moved out of town or dying during study	Two capsules of 750 mg Nigella, twice daily. 3 months	Flour	• In the treatment group, complaints related to central obesity disappear in first week. • On comparison between both groups, we found a very significant reduction on BW (P = 0.000) and WC (P = 0.000).
To investigate if powdered black cumin seeds improves serum lipids, atherogenic index of plasma and modulates anthropometric features in	**NIGELLA**	Mahdieh Abbasalizad Farhangi, 2018, Iran	Double - blinded randomized placebo controlled trial 40	• Age: 20–50 years • Having Hashimoto's thyroiditis according to physician diagnosis	• Taking any nutritional supplements for at least 3 months prior participation or during the trial • Any history of autoimmune disease, cardiovascular	Nigella seed powder, 2 g/day in two divided dosages. 8 weeks	Starch	• Treatment with Nigella sativa significantly reduced BW (P = 0.004) and BMI (P = 0.002) when compared to placebo.

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Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
patients with Hashimoto's thyroiditis **47**					events, other thyroid abnormalities including Grave's disease • Being pregnant or lactating • Any history of thyroid surgeries • Being on any dietary regimens during and 3 months before recruitment in the trial			
The evaluate the effects of Nigella sativa on thyroid function, serum Vascular Endothelial Growth Factor (VEGF) − 1, Nesfatin-1 and anthropometric features in patients with Hashimoto's thyroiditis **48**	**NIGELLA**	Mahdieh Abbasalizad Farhangi, 2016, Iran	Double - blinded randomized placebo controlled trial 40	• Age: 20–50 years • Having Hashimoto's thyroiditis according to physician diagnosis	• Taking any nutritional supplements for at least 3 months prior participation or during the trial • Any history of autoimmune disease, cardiovascular events, other thyroid abnormalities including Grave's disease • Being pregnant or lactating • Any history of thyroid surgeries • Being on any dietary regimens during and 3 months before recruitment in the trial	2 g Nigella sativa powder per day; Each capsule was prepared containing 1 g powder of Nigella Sativa. 8 weeks	Starch	• Nigella sativa supplementation significantly reduced BW, BMI, WC and HC in patients with Hashimoto's thyroiditis ($P < 0.05$) • While no significant change in placebo treated group was observed.
To evaluate the effectiveness, safety, and tolerability of powdered Nigella sativa (kalonji) seed in capsules on serum lipid levels, blood sugar, blood pressure, and body weight in adults **49**	**NIGELLA**	Waris Qidwa, 2009, Pakistan	Double - blind randomized trial 123	• Adult men and women of Pakistani origin • 18 years or older and available to participate in the study for 6 weeks • Serum total cholesterol level between > 180 to 250 mg/dL, or serum total cholesterol level 250 mg/dL and taking statins for at least 1 month. Those on statins were recruited only if they were on them for a minimum of 4 weeks	• Who had diabetes, hypo-thyroidism, renal disease or malignancy • On thiazide diuretics, b-blockers or corticosteroids • Had admission to hospital with a severe illness within the previous 3 months • Pregnant or breast feeding within the previous 12 months • Those with a known cardiovascular condition (ischemic heart disease, peripheral arterial disease, abdominal aortic aneurysm, and carotid artery disease) • Those with fasting triglyceride concentration 236 mg/dL	Powdered Nigella sativa seed, 500 mg capsules each, 2 capsules twice daily. 6 weeks	Calcium lactate	• The results of the study did not prove effectiveness of powdered N. sativa seed in capsule on serum lips, blood sugar and BMI due to small sample size and loss to follow up of a large number of study subjects. • Favourable impact of powdered N. sativa (Kalonji) seed in capsule was noted on almost all variables but results were not statistically significant.
To investigate the effect of turmeric on glycemic status, lipid profile, hs-CRP, and total antioxidant capacity in hyperlipidemic type 2 diabetes	**TURMERIC**	Zohreh Adab, 2019, Iran	Double - blind randomized clinical trial 80	• 30 to 70 years old • hyper-lipidemic • Type 2 diabetic patients with fasting blood sugar < 200 mg/dl, haemoglobin A1c (HbA1C) > 6% • TG > 150 mg/dl,	• Any changes in physical activity, diet and drug intake during the period of the study • Fasting blood sugar > 200 mg/dl or LDL-C > 160 mg/dl • Acute heart disease,	Rhizome of turmeric, dried and grounded into powder, 2100 mg/day (three 700 mg after meals). 8 weeks	Corn starch flour	• BW ($P = 0.001$), BMI ($P < 0.001$), mean differences of BMI ($P = 0.001$) reduced significantly in the intervention group during the study.

(*continued on next page*)

Table 3 (*continued*)

Aim & Reference Number	Herb	Author/Year/ Country	Study design & Total participants	Inclusion criteria	Exclusion criteria	Herb. Form, Dosage & Duration	Placebo	Outcome
mellitus patients **50**				or LDL- C > 100 mg/dl • BMI between 20 and 35 kg/m^2 • No insulin therapy • No use of antioxidants, multivitamin, or polyphenols supplements for the last 3 months prior to the study	renal or liver failure, thyroid disease, severe GI disease, gastric ulcers, biliary stones • Pregnancy or lactation			
To investigate the effects of turmeric and chicory seed supplementation on antioxidant and inflammatory biomarkers in patients with non-alcoholic fatty liver disease (NAFLD) **51**	**TURMERIC**	Aida Ghaffari, 2018, Iran	Double - blind randomized controlled clinical trial 92	• NAFLD subjects • Aged 20–60 years • BMI of 24.9–40 kg/m^2	• With the history of thyroid disorders, cancer, biliary and kidney stone, viral hepatitis and other hepatic diseases • Being post menopause, pregnant or breast feeding • Who consumed tobacco and alcohol, nutritional supplements within the previous 4 weeks or during 12 weeks study period	Turmeric rhizome crushed, 3 g/d (6 × 500 mg capsules three times a day with meals). 12 weeks	Corn starch	• After 12 weeks interventions, BMI significantly reduced in TUR, CHI and TUR + CHI groups in comparison with baseline values (P < 0.05).
To evaluate if turmeric supplementation can improve serum glucose indices and leptin levels in patients with Non alcoholic fatty liver diseases **52**	**TURMERIC**	Roya Navekar, 2017, Iran	Double - blind randomized controlled clinical trial 46	• Patients diagnosed with NAFLD •Age: Females: 20–50 years and males: 20–60 years • BMI ranging from 24.9 to 40 kg/m^2	• Diabetes, alcohol consumption, liver transplan-tation, liver disorders (hepatitis B or C, liver infection etc.), biliary disease or presence of gallstones, inherited disorders affecting the liver (iron and copper storage disease etc.), autoimmune diseases, cancer, the risk of other chronic or acute diseases, anaemia • Medicine consumption such as glucose lowering drugs and dietary supplements	Turmeric rhizome powder, 6 turmeric capsules daily. Each capsule contained 500 mg turmeric powder. 12 weeks	Starch	• Turmeric supplementation was associated with a significant (P < 0.05) decrease in the BW and BMI of subjects compared to baseline values. Changes in weight, BMI and liver enzymes were not significant compared to the placebo group.
To investigate the beneficial effects of turmeric and chicory seed on obesity markers and lipid profile in non-alcoholic fatty liver disease (NAFLD) **53**	**TURMERIC**	Aida Ghaffari, 2019, Iran	Double - blind randomized controlled clinical trial 92	• Age: 20–60 years • Diagnosed with NAFLD • BMI ranged from 24.9 to 40 kg/m^2	• History of thyroid disorders, severe anaemia, cancer, biliary and kidney stone, viral hepatitis and other hepatic diseases • Being post menopause, pregnant or breast feeding • Patients who consumed tobacco, alcohol, anticoagulant, oral contraceptive and lipid lowering medication one month before study and during study period	Turmeric rhizome crushed, 3 g/d (1000 mg three times a day with meals). 12 weeks	Corn starch capsules	• After interventions, BW and BMI dramatically decreased in TUR, CHI and TUR + CHI groups in comparison with baseline values (P < 0.05). Mean WC declined in all groups in comparison with their baseline values (P < 0.05).

3.9. Key characteristics of successful interventions

Overall, 24 studies investigating basil, cardamom, cinnamon, coriander, garlic, ginger, nigella and turmeric reported significant ($P < 0.05$) reductions on anthropometric measures of obesity either compared to baseline or to the placebo. (Table 4). In total, the duration, dose and the sample size of studies that showed significant reductions in BW, BMI, WC, HC or BFP varied between different intervention types. The study on fenugreek did not report any significant changes in obesity indices. Reduction in obesity indices like BW, BMI and WC were seen in studies with cardamom, cinnamon, ginger, nigella and turmeric. While ginger and nigella studies also showed reduction in HC apart from BW, BMI and WC and garlic on just BMI and WC. BFP reduction was seen in cinnamon, nigella and turmeric studies. Lastly, studies on basil showed a reduction in BW and BMI while coriander showed a reduction only in BMI. A summary of the effects on obesity indices is given in (Table 5).

3.9.1. Body weight

Among the 24 included significant studies, 14 clinical papers on herbs or spices including basil (OB: $P = 0.025$; PP: $P = 0.00$) (Akbarian et al., 2016); cardamom ($P < 0.05$) (Daneshi-Maskooni et al., 2018); cinnamon ($P < 0.05$) (Borzoei et al., 2018), ($P = 0.001$) (Gupta Jain et al., 2017), ($P = 0.017$) (Vafa et al., 2012), ($P < 0.05$) (Akilen et al., 2010); ginger ($P = 0.023$) (Ebrahimzadeh Attari et al., 2015); nigella ($P = 0.041$) (Hussain et al., 2017), ($P = 0.000$) (Datau et al., 2010), ($P = 0.004$) (Farhangi et al., 2018), ($P < 0.004$) (Farhangi et al., 2016) and turmeric ($P = 0.001$) (Adab et al., 2019), ($P < 0.05$) (Navekar et al., 2017), ($P < 0.05$) (Ghaffari et al., 2019) reported a significant ($P < 0.05$) decrease in body weight with a varied dosage between 1 g/day and 10 g/day and with an intervention period between 8 and 16 weeks.

3.9.2. Body mass index

Twenty out of 24 significant studies investigated BMI and the herbs or spices interventions which showed significant reductions on BMI included basil (OB and PP: $P = 0.01$) (Akbarian et al., 2016); cardamom ($P < 0.05$) (Daneshi-Maskooni et al., 2018); cinnamon ($P = 0.002$) (Borzoei et al., 2018), ($P = 0.001$) (Gupta Jain et al., 2017), ($P = 0.010$) (Vafa et al., 2012), ($P < 0.001$) (Zare et al., 2019), ($P < 0.05$) (Akilen et al., 2010), ($P = 0.001$) (Mirfeizi et al., 2016); coriander ($P < 0.05$) (Zeb et al., 2018); garlic ($P < 0.05$) (Zeb et al., 2018); ginger ($P = 0.019$) (Ebrahimzadeh Attari et al., 2016), ($P = 0.019$) (Ebrahimzadeh Attari et al., 2015), ($P < 0.001$) (El Gayar et al., 2019); nigella ($P = 0.012$) (Hussain et al., 2017), ($P = 0.002$) (Farhangi et al., 2018), ($P < 0.002$) (Farhangi et al., 2016), (black seed at 4 weeks, $P = 0.004$) (Amin et al., 2015) and turmeric ($P = 0.001$) (Adab et al., 2019), ($P < 0.05$) (Ghaffari et al., 2018), ($P < 0.05$) (Navekar et al., 2017), ($P < 0.05$) (Ghaffari et al., 2019), (turmeric at 4 weeks, $P < 0.001$) (Amin et al., 2015) with a dosage varying between 1.5 g/day and 3 g/day and with an intervention period between 60 days and 12 weeks.

3.9.3. Waist circumference

Of 24 significant studies, nine explored the effects of different herbs or spices such as cardamom ($P = 0.03$) (Fatemeh et al., 2017); cinnamon ($P = 0.002$) (Gupta Jain et al., 2017), ($P < 0.05$) (Akilen et al., 2010); garlic ($P < 0.05$) (Choudhary et al., 2018); ginger ($P = 0.011$) (Ebrahimzadeh Attari et al., 2015); nigella ($P = 0.000$) (Datau et al., 2010), ($P = 0.006$) (Farhangi et al., 2016), ($P < 0.01$) (Amin et al., 2015) and turmeric ($P < 0.01$) (Amin et al., 2015), ($P < 0.05$) (Ghaffari et al., 2019) on waist circumference and found a significant decrease in waist circumference with an intervention period between 4 and 16 weeks and a dosage varying between 1.5 g and 4 g/day except for a study on garlic which used 100 mg/kg body weight of garlic twice daily (Choudhary et al., 2018).

3.9.4. Hip circumference

Only three out of 24 significant studies investigated the effects of intervention on hip circumference and included ginger ($P = 0.003$) (Ebrahimzadeh Attari et al., 2015), ($P = 0.027$) (Mohammadzadeh Honarvar et al., 2019) and nigella ($P = 0.001$) (Farhangi et al., 2016). All the three studies reported a significant decrease in the hip circumference with a dosage of 2 g/day (both ginger and nigella) and had an intervention period between 8 and 12 weeks.

3.9.5. Body fat percentage and body fat mass

Effects of cinnamon, nigella and turmeric on body fat percentage were explored by only two studies, one on cinnamon (Gupta Jain et al., 2017) and the other was on nigella and turmeric (Amin et al., 2015), both studies showed a significant reduction in BFP ($P = 0.011$) (Gupta Jain et al., 2017), ($P < 0.001$) (turmeric and nigella) (Amin et al., 2015) respectively. 22 other significant studies did not show any decrease in body fat percentage. The dosage of the herbs or spices used in the significant studies was 1.5 g/day (Amin et al., 2015) and 3 g/day (Gupta Jain et al., 2017) with an intervention period of 8 weeks (Amin et al., 2015) and 16 weeks (Gupta Jain et al., 2017). Two studies pertaining to basil (Akbarian et al., 2016) and cinnamon (Vafa et al., 2012) investigated the effect on body fat mass and found a significant reduction (OB group, $P = 0.04$) (Akbarian et al., 2016) ($P = 0.047$) (Vafa et al., 2012) and used a dose of 10 g/day (Akbarian et al., 2016) and 3 g/day (Vafa et al., 2012) for a period of 12 weeks (Akbarian et al., 2016) and 8 weeks (Vafa et al., 2012).

4. Discussion

4.1. Summary of evidence

The aim of this systematic review was to determine the evidence from human studies on the effects of culinary herbs and spices, when taken in supplemental form on obesity. The present review investigated 30 culinary herbs and spices including anise, basil, black pepper, caraway, cardamom, chili pepper, cinnamon, clove, coriander, cumin, dill, fennel, fenugreek, garlic, ginger, hibiscus, lemongrass, marjoram, nigella, nutmeg, oregano, parsley, peppermint, rosemary, saffron, sage, spearmint, tarragon, thyme and turmeric. Twenty-four of the 33 studies reported significant ($P < 0.05$) reductions in obesity indices either compared to baseline or to the placebo when using basil, cinnamon, cardamom, coriander, garlic, ginger, nigella or turmeric as the intervention herb or spice. However, it should be noted that there were only a limited number of studies on herbs/spices such as basil, cardamom, garlic and coriander. Therefore, valuable information can be garnered from further research that needs to be done on larger population for a longer duration with these herbs and spices.

4.2. Evidence for various herbs and spices investigated

4.2.1. Basil

One study explored the effects of Plantago psyllium (PP) and Ocimum basilicum (OB) seeds on anthropometric measures in non-alcoholic fatty liver patients (Akbarian et al., 2016). It was reported that the BW, BMI and BFM was significantly reduced in the OB group and body weight, BMI, SLM and LBM was significantly reduced in the PP group with the control group also showing considerable reductions in BW and BMI. Hence, the study concluded that the supplementation with either PP, OB or PP and OB mix did not improve BW, BMI, SLM, LBM, BFM and BFP significantly when compared to placebo. There is limited research on basil and further research needs to be done considering the higher dose of PP and OB in the bigger population.

4.2.2. Cardamom

Three studies investigated the effects of cardamom (Aghasi et al., 2019; Daneshi-Maskooni et al., 2018; Fatemeh et al., 2017) with only one of the studies (Aghasi et al., 2019) showing a non-significant outcome which was conducted on patients with type 2 diabetes

mellitus and had participants with a BMI of 25–34.9 (Aghasi et al., 2019). The other two studies included participants with a BMI of 25–35 (Daneshi-Maskooni et al., 2018) and of 25–39.9 (Fatemeh et al., 2017), which showed significant reductions in BW (Daneshi-Maskooni et al., 2018) and BMI (Daneshi-Maskooni et al., 2018) when compared to baseline and WC when compared to placebo (Fatemeh et al., 2017). There were no changes in mean BW and BMI in the study (Fatemeh et al., 2017). However, there is limited research on cardamom and more research needs to be done investigating the effects on obesity.

4.2.3. Cinnamon

There were eight studies that investigated the effects of cinnamon (Akilen et al., 2010; Borzoei et al., 2018; Gupta Jain et al., 2017; Hajimonfarednejad et al., 2018; Mirfeizi et al., 2016; Sharma et al., 2012; Vafa et al., 2012; Zare et al., 2019). Six studies found a statistically significant decrease in BW (Borzoei et al., 2018; Gupta Jain et al., 2017; Vafa et al., 2012), BMI (Akilen et al., 2010; Borzoei et al., 2018; Mirfeizi et al., 2016; Vafa et al., 2012; Zare et al., 2019), WC (Akilen et al., 2010; Gupta Jain et al., 2017), BFP (Gupta Jain et al., 2017), BFM (Vafa et al., 2012) and TBF (Zare et al., 2019). The study populations included women with polycystic ovary syndrome having a BMI of 25–40 (Borzoei et al., 2018), patients with metabolic syndrome having WC $>$ 90 cms in men and $>$ 80 cms in women (Gupta Jain et al., 2017) and patients with type 2 diabetes mellitus (Akilen et al., 2010; Mirfeizi et al., 2016; Vafa et al., 2012; Zare et al., 2019). One study showed a significant decrease in BW and BMI when compared to baseline values (Borzoei et al., 2018) There was a significant decrease in BW, BMI, WC, WHR and BFP as compared to the placebo groups in a study which was conducted in a group of Asian Indians (Gupta Jain et al., 2017). One study reported BW, BMI and BFM to be significantly reduced in the cinnamon intervention group when compared to baseline (Vafa et al., 2012). Another study showed a significant decrease in patient's anthropometric indices, including their BMI, TBF and visceral fat ($P < 0.001$) in the cinnamon group and results were prominent on patients with higher baseline BMI (>=27) (Zare et al., 2019). Significant reductions in BW, WC and BMI were seen in one study when compared to baseline (Akilen et al., 2010). In another study, there was significant reduction of just BMI in the cinnamon group compared to both baseline and placebo. However, the degree of weight loss was less than 5–10% of total body weight (Mirfeizi et al., 2016). The other two studies which were conducted on patients with type 2 diabetes mellitus (Sharma et al., 2012) and women with polycystic ovary syndrome (Hajimonfarednejad et al., 2018) did not show statistically significant reductions in BMI and BW. This suggests that cinnamon could potentially decrease the anthropometric indices of obesity especially BMI as six of the eight studies showed significant reduction in BMI.

4.2.4. Coriander

Only one study investigated the effect of coriander on body mass index in hyperlipidemic patients (Zeb et al., 2018). The study explored two herbs coriander and garlic individually and in combination. Finally the study concluded that each of the supplements significantly reduced the BMI whereas the impact of coriander was more pronounced on blood pressure than BMI. Evidence is limited and further research needs to be conducted in populations with obesity and considering single herb intervention only.

4.2.5. Fenugreek

One study explored the effects of fenugreek (Yousefi et al., 2017) in patients with borderline hyperlipidaemia and did not show a significant difference in BMI when compared to baseline and placebo groups. Current research in fenugreek is very limited on its effect on obesity and more research needs to be conducted.

4.2.6. Garlic

Two studies investigated the effects of garlic. The first study was on just garlic which received a neutral quality rating (ADA quality checklist) but still it was included in this review. The study was done on patients with metabolic syndrome for four weeks and showed a significant reduction in abdominal obesity or waist circumference (Choudhary et al., 2018). The other study was garlic with coriander on hyperlipidemic patients for 60 days and garlic exclusively showed a significant result and a greater influence on BMI than coriander (Zeb et al., 2018). In both studies, there was a reduction in BMI. Therefore, further research needs to be done for a longer duration and on a larger population to understand the effect of coriander and garlic on obesity.

4.2.7. Ginger

There were seven studies that investigated the effects of ginger (Ebrahimzadeh Attari et al., 2015, 2016; El Gayar et al., 2019; Mohammadzadeh Honarvar et al., 2019). Of the seven studies, four studies found a significant reduction in BW (Ebrahimzadeh Attari et al., 2015), BMI (Ebrahimzadeh Attari et al., 2015, 2016; El Gayar et al., 2019), WC (Ebrahimzadeh Attari et al., 2015) and HC (Ebrahimzadeh Attari et al., 2015; Mohammadzadeh Honarvar et al., 2019) which was seen in obese patients (Ebrahimzadeh Attari et al., 2015, 2016; El Gayar et al., 2019) and type 2 diabetes patients (El Gayar et al., 2019; Mohammadzadeh Honarvar et al., 2019). The studies included people with BMI of 30–40 kg/m^2 (Ebrahimzadeh Attari et al., 2015, 2016) while the other two studies had people with BMI >=30 (El Gayar et al., 2019) and 18.5–35 kg/m^2 (Mohammadzadeh Honarvar et al., 2019) respectively. One study revealed that ginger consumption for 12 weeks resulted in a statistically significant decrease in BMI as compared to the placebo and baseline data ($P < 0.0001$) (Ebrahimzadeh Attari et al., 2016) while another study showed a slight, but significant reduction in BW, WC and HC along with BMI as compared to the placebo (Ebrahimzadeh Attari et al., 2015). In another study (El Gayar et al., 2019), the results showed a highly significant reduction in just BMI in 8 weeks although the dose (1.8 g/day) was less than the other two studies (2 g/day) (Ebrahimzadeh Attari et al., 2015, 2016). BFP, BFM and WC decreased compared to baseline in the ginger group with resistance training but remained unchanged in the ginger alone group after 10 weeks (Atashak et al., 2011a, 2011b). In the other study, changes in the BW was not statistically significant when compared to the placebo (Fatima et al., 2018). Lastly, HC was significantly reduced and BMI and WC was reduced slightly ($P < 0.1$) in the ginger group (Mohammadzadeh Honarvar et al., 2019). This suggests that ginger could potentially have a positive impact on obesity indices but more research needs to be done and without exercise intervention.

4.2.8. Nigella

Seven studies explored the effects of nigella (Amin et al., 2015; Badar et al., 2017; Datau et al., 2010; Farhangi et al., 2016, 2018; Hussain et al., 2017; Qidwai et al., 2009), of these studies, five reported a significant reduction in BW (Datau et al., 2010; Farhangi et al., 2016, 2018; Hussain et al., 2017), BMI (Amin et al., 2015; Farhangi et al., 2016, 2018; Hussain et al., 2017), WC (Amin et al., 2015; Datau et al., 2010; Farhangi et al., 2016), HC (Farhangi et al., 2016) and BFP (Amin et al., 2015). These studies had various types of participant populations including participants with non-alcoholic fatty liver disease having a BMI of >=25 (Hussain et al., 2017), central obesity (Datau et al., 2010), hashimoto's thyroiditis (Farhangi et al., 2016, 2018) and metabolic syndrome with a WC $>$ 90 cm (Amin et al., 2015). One study which investigated the effects of turmeric and black seeds; found that nigella intervention led to improvements in BMI, WC and BFP at 4 weeks when compared to baseline but the combination of nigella and turmeric (60% dose of individual herbs) showed a significant reduction in HC, BFP and BW at 8 weeks when compared to the black seed group alone (Amin et al., 2015). Nigella supplementation significantly reduced almost all of the anthropometric variables including BW, BMI, WC and HC and no such changes were seen in the placebo group (Farhangi et al., 2016), while in the two other studies there was a significant reduction in BW

Table 4
Summary of significant studies.

Name of herb/ spice	Significant study (Reference number)	Dosage	Duration	Effect on BW	Effect on BMI	Effect on WC	Effect on WHR	Effect on HC	Effect on BFP	Effect on BFM	Effect on TBF
Basil (OB & PP)	22	10 g/day	12 weeks	Y (OB & PP)	Y (OB & PP)	N	N	N	N	Y (OB)	N
Cardamom	24	3 g/day	3 months	Y	Y	N	N	N	N	N	N
	25	3 g/day	2 months	N	N	Y	N	N	N	N	N
Cinnamon	27	1.5 g/day	8 weeks	Y	Y	N	N	N	N	N	N
	28	3 g/day	16 weeks	Y	Y	Y	Y	N	Y	N	N
	29	3 g/day	8 weeks	Y	Y	N	N	N	N	Y	N
	30	1 g/day	3 months	N	Y	N	N	N	N	N	Y
	31	2 g/day	12 weeks	Y	Y	Y	N	N	N	N	N
	33	1 g/day	3 months	N	Y	N	N	N	N	N	N
Coriander	36	2 g/day	60 days	N	Y	N	N	N	N	N	N
Garlic	35	100 mg/kg body weight of garlic twice daily	4 weeks	N	N	Y	N	N	N	N	N
	36	2 g/day	60 days	N	Y	N	N	N	N	N	N
Ginger	37	2 g/day	12 weeks	N	Y	N	N	N	N	N	N
	38	2 g/day	12 weeks	Y	Y	Y	Y	Y	N	N	N
	39	1.8 g/day	8 weeks	N	Y	N	N	N	N	N	N
	43	2 g/day	10 weeks	N	N	N	N	Y	N	N	N
Nigella	21	1.5 g/day	8 weeks	N	Y	Y	N	N	Y	N	N
	45	2 g/day	3 months	Y	Y	N	N	N	N	N	N
	46	3 g/day	3 months	Y	N	Y	N	N	N	N	N
	47	2 g/day	8 weeks	Y	Y	N	N	N	N	N	N
	48	2 g/day	8 weeks	Y	Y	Y	N	Y	N	N	N
Turmeric	21	1.5 g/day	8 weeks	N	Y	Y	N	N	Y	N	N
	50	2.1 g/day	8 weeks	Y	Y	N	N	N	N	N	N
	51	3 g/day	12 weeks	N	Y	N	N	N	N	N	N
	52	3 g/day	12 weeks	Y	Y	N	N	N	N	N	N
	53	3 g/day	12 weeks	Y	Y	Y	N	N	N	N	N

Y = Yes, N = No

and BMI when compared to placebo (Farhangi et al., 2018; Hussain et al., 2017). Another study found a very significant reduction on BW and WC in comparison to the control group and the complaints related to central obesity in the treatment group disappeared within the first week (Datau et al., 2010). The other two studies showed no significant changes in the anthropometric variables of obesity (Badar et al., 2017; Qidwai et al., 2009). In one study, WC and HC slightly increased in the nigella group. The authors reported that it was difficult to explain the reason for this increase and changes could have been due to the different exercise duration in intervention and control arms (Qidwai et al., 2009). This suggests that nigella could potentially decrease anthropometric indices of obesity like BW, BMI and WC. More studies with adequate sample size needs to be conducted.

4.2.9. Turmeric

There were five studies investigating turmeric - three studies contained patients with non-alcoholic fatty liver disease and with a BMI ranging from 24.9 to 40 kg/m^2 (Ghaffari et al., 2018, 2019; Navekar et al., 2017), one study included hyperlipidemic type 2 diabetes mellitus patients with a BMI between 20 and 35 kg/m^2 (Adab et al., 2019) and the last one was a study exploring the effects of turmeric and nigella together which had patients with metabolic syndrome (Amin et al., 2015). Of the five studies, all the studies found significant reductions in BW (Adab et al., 2019; Ghaffari et al., 2019; Navekar et al., 2017), BMI (Adab et al., 2019; Amin et al., 2015; Ghaffari et al., 2018, 2019; Navekar et al., 2017), WC (Amin et al., 2015; Ghaffari et al., 2019) and BFP (Amin et al., 2015). In patients who received turmeric, BW, BMI and mean differences of BMI reduced significantly in the turmeric group (Adab et al., 2019). However, between group differences in BW at start and end of the study were not statistically significant ($P > 0.05$). Another study showed a dramatic decrease in BW, BMI and WC values from the baseline but were not pronounced when compared to other groups in the study like turmeric and chicory, chicory alone and placebo (Ghaffari et al., 2019); while the other study which also had similar groups showed a significant reduction in BMI in the turmeric group when compared to baseline (Ghaffari et al., 2018). In the other study, there was significant reduction in BW and BMI compared to baseline (Navekar et al., 2017). A study which explored both turmeric and nigella showed improvement in BMI, WC and BFP individually at 4 weeks but at 8 weeks, the combination group with 60% dose of the individual herbs showed an improvement in all parameters including HC ($P = 0.001$), BFP ($P = 0.008$) and BW ($P < 0.001$) (Amin et al., 2015). All studies showed a significant reduction in obesity indices and this indicates that turmeric could be a potential herb for obesity and more research needs to be done considering the dose, duration, whole herb and the sample size.

Table 5
Summary of effect size of herbs and spices on obesity indices.

Herb/spice	Study No.	BW (Kg)		BMI (kg/m^2)		WC (cm)		HC (cm)		BFP (%)		BFM (%)	
		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Basil (OB & PP)	**22**	OB:79.5 ± 3.6	OB:78.1 ± 3.5	OB: 30.1 ± 1.1	OB: 29.5 ± 1.1							27.8 ± 2.0	26.5 ± 2.3
		PP: 80.4 ± 2.4	PB: 78.5 ± 2.3	PP: 29.9 ± 0.8	PP:29.2 ± 0.8								
		OB, PP	OB, PP	OB, PP	OB, PP							OB	OB
Cardamom	**24**	85.2 (11.3) Mean (SD)	84.2 (11.3) Mean (SD)	30.5 (2.4) Mean (SD)	30.1(2.4) Mean(SD)								
	25					100.7 (8.1) Mean (SD)	100.2 (8,0.1) Mean (SD)						
Cinnamon	**27**	76.6 (12.3) Mean (SD)	76.1 (12.1) Mean (SD)	30.7 (5.04) Mean (SD)	30.6(4.99) Mean(SD)								
	28	89.1 ± 14.1	85.6 ± 13.7	33.6 ± 5.4	32.3 ± 5.2	106.6 ± 9.2	101.0 ± 9.1			37.9 ± 9.5	36.4 ± 9.5		
	29	74.94 ± 13.34	74.05 ± 12.8	29.23 ± 3.98	28.87 ± 3.63							33.19 ± 5.34	32.74 ± 4.82
	30			29.9 ± 12.3	Not mentioned Change is 0.53 kg/m^2, 95% CI:0.24e0.73 kg/m^2, p < 0.001								
	31	87.60 ± 17.51	84.70 ± 16.43	33.36 ± 4.20	32.30 ± 3.87	106.36 ± 11.89	103.94 ± 10.80						
	33			28.36 ± 3.27	27.76 ± 3.01								
Coriander	**36**			27.30 ± 4.6	27.11 ± 4.7								
Garlic	**35**			28.01 ± 3.1	27.63 ± 4.1	101.41 ± 8.59	97.95 ± 6.58						
	36												
Ginger	**37**			34.34 ± 3.61	Not mentioned (p < 0.0001)								
	38	88.75 ± 9.18	87.69 ± 8.90	34.34 ± 3.61	33.92 ± 3.48	102.60 ± 7.41	99.89 ± 7.32	119.70 ± 7.16	118.50 ± 7.08				
	39			32.35 ± 1.51	31.81 ± 1.21								
	43							107.07 ± 6.05	106.59 ± 5.98				
Nigella	**21**			27.4 ± 3.1	27.2 ± 3.0	100.7 ± 8.1	99.4 ± 7.8			32.7 ± 4.8	31.4 ± 5.0		
	45	86 ± 13.8	76 ± 12.6	29.06 ± 4.6	26.25 ± 6.2								
	46	77.11 ± 4.86	72.60 ± 5.41			101.2 ± 1.38	99.8 ± 1.78						
	47	70.52 ± 12.27	69.39 ± 11.84	27.10 ± 4.63	26.63 ± 4.42								
	48	70.52 ± 12.27	69.39 ± 11.84	27.10 ± 4.63	26.63 ± 4.42	88.56 ± 7.29	87.72 ± 6.92	102.85 ± 6.25	101.56 ± 5.51				
Turmeric	**21**			28.1 ± 5.0	27.6 ± 4.8	95.7 ± 12.4	95.1 ± 12.3			32.5 ± 7.02	31.2 ± 6.6		
	50	76.86 ± 10.36	75.05 ± 9.96	28.98 ± 3.68	28.26 ± 3.45								
	51			31.81 ± 4.58	31.52 ± 4.73								

(*continued on next page*)

Table 5 (*continued*)

Herb/spice	Study No.	BW (Kg)		BMI (kg/m^2)		WC (cm)		HC (cm)		BFP (%)		BFM (%)	
		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
	52	85.26 (16.47) Mean (SD)	84.49 (16.76) Mean (SD)	31.81 (4.58) Mean (SD)	31.52(4.73) Mean(SD)								
	53	85.2 ± 16.4	84.4 ± 16.7	31.8 ± 4.58	31.5 ± 4.73	104 ± 12.1	101 ± 11.3						

BW - body weight; BMI - body mass index, WC - waist circumference, HC - hip circumference, BFP - body fat percentage, BFM- body fat mass, PP - Plantago psyllium, OB - Ocimum basilicum.

4.3. Molecular mechanisms of herbs/spices

The exact molecular mechanisms associated with herbs and spices and their role in obesity are not completely understood. However, herbs and spices are rich in phytochemicals which have antioxidant and anti-inflammatory effects. There is a growing interest in identifying and understanding the phytochemicals of herb/spice that form the basis for molecular mechanisms involved in therapeutic effects against obesity. Based on the evidence presented in this systematic literature review, herbs and spices including basil, cinnamon, cardamom, coriander, garlic, ginger, nigella and turmeric showed significant reductions in obesity indices and these herbs and spices also have been reported as acting as antioxidants and anti-inflammatory or hypolipidemic effects (Adab et al., 2019; Aghasi et al., 2019; Akbarian et al., 2016; Akilen et al., 2010; Amin et al., 2015; Atashak et al., 2011a, 2011b; Badar et al., 2017; Borzoei et al., 2018; Choudhary et al., 2018; Daneshi-Maskooni et al., 2018; Datau et al., 2010; Ebrahimzadeh Attari et al., 2015, 2016; El Gayar et al., 2019; Fatemeh et al., 2017; Fatima et al., 2018; Gupta Jain et al., 2017; Hajimonfarednejad et al., 2018; Hussain et al., 2017; Mirfeizi et al., 2016; Mohammadzadeh Honarvar et al., 2019; Navekar et al., 2017; Qidwai et al., 2009; Sharma et al., 2012; Tapsell et al., 2006; Vafa et al., 2012; Yousefi et al., 2017; Zare et al., 2019; Zeb et al., 2018). As obesity is associated with the oxidative processes in the body, the use of these herbs and spices to combat obesity warrants further attention along with investigation into the molecular mechanisms of action.

5. Strengths and limitations

This is the first comprehensive systematic literature review on the effects of culinary herbs and spices in the natural form (either fresh or dried and taken as a supplement) on obesity, as far as the authors are aware. The strengths of this review are that it included human intervention studies, and used an extensive and comprehensive literature search using both common names and scientific names for each herb/spice. Some limitations were that the included studies had different participant populations, that study duration was limited in a number of studies and also that obesity was not the primary outcome for most of the studies. Therefore, further research needs to be conducted in a population with obesity considering dose, duration and sample size. Additionally, there could be animal studies showing the effects of herbs or spices on obesity that are not investigated in this review. We have looked at culinary herbs/spices in their natural form, either fresh or dried, in this review as this is the most commonly used, convenient and cost effective form to deliver herbs and spices as a potential treatment for obesity. Furthermore, extracts are varied in method of extraction, concentration and purity, which can increase variability of results. Investigation of extracts alone, also warrants further research. Finally, the herbs/spices included in these studies may have an altered effect on obesity indices if consumed in a different form (for example - nigella oil), in different dosage and in combination with other culinary herbs (Amin et al., 2015) or with exercise (Atashak et al., 2011). The results from this literature review suggest that there is scope for successful human obesity intervention studies using the particular herbs and spices identified as having significant positive impact on obesity indices.

6. Conclusion

The important finding of this review is that a number of culinary herbs and spices have been investigated and reported to significantly reduce obesity indices. The identified herbs and spices include basil (on BW and BMI), cardamom (on BW, BMI and WC), cinnamon (on BW, BMI, PBF and WC), coriander (on BMI), garlic (on BMI and WC), ginger (on BW, BMI, WC and HC), nigella (on BW, BMI, WC, BFP and HC) and turmeric (BMI, BW, BFP and WC) when compared to baseline or to a placebo with a dosage of herb/spice between 1 g and 3 g per day for a period between 4 and 16 weeks. These findings suggest herbs and spices have the potential to ameliorate obesity and its associated risk factors. For future research, valuable information can be garnered with particular focus on dosage, duration, sample size and well-designed clinical trials in participants with obesity to further understand the effects of these culinary herbs and spices on obesity indices.

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CRediT authorship contribution statement

Chandana Deekshith: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - original draft. **Markandeya Jois:** Supervision, Conceptualization, Methodology, Writing - review & editing. **Jessica Radcliffe:** Validation, Formal analysis, Writing - review & editing. **Jency Thomas:** Conceptualization, Methodology, Writing - review & editing, Supervision, Project administration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jff.2021.104449.

References

American Dietetic Association. ADA Evidence Analysis Manual 2008. ADA Quality Criteria Checklist - Primary Research. pp. 55–56.

Adab, Z., Eghtesadi, S., Vafa, M. R., Heydari, I., Shojaii, A., Haqqani, H., … Eghtesadi, M. (2019). Effect of turmeric on glycemic status, lipid profile, hs-CRP, and total antioxidant capacity in hyperlipidemic type 2 diabetes mellitus patients. *Phytotherapy Research, 33*(4), 1173–1181. https://doi.org/10.1002/ptr.6312.

Ademi, Z., Liew, D., Hollingsworth, B., Steg, P. G., Bhatt, D. L., & Reid, C. M. (2010). Predictors of annual pharmaceutical costs in Australia for community-based individuals with, or at risk of, cardiovascular disease: Analysis of australian data from the reach registry. *American Journal of Cardiovascular Drugs, 10*(2), 85–94. https://doi.org/10.2165/11530670-000000000-00000.

Afshin, A., Forouzanfar, M. H., Reitsma, M. B., Sur, P., Estep, K., Lee, A., … Murray, C. J. L. (2017). Health effects of overweight and obesity in 195 countries over 25 years. *New England Journal of Medicine, 377*(1), 13–27. https://doi.org/10.1056/NEJMoa1614362.

Aghasi, M., Koohdani, F., Qorbani, M., Nasli-Esfahani, E., Ghazi-Zahedi, S., Khoshamal, H., … Sotoudeh, G. (2019). Beneficial effects of green cardamom on serum SIRT1, glycemic indices and triglyceride levels in patients with type 2 diabetes mellitus: A randomized double-blind placebo controlled clinical trial. *Journal of the Science of Food and Agriculture, 99*(8), 3933–3940. https://doi.org/10.1002/jsfa.9617.

Akbarian, S. A., Asgary, S., Feizi, A., Iraj, B., & Askari, G. (2016). Comparative study on the effect of Plantago psyllium and Ocimum basilicum seeds on anthropometric measures in nonalcoholic fatty liver patients. *International Journal of Preventive Medicine, 2016*(OCTOBER), 2014–2017. https://doi.org/10.4103/2008-7802.191865.

Akilen, R., Tsiami, A., Devendra, D., & Robinson, N. (2010). Glycated haemoglobin and blood pressure-lowering effect of cinnamon in multi-ethnic Type 2 diabetic patients in the UK: A randomized, placebo-controlled, double-blind clinical trial. *Diabetic Medicine, 27*(10), 1159–1167. https://doi.org/10.1111/j.1464-5491.2010.03079.x.

Amin, F., Islam, N., Anila, N., & Gilani, A. H. (2015). Clinical efficacy of the co-administration of Turmeric and Black seeds (Kalongi) in metabolic syndrome - A double blind randomized controlled trial - TAK-MetS trial. *Complementary Therapies in Medicine, 23*(2), 165–174. https://doi.org/10.1016/j.ctim.2015.01.008.

Atashak, S., Peeri, M., Azarbayjani, M. A., Stannard, S. R., & Haghighi, M. M. (2011bb). Obesity-related cardiovascular risk factors after long- term resistance training and ginger supplementation. *Journal of Sports Science and Medicine, 10*(4), 685–691.

Atashak, S., Peeri, M., Jafari, A., & Azarbayjani, M. A. (2011aa). Effects of ginger supplementation and resistance training on lipid profiles and body composition in obese men. *Journal of Medicinal Plants Research, 5*(16), 3827–3832.

Badar, A., Kaatabi, H., Bamosa, A., Al-Elq, A., Abou-Hozaifa, B., Lebda, F., … Al-Almaie, S. (2017). Effect of Nigella sativa supplementation over a one-year period on lipid levels, blood pressure and heart rate in type-2 diabetic patients receiving oral hypoglycemic agents: Nonrandomized clinical trial. *Annals of Saudi Medicine, 37*(1), 56–63. https://doi.org/10.5144/0256-4947.2017.56.

Borzoei, A., Rafraf, M., & Asghari-Jafarabadi, M. (2018). Cinnamon improves metabolic factors without detectable effects on adiponectin in women with polycystic ovary syndrome. *Asia Pacific Journal of Clinical Nutrition, 27*(3), 556–563. https://doi.org/10.6133/apjcn.062017.02.

Choudhary, P. R., Jani, R. D., & Sharma, M. S. (2018). Effect of raw crushed garlic (Allium sativum L.) on components of metabolic syndrome. *Journal of Dietary Supplements, 15*(4), 499–506. https://doi.org/10.1080/19390211.2017.1358233.

Daneshi-Maskooni, M., Keshavarz, S. A., Qorbani, M., Mansouri, S., Alavian, S. M., Badri-Fariman, M., … Sotoudeh, G. (2018). Green cardamom increases Sirtuin-1 and reduces inflammation in overweight or obese patients with non-alcoholic fatty liver disease: A double-blind randomized placebo-controlled clinical trial. *Nutrition and Metabolism, 15*(1), 1–12. https://doi.org/10.1186/s12986-018-0297-4.

Datau, E. A., Wardhana, Surachmanto, E. E., Pandelaki, K., Langi, J. A., & Fias. (2010). Efficacy of Nigella sativa on serum free testosterone and metabolic disturbances in central obese male. *Acta Medica Indonesiana, 42*(3), 130–134.

Ebrahimzadeh Attari, V., Asghari Jafarabadi, M., Zemestani, M., & Ostadrahimi, A. (2015). Effect of Zingiber officinale supplementation on obesity management with respect to the uncoupling protein 1–3826A>G and β3-adrenergic receptor Trp64Arg polymorphism. *Phytotherapy Research, 29*(7), 1032–1039. https://doi.org/10.1002/ptr.5343.

Ebrahimzadeh Attari, V., Ostadrahimi, A., Asghari Jafarabadi, M., Mehralizadeh, S., & Mahluji, S. (2016). Changes of serum adipocytokines and body weight following Zingiber officinale supplementation in obese women: A RCT. *European Journal of Nutrition, 55*(6), 2129–2136. https://doi.org/10.1007/s00394-015-1027-6.

El Gayar, M. H., Aboromia, M. M. M., Ibrahim, N. A., & Abdel Hafiz, M. H. (2019). Effects of ginger powder supplementation on glycemic status and lipid profile in newly diagnosed obese patients with type 2 diabetes mellitus. *Obesity Medicine, 14*(October 2018). https://doi.org/10.1016/j.obmed.2019.100094.

European Spice Association (ESA): List of culinary herbs and spices - https://www.esa-spices.org/index-esa.html/publications-esa (accessed August, 2019).

Farhangi, M. A., Dehghan, P., & Tajmiri, S. (2018). Powdered black cumin seeds strongly improves serum lipids, atherogenic index of plasma and modulates anthropometric features in patients with Hashimoto's thyroiditis. *Lipids in Health and Disease, 17*(1), 1–7. https://doi.org/10.1186/s12944-018-0704-x.

Farhangi, M. A., Dehghan, P., Tajmiri, S., & Abbasi, M. M. (2016). The effects of Nigella sativa on thyroid function, serum Vascular Endothelial Growth Factor (VEGF) - 1, Nesfatin-1 and anthropometric features in patients with Hashimoto's thyroiditis: A randomized controlled trial. *BMC Complementary and Alternative Medicine, 16*(1), 1–9. https://doi.org/10.1186/s12906-016-1432-2.

Fatemeh, Y., Siassi, F., Rahimi, A., Koohdani, F., Doostan, F., Qorbani, M., & Sotoudeh, G. (2017). The effect of cardamom supplementation on serum lipids, glycemic indices and blood pressure in overweight and obese pre-diabetic women: A randomized controlled trial. *Journal of Diabetes and Metabolic Disorders, 16*(1), 1–9. https://doi.org/10.1186/s40200-017-0320-8.

Fatima, A., Niaz, K., Suhail, B., & Murad, S. (2018). Ginger pasted-powder prevents dyslipidemia and body weight. *Pakistan Journal of Medical and Health Sciences, 12*(3), 974–976.

Ghaffari, A., Rafraf, M., Navekar, R., & Asghari-Jafarabadi, M. (2018). Effects of turmeric and chicory seed supplementation on antioxidant and inflammatory biomarkers in patients with non-alcoholic fatty liver disease (NAFLD). *Advances in Integrative Medicine, 5*(3), 89–95. https://doi.org/10.1016/j.aimed.2018.01.002.

Ghaffari, A., Rafraf, M., Navekar, R., Sepehri, B., Asghari-Jafarabadi, M., & Ghavami, S. M. (2019). Turmeric and chicory seed have beneficial effects on obesity markers and lipid profile in non-alcoholic fatty liver disease (NAFLD). *International Journal for Vitamin and Nutrition Research, 89*(5–6), 293–302. https://doi.org/10.1024/0300-9831/a000568.

Gupta Jain, S., Puri, S., Misra, A., Gulati, S., & Mani, K. (2017). Effect of oral cinnamon intervention on metabolic profile and body composition of Asian Indians with metabolic syndrome: A randomized double -blind control trial. *Lipids in Health and Disease, 16*(1), 1–11. https://doi.org/10.1186/s12944-017-0504-8.

Hajimonfarednejad, M., Nimrouzi, M., Heydari, M., Zarshenas, M. M., Raee, M. J., & Jahromi, B. N. (2018). Insulin resistance improvement by cinnamon powder in polycystic ovary syndrome: A randomized double-blind placebo controlled clinical trial. *Phytotherapy Research, 32*(2), 276–283. https://doi.org/10.1002/ptr.5970.

Hasani-Ranjbar, S., Jouyandeh, Z., & Abdollahi, M. (2013). A systematic review of anti-obesity medicinal plants - an update. *Journal of Diabetes and Metabolic Disorders, 12*(1). https://doi.org/10.1186/2251-6581-12-28.

Hussain, M., Tunio, A. G., Akhtar, L., & Shaikh, G. S. (2017). Effects of nigella sativa on various parameters in Patients of non-alcoholic fatty liver disease. *Journal of Ayub Medical College, Abbottabad: JAMC, 29*(3), 403–407.

Ikramuddin, S., Korner, J., Lee, W. J., Bantle, J. P., Thomas, A. J., Connett, J. E., … Billington, C. J. (2016). Durability of addition of Roux-en-Y Gastric Bypass to lifestyle intervention and medical management in achieving primary treatment goals for uncontrolled type 2 diabetes in mild to moderate obesity: A randomized control trial. *Diabetes Care, 39*(9), 1510–1518. https://doi.org/10.2337/dc15-2481.

Jungbauer, A., & Medjakovic, S. (2012). Anti-inflammatory properties of culinary herbs and spices that ameliorate the effects of metabolic syndrome. *Maturitas, 71*(3), 227–239. https://doi.org/10.1016/j.maturitas.2011.12.009.

Mirfeizi, M., Mehdizadeh Tourzani, Z., Mirfeizi, S. Z., Asghari Jafarabadi, M., Rezvani, H. R., & Afzali, M. (2016). Controlling type 2 diabetes mellitus with herbal medicines: A triple-blind randomized clinical trial of efficacy and safety. *Journal of Diabetes, 8*(5), 647–656. https://doi.org/10.1111/1753-0407.12342.

Mofrad, M. D., Milajerdi, A., Koohdani, F., Surkan, P. J., & Azadbakht, L. (2019). Garlic supplementation reduces circulating C-reactive protein, tumor necrosis factor, and interleukin-6 in Adults: A systematic review and meta-analysis of randomized controlled trials. *Journal of Nutrition, 149*(4), 605–618. https://doi.org/10.1093/jn/nxy310.

Mohammadzadeh Honarvar, N., Zarezadeh, M., Khorshidi, M., Makhdoomi Arzati, M., Yekaninejad, M. S., Abdollahi, M., Effatpanah, M., Hashemi, R., & Saedisomeolia, A. (2019). The effect of an oral ginger supplementation on NF-κB concentration in peripheral blood mononuclear cells and anthropomorphic data of patients with type 2 diabetes: A randomized double-blind, placebo-controlled clinical trial. *Complementary Therapies in Medicine, 42*(July), 7–11. https://doi.org/10.1016/j.ctim.2018.10.019.

Mohtashami, A., & Entezari, M. H. (2016). Effects of nigella sativa supplementation on blood parameters and anthropometric indices in adults: A systematic review on clinical trials. *Journal of Research in Medical Sciences, 21*(1). https://doi.org/10.4103/1735-1995.175154.

Mousavi, S. M., Sheikhi, A., Varkaneh, H. K., Zarezadeh, M., Rahmani, J., & Milajerdi, A. (2018). Effect of Nigella sativa supplementation on obesity indices: A systematic review and meta-analysis of randomized controlled trials. *Complementary Therapies in Medicine, 38*(44), 48–57. https://doi.org/10.1016/j.ctim.2018.04.003.

Navekar, R., Rafraf, M., Ghaffari, A., Asghari-Jafarabadi, M., & Khoshbaten, M. (2017). Turmeric supplementation improves serum glucose indices and leptin levels in patients with nonalcoholic fatty liver diseases. *Journal of the American College of Nutrition, 36*(4), 261–267. https://doi.org/10.1080/07315724.2016.1267597.

Obesity drug outcome measures: A product of - The George Washington University School of Public Health and Health Services Department of Health Policy Washington https://publichealth.gwu.edu/pdf/obesitydrugmeasures.pdf (accessed 2020).

Obesity: preventing and managing the global epidemic (Report of a WHO Consultation (WHO Technical Report Series 894) https://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/ (accessed June 2020).

Opara, E. I., & Chohan, M. (2014). Culinary herbs and spices: Their bioactive properties, the contribution of polyphenols and the challenges in deducing their true health benefits. *International Journal of Molecular Sciences, 15*(10), 19183–19202. https://doi.org/10.3390/ijms151019183.

Overweight and obesity: an interactive insight - https://www.aihw.gov.au/reports/overweight-obesity/overweight-and-obesity-an-interactive-insight/data (accessed June 2020).

Park, J. Y., & Kim, Y. J. (2016). Laparoscopic Roux-en-Y gastric bypass in obese Korean patients: Efficacy and potential adverse events. *Surgery Today, 46*(3), 348–355. https://doi.org/10.1007/s00595-015-1170-y.

Qidwai, W., Hamza, H. B., Qureshi, R., & Gilani, A. (2009). Effectiveness, safety, and tolerability of powdered Nigella sativa (kalonji) seed in capsules on serum lipid levels, blood sugar, blood pressure, and body weight in adults: Results of a randomized, double-blind controlled trial. *Journal of Alternative and Complementary Medicine (New York, N.Y.), 15*(6), 639–644. https://doi.org/10.1089/acm.2008.0367.

Sharma, P., Sharma, S., Agrawal, R. P., Agrawal, V., & Singhal, S. (2012). A randomised double blind placebo control trial of cinnamon supplementation on glycemic control and lipid profile in type 2 diabetes mellitus. *Australian Journal of Herbal Medicine, 24*(1), 52–57.

Sheba, A., & Ilakkia, A. (2016). Anti-obesity effect of hibiscus Sabdariffa L.: A review. *International Journal of Pharma and Bio Sciences., 7*(4), 341–345.

Shekarchizadeh-Esfahani, P., Arab, A., Ghaedi, E., Hadi, A., & Jalili, C. (2020). Effects of cardamom supplementation on lipid profile: A systematic review and meta-analysis of randomized controlled clinical trials. *Phytotherapy Research, 34*(3), 475–485. https://doi.org/10.1002/ptr.6543.

Tapsell, L. C., Hemphill, I., Cobiac, L., Patch, C. S., Sullivan, D. R., Fenech, M., … Inge, K. E. (2006). Health benefits of herbs and spices: The past, the present, the future. *The Medical Journal of Australia, 185*(S4), S1–S24. https://doi.org/10.5694/j.1326-5377.2006.tb00548.x.

Vafa, M., Mohammadi, F., Shidfar, F., Sormaghi, M. S., Heidari, I., Golestan, B., & Amiri, F. (2012). Effects of cinnamon consumption on glycemic status, lipid profile and body composition in type 2 diabetic patients. *International Journal of Preventive Medicine, 3*(8), 531–536.

Vázquez-Fresno, R., Rosana, A. R. R., Sajed, T., Onookome-Okome, T., Wishart, N. A., & Wishart, D. S. (2019). Herbs and spices- biomarkers of intake based on human intervention studies - a systematic review. *Genes and Nutrition, 14*(1), 1–27. https://doi.org/10.1186/s12263-019-0636-8.

Wang, Y., Beydoun, M. A., Liang, L., Caballero, B., & Kumanyika, S. K. (2008). Will all Americans become overweight or obese? Estimating the progression and cost of the US obesity epidemic. *Obesity, 16*(10), 2323–2330. https://doi.org/10.1038/oby.2008.351.

WHO: Obesity and Overweight fact sheets https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (accessed June 2020).

Yousefi, E., Zareiy, S., Zavoshy, R., Noroozi, M., Jahanihashemi, H., & Ardalani, H. (2017). Fenugreek: A therapeutic complement for patients with borderline hyperlipidemia: A randomised, double-blind, placebo-controlled, clinical trial. *Advances in Integrative Medicine, 4*(1), 31–35. https://doi.org/10.1016/j.aimed.2016.12.002.

Zare, R., Nadjarzadeh, A., Zarshenas, M. M., Shams, M., & Heydari, M. (2019). Efficacy of cinnamon in patients with type II diabetes mellitus: A randomized controlled clinical trial. *Clinical Nutrition, 38*(2), 549–556. https://doi.org/10.1016/j.clnu.2018.03.003.

Zeb, F., Safdar, M., Fatima, S., Khan, S., Alam, S., Muhammad, M., … Shakoor, H. (2018). Supplementation of garlic and coriander seed powder: Impact on body mass index, lipid profile and blood pressure of hyperlipidemic patients. *Pakistan Journal of Pharmaceutical Sciences, 31*(5), 1935–1941.