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REVIEW ARTICLE

THE IMPACT OF BERGAMOT SUPPLEMENTATION ON HUMAN METABOLIC AND MENTAL HEALTH – A REVIEW OF CURRENT CLINICAL STUDIES

Patrycja N. DADYŃSKA[1], Mateusz BARTKOWIAK[1], Natasza BOLESŁAWSKA-KRÓL[2], Alicja DRZEWIECKA[2], Elżbieta JANDA[3], Izabela BOLESŁAWSKA[4], Sławomira DRZYMAŁA-CZYŻ[4]

[1] Karol Marcinkowski University Hospital in Zielona Gora, Zielona Gora, Poland

[2] Student Society of Radiotherapy, Collegium Medicum, University of Zielona Gora, Zielona Gora, Poland

[3] Magna Graecia University, Department of Health Sciences, Campus Germaneto, Catanzaro, Italy

[4] Department of Bromatology, Poznan University of Medical Sciences, Poznan, Poland

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Author's address: I. Bolesławska, Department of Bromatology, Poznan University of Medical Sciences, Rokietnicka Street 3, 60-806 Poznan, Poland, e-mail: ibolesla@ump.edu.pl

Introduction: Given the growing burden of non-communicable diseases, particularly metabolic disorders and mental health issues, there is increasing interest in natural bioactive substances as complementary interventions alongside conventional therapies. The aim of this review was to criti cally evaluate the available clinical studies assessing the effi cacy of bergamot (Citrus bergamia) supplements and essenti al oils in the prevention and treatment of selected metabolic conditi ons, such as dyslipidaemia, insulin resistance, hyperglycaemia, hepati c steatosis, and infl ammatory markers, as well as sleep and mood disorders.

Methods: This review was based on a literature search conducted in PubMed, Scopus and Google Scholar databases, covering publicati ons published between 2019 and 2025. Only studies reporti ng clinical data on the eff ects of bergamot extracts in humans were included, while in vitro and animal studies were excluded.

Results: Clinical studies indicate that bergamot preparati ons most consistently improve the lipid profile, parti cularly by lowering total cholesterol, LDL-C and triglycerides, with less consistent eff ects on HDL-C, glycaemia, and infl ammatory markers. Essenti al oil inhalation may reduce stress, corti sol, and sleep disturbances, although the evidence remains heterogeneous.

Conclusions: Bergamot demonstrates broad therapeutic potenti al, including beneficial effects on lipid metabolism, cardiovascular function, hepati c homeostasis, and mental health. Therefore, it may be of parti cular relevance to military aviati on personnel, who are exposed to chronic stress, sleep disturbances, and high cogniti ve and physical demands. However, the potenti al of bergamot as a safe and well-tolerated supportive intervention in environments with a high psychophysiological burden warrants further well-designed clinical trials.

Keywords: bergamot (Citrus bergamia), lipid profile, insulin resistance, body weight, liver parameters, inflammatory markers, mental health

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INTRODUCTION

The modern world is facing a growing burden of non-communicable diseases (NCDs), which are among the most important health challenges of the 21st century [12,60]. Among them, chronic metabolic diseases are particularly important, as their increasing prevalence [11,62] is the result of the cumulative impact of rapid socio-economic changes, population ageing, and lifestyle changes, including poor nutrition, physical inactivity, chronic stress, sleep disorders, and exposure to environmental factors [39,40].

This is particularly important in environments that require maximum mental and physical fitness, such as the armed forces, especially military aviation. Pilots and flight personnel are exposed to specific risk factors, including chronic stress, irregular routines, circadian rhythm disorders, and intense cognitive and physical demands. These factors contribute to the development of metabolic disorders and non-communicable diseases, and their long-term effects can affect operational readiness and decision-making abilities in high-risk situations. Therefore, identifying effective, well-tolerated interventions that support metabolic and mental health in this professional group is important from both aviation medicine and preventive health perspectives.

The most common and preventable metabolic disorders include hyperglycaemia, insulin resistance, hypertension, obesity and its consequences, hypercholesterolaemia and fatty liver disease associated with metabolic dysfunction [12,62]. These diseases often coexist, forming the basis of metabolic syndrome, a major predictor of type 2 diabetes, cardiovascular diseases, certain cancers, and chronic kidney and neurological diseases [44].

The common pathophysiological mechanism underlying most NCDs is chronic, low-grade inflammation [22,41]. It is associated with the overproduction of pro-inflammatory mediators and elevated levels of inflammatory markers, including high-sensitivity C-reactive protein (hs-CRP) [61].

A growing body of research highlights the role of psychobiological factors — such as chronic stress, sleep disturbances, and depressed mood — as both consequences and significant risk factors for metabolic diseases. Chronic stress, through activation of the hypothalamic-pituitary-adrenal (HPA) axis, leads to excessive cortisol secretion, which disrupts glucose and insulin metabolism and promotes the development of insulin resistance and type 2 diabetes [1]. Abnormal sleep patterns and a sedentary lifestyle are also strongly correlated with visceral obesity, lipid disorders, and an increased risk of type 2 diabetes [12,13].

In recent decades, significant progress has been made in the pharmacotherapy of chronic diseases. Many new drugs targeting specific molecular pathways have been introduced on the market [3,15,51]. Despite this, their therapeutic efficacy does not necessarily translate into reduced disease incidence, and in addition, their side effects often prompt patients to discontinue therapy [16,29]. In response to these limitations, there is growing interest in natural bioactive substances of plant origin, which have multidirectional effects, often with better tolerance and a lower risk of side effects compared to conventional drugs.

Among the numerous plant-derived compounds are bergamot extracts (Citrus bergamia Risso & Poit., synonym: Citrus aurantium L. subsp. bergamia (Risso et Poit.) Wight et Arn. Engl.), which are derived from a citrus fruit found along the Ionian coast in the province of Reggio Calabria (Italy) [47]. Traditionally used in the perfume and food industries, bergamot has also been found to exhibit a broad spectrum of biological activity [2]. Numerous scientific studies suggest that bergamot formulations can reduce the proliferation of a wide range of cancer cell types in vitro by inducing cell cycle arrest [2]. Promising results have also been observed in the context of non-alcoholic fatty liver disease (NAFLD), osteosarcopenia, and erectile dysfunction, as well as its potential in dermatological applications, particularly in counteracting photoaging [27,33,42].

Bergamot extracts may also play a protective role in the management of various features of metabolic syndrome (MetS), including visceral obesity, insulin resistance, high triglyceride (TG) levels, low-density lipoprotein (HDL-C), and hypertension, which are associated with an increased risk of developing type 2 diabetes and atherosclerotic cardiovascular disease [7,31,43].

Bergamot essential oil (BEO) is widely used in aromatherapy as an aid in reducing mental stress and anxiety symptoms. The results of some studies suggest that inhaling BEO together with water vapour may contribute to improving mental well-being in a relatively short time [57]. However, the available data are inconsistent — some studies have not shown significant differences in the effectiveness of aromatherapy with BEO compared to other essential oils, and in some cases, BEO has even been found to be less effective than other oils in relieving symptoms of anxiety and nausea [43]. Similar ambiguity applies to the effect of bergamot

extracts on selected metabolic parameters — not all human studies confirm a significant improvement in glycaemia or lipid profile as a result of supplementation with this ingredient [17].

Despite existing reviews on the impact of bergamot on metabolic and mental health, previous studies have not comprehensively covered the latest clinical trial results, nor have they analysed the multidimensional impact of bergamot on key metabolic and mental indicators.

The aim of this review was therefore to provide a synthetic analysis and critical assessment of current clinical data on the use of bergamot preparations, with particular emphasis on their impact on: lipid profile, glycaemic parameters and insulin resistance, body mass and body composition indicators, liver function markers, inflammatory parameters, and selected psychophysiological factors such as sleep quality and mood. The review aims to identify potential therapeutic benefits as well as research gaps and discrepancies in results, which may form the basis for planning future, more targeted clinical trials.

METHODS

The review is narrative in nature and was conducted to collect and summarise current knowledge on the potential use of bergamot extract (Citrus bergamia) in the prevention and treatment of selected non-communicable diseases, with particular emphasis on metabolic disorders. The literature search was conducted in PubMed, Scopus, and Google Scholar databases, covering publications from 2019 to 2025. Earlier publications were also included when relevant to the scope of the review. The following combinations of terms were used in the search: 'bergamot', 'Citrus bergamia', 'bergamot polyphenolic fraction', 'cardiometabolic diseases', 'metabolic syndrome', 'insulin resistance', 'dyslipidaemia', 'oxidative stress', 'inflammation', 'clinical trial', 'mental health', 'anxiety', 'depression', 'mood', 'stress', and 'sleep'. The search was limited to publications in English, focusing on clinical studies containing results on the effects of bergamot in humans (e.g. lipid profile, glycaemia, inflammatory markers), published in peer-reviewed scientific journals. In vitro and animal studies, publications in the form of conference abstracts, letters, editorial comments, and articles that did not contain specific data on the effects of bergamot on the human body were excluded.

Bergamot – characteristics and origin

Bergamot (Citrus bergamia Risso & Poit., synonym: Citrus aurantium L. subsp. bergamia (Risso et Poit.) Wight et Arn. Engl.) is an aromatic citrus fruit, similar in size to an orange, with a yellow colour similar to that of a lemon [47]. The plant belongs to the Rutaceae family, genus Citrus, and was first mentioned by the Jesuit Giovanni Battista Ferrari, who published his monograph Hesperides sive de malorum aureorum cultura et usu in Rome in 1646, describing bergamot as 'aurantium stellatum et roseum', which may be loosely translated as 'starry and pink orange' [2,32]. Citrus bergamia is defined as a hybrid of sour orange (C. aurantium L.) and lemon (C. limon L. Burm. f.) or a mutation of the latter. Other authors considered it a hybrid of sour orange and lime (C. aurantifolia) [38].

Bergamot has been known in the Mediterranean region for centuries, but its unique essential oil did not gain wider recognition until around the mid-18th century [55]. Despite numerous studies, it has not yet been possible to clearly determine either the place of origin of this plant or the origin of its name. One hypothesis suggests that the word 'bergamot' may come from the Turkish 'beg-a-mudi', which means 'prince's pear', due to its visual similarity to the bergamot pear depicted in Bartolomeo Bimbi's painting from 1715 [32]. Another source points to a possible connection with the Italian city of Bergamo, where bergamot oil is believed to have been first sold [46]. However, it is most likely that the name 'bergamot' comes from the Spanish city of Berg, from where the plant was later transported to Calabria [38].

Bergamot fruits are a valuable source of essential oil (Bergamot Essential Oil, BEO), obtained by cold pressing and mechanical friction of the fruit peel. BEO is characterised by an intense, fresh aroma and a bitter, aromatic taste, and its colour ranges from greenish to brownish-yellow, reflecting the beginning and end of the harvest season. Due to its aromatic and organoleptic properties, bergamot oil is widely used in the perfume, cosmetics, food, and confectionery industries [38].

Initially, the essential oil was extracted entirely by hand by squeezing the peel of the fruit, from which the essence was absorbed into natural sponges placed in special bowls called concoline. The entire process was carried out at night by skilled craftsmen known as sfumatori. The cool night-time conditions were conducive to preserving the delicate, volatile aromatic compounds, protecting them from evaporation and sunlight, which could affect the quality of the essence. This technique

was described in detail by Domenico Sestini as early as 1780 [18]. Currently, natural oil is obtained by cold pressing the fruit peel, and to obtain one kilogram of essential oil, approximately 200 kilograms of fresh fruit must be processed.

Bergamot juice, obtained from the endocarp of the fruit after the essential oil has been extracted, was long considered a by-product and did not find widespread application, mainly due to its intensely bitter taste. In recent years, however, it has attracted growing interest due to the discovery of its potential health-promoting properties and its richness in bioactive polyphenolic compounds [38]. Since the 18th century, bergamot has been grown almost exclusively in Calabria, mainly in the province of Reggio di Calabria. The plant grows there on a narrow, approximately 100-kilometre-long strip of coastline stretching between Villa San Giovanni and Gioiosa Ionica. The cultivation area covers approximately 1,200 hectares and is located in the only region in the world from which more than 90% of global bergamot production originates [32,38].

Chemical composition

There are three main varieties: 'fantastico', 'feminello' and 'castagnaro'. They differ in plant morphology, fruit appearance, aroma, and taste. Traditionally used mainly for the production of essential oil from the peel, bergamot also attracts the attention of researchers in terms of the properties of its pulp. It turns out that it contains significant amounts of phenolic compounds. Compared with the juice of other citrus fruits, bergamot juice has a unique chemical profile; it is rich in various classes of bioactive compounds, including furanocoumarins, flavonoids, C- and O-glycosides [36]. Three acylated flavanones have been identified, which appear to correspond to derivatives of neoeriocitrin, naringin and neohesperidin. Other major flavanones include naringin, neohesperidin and neoeriocitrin. As for flavones, their total content was approximately 160 mg/l, with vicenin-2, stellarin-2, rhoifolin, and neodiosmin being the main ones. Bergapten and bergamottin were the main furanocoumarins in bergamot [23].

The phytochemical composition of bergamot was characterised in detail using gas chromatography, high-performance liquid chromatography (HPLC), and mass spectrometry techniques. The analyses were performed on both cold-pressed juice and industrial fruit extracts and peel oil.

Both bergamot essential oil and bergamot juice contain a predominantly volatile fraction (93–96%), which includes monoterpene and sesquiterpene hydrocarbons (e.g. limonene – 25–53%), as well as oxygen compounds such as linalool (2–20%) and linalyl acetate (15–40%). Other important components found in the oil are α-pinene and terpinene [14,21]. In addition, the oil also contains a non-volatile fraction, including waxes, polymethoxylated flavones, coumarins, and psoralens, such as bergapten and bergamottin [24,26,56].

Compounds such as linalool and linalyl acetate are responsible for the characteristic fragrance notes of bergamot oil and extracts, and their content is considered an important indicator of product quality [52]. Studies using gas chromatography coupled with olfactometry and mass spectrometry have shown that the characteristic aromas of various citrus blends, such as those found in black tea, are due to the presence of compounds such as alkenes. Their profile varies depending on the citrus species, thus determining the unique aroma and taste characteristics [58].

The significant variability in the composition of the volatile fraction of bergamot oil and extracts is due to many factors, such as the time of harvest, plant variety, place of cultivation, and extraction method used. For example, one of the more recent studies has shown that the use of the screw-pressing method allows for the production of juice with a higher content of flavanone glycosides compared to other techniques, resulting in greater antioxidant activity while maintaining the nutritional value of fresh juice [8]. For this reason, it is important to precisely determine the optimal growing and harvesting conditions. Research by Giuffrè and colleagues has identified the best harvest time for each of the three genetic varieties, maximising both the quantity and quality of the raw material obtained [25].

As for the main compounds, which accounted for over 65% of BEO, the Food and Drug Administration considers linalyl acetate, limonene and linalool to be substances generally recognised as safe [54]. The use of bergamot in numerous clinical studies has consistently shown that it is well tolerated in studies lasting from 30 days to 12 weeks [37].

In order to fully exploit the potential of bergamot products as dietary supplements, it is necessary to study the biological activity of various forms of preparations. In addition to essential oil, the most commonly used forms are bergamot extracts obtained from juice and/or fruit pulp and the bergamot polyphenolic fraction, enriched with compounds such as neoeriocitrin, neohesperidin and naringin [4,53,59]. The latter form, which is of great interest to industry and nutraceuticals,

has been characterised in detail using liquid chromatography coupled with diode array detection and mass spectrometry. These analyses, supported by separation techniques and nuclear magnetic resonance (NMR) spectroscopy of isolated compounds, have led to the identification of new glycoside flavonoids, such as bergamjuicin [21].

RESULTS

Lipid profile

In recent years, several reviews summarising the effect of bergamot on cardiometabolic health have been published. Previous studies, including a review by Lamiquiz-Moneo et al. [30] covering 12 articles and a mini-review by Nauman et al. [37] covering the results of five different clinical studies using bergamot in various forms, have suggested that the bergamot polyphenol fraction may lower LDL cholesterol (LDL-C) and total cholesterol (TC) levels. Several studies suggest that bergamot polyphenols may reduce triglycerides (TG) and increase HDL cholesterol (HDL-C), but the results were not consistent across all studies. As the authors pointed out, the studies had heterogeneous designs and their quality was rather limited [30,37].

More recent clinical studies not included in previous reviews have produced results confirming the beneficial effects of bergamot in lowering TCH [20,48,49], LDL-C [5,20,48,49], TG [20,48], and increasing HDL-C [48]. The use of bergamot flavonoid supplementation (Bergavit®) in people with elevated LDL-C levels who had not previously used statins resulted not only in improved lipid parameters but also in a reduction in carotid artery intima-media thickness (cIMT) after 6 months, suggesting an anti-atherosclerotic effect [53].

This effect was particularly evident with higher doses of bergamot extract (Endoberg/Kalita, 700 mg) and preparations derived from bergamot juice, enriched with flavonoids and pectins (1300 mg), showing a beneficial effect on TCH, LDL-C, HDL-C, and TG after only 6–9 weeks of treatment [6,20].

Interestingly, the combination of bergamot with other plant ingredients, such as artichoke leaf extract, produced synergistic therapeutic effects. Studies conducted by Riva et al. [48] showed that in patients with mild hypercholesterolaemia, in whom the previous use of bergamot alone did not produce the expected results, this combination led to a significant improvement in the lipid profile. Fogacci et al. [19] showed that after 6 weeks of dietary supplementation with a mixture of nutraceuticals containing bergamot and artichoke extracts, in addition to an improvement in the lipid profile, there was a significant improvement in the levels of apolipoprotein B-100 (Apo B-100) and apolipoprotein AI (Apo AI) levels, as well as non-high-density lipoprotein cholesterol (Non-HDL-C) levels compared to baseline values.

However, bergamot in combination with phytosterols, olive oil, and vitamin K2 did not affect the lipid profile of patients with hypercholesterolaemia without a clinical history of cardiovascular disease [45].

A summary of the results of studies on the effectiveness of bergamot in improving lipid parameters, anti-inflammatory markers, glucose tolerance, liver enzymes, and weight reduction is presented in Table 1.

Table 1. The effect of bergamot on metabolic parameters in humans.

No.	Type of study	Form of bergamot	Main outcome measures	Participants	Findings	References
1	Randomised, double-blind, placebo-controlled study lasting 12 weeks	Study group: CitriCholess capsules twice daily (500 mg of Citrus Bergamia Risso extract)	The effect of Citrus Bergamia extract supplementation on cholesterol levels and body weight in elderly people with dyslipidaemia	98 people over 50 years of age. Study group n=48, placebo n=48	Participants receiving CitriCholess experienced a statistically significant reduction in LDL-C levels (by 0.30 mmol/l; p = 0.032) compared to the placebo group. - A reduction in body weight (−0.604 kg vs +0.06 kg; p <0.01), waist circumference (−0.60 cm vs −0.16 cm; p <0.01) and BMI (−0.21 kg/m2 vs +0.025 kg/m2; p <0.01) was also observed. - Total cholesterol and triglycerides showed a downward trend, but without statistical significance	[5]
2	Randomised, double-blind, placebo-controlled study lasting 12 weeks	Study group: 2 tablets per day, containing a total of 500 mg of bergamot phytosome	The effect of bergamot phytosome supplementation on cholesterol levels and body weight in overweight or obese individuals with hypercholesterolaemia	64 overweight and obese individuals with mild hypercholesterolaemia	- After 30 days of supplementation, a reduction in visceral adipose tissue and TCH and LDL-C concentrations was observed in the bergamot phytosome group, but not in the placebo group. - No significant changes were observed in the other parameters (glucose, insulin, homeostasis model assessment, high-density lipoprotein cholesterol, triglycerides, lean body mass, fat mass)	[49]

No.	Type of study	Form of bergamot	Main outcome measures	Participants	Findings	References
3	Clinical trial (randomised, double-blind, placebo-controlled, 12 weeks)	Phytocomplex from bergamot fruit (Endoberg/Kalita), 350 mg and 700 mg daily	Assessment of metabolic and vascular effects after administration of a highly standardised bergamot supplement in healthy volunteers with features of metabolic syndrome	90 healthy adults (30 in each group) with metabolic syndrome characteristics	- After 12 weeks of using a higher dose: TCH ↓ by 13.2%, LDL-C ↓ 17.7%, TG ↓ 16.6%, HOMA-IR ↓ 12.2%, hs-CRP ↓ 17.9%, GGT ↓ 22.2%, with improvement in fat mass and endothelial reactivity; statistically significant improvement compared with placebo	[20]
4	Randomised, double-blind, placebo-controlled study lasting 60 days	Preparation containing 600 mg of bergamot polyphenol phytosome and 100 mg of standardised artichoke leaf extract (Indena SpA). Control group: tablets identical in shape, colour, taste, and smell	The effect of a 600 mg of phytosome containing bergamot polyphenols and artichoke leaf extract on cholesterol levels in individuals with a limited response to bergamot monotherapy	60 individuals aged 18–65 with mild hypercholesterolaemia and a BMI of 25–35 kg/m², without overt cardiovascular disease, who had previously responded poorly to bergamot supplementation	An improvement in the lipid profile was observed: a significant reduction in total cholesterol and LDL-C levels and an increase in HDL-C during supplementation. No similar changes were observed in the placebo group	[48]
5	Randomised, double-blind, placebo-controlled trial conducted over a period of 12 weeks.	Intervention group: tablets containing dry extract of artichoke, dry extract of bergamot, astaxanthin, chromium picolinate, and folic acid. Control group: placebo.	The effect of a supplement containing dry extracts of bergamot and artichoke on lipid profile, glycaemia, and liver function in individuals with mildly elevated cardiovascular risk and mild hypercholesterolaemia	90 patients aged 18 to 70 years, with LDL-C levels between >115 mg/dL and <190 mg/dL, triglycerides (TG) <400 mg/dL, and an estimated 10-year cardiovascular risk of <5%	Supplementation with polyphenols derived from dry extracts of artichoke and bergamot demonstrated beneficial effects on lipid profile, inflammatory status, liver steatosis markers, and endothelial function	[19]
6	Prospective observational study. The study lasted for 6 months.	Flavonoid extract from bergamot (Bergavit R(®)) in a fixed daily dose (150 mg flavonoids, with 16% neoeriocitrin, 47% neohesperidin and 37% naringin)	The effect of bergamot extract supplementation in patients not previously taking statins on lipid metabolism in individuals with moderate hypercholesterolaemia	80 people with hypercholesterolaemia, aged 55 on average, who had not previously taken statins	- Supplementation significantly reduced plasma lipid concentrations, including TCH, TG and LDL-C, and had a beneficial effect on the lipoprotein profile by reducing the number of small dense LDL particles. - A significant reduction in cIMT was observed	[53]
7	Randomised, double-blind, placebo-controlled study. The study lasted 90 days	BPE-C - Bergamot juice polyphenol extract complex (ВПЕ-complex TM) in capsule form at a dose of 0/650/1300 mg/day	Assessment of the effectiveness of the polyphenol complex of bergamot extract on certain parameters of metabolic syndrome, including body weight, BMI, TC, LDL-C, TG and blood glucose concentration	52 individuals aged 40–80 years with metabolic syndrome, who had not previously received lipid-lowering therapy, were enrolled in the study. Participants were divided into three groups: low-dose BPE-C treatment (n=17), high-dose BPE-C treatment (n=18), and a control group (n=17). The study was completed by 45 participants	Reduction in body weight and body mass index (BMI). Decrease in fasting glucose levels in the low- and high-dose BPE-C treatment groups by 12.1% and 18%, respectively, compared to the placebo group. Significant reduction in total cholesterol (TCH) and low-density lipoprotein cholesterol (LDL-C), accompanied by an increase in high-density lipoprotein cholesterol (HDL-C), in both the low- and high-dose BPE-C treatment groups. Decrease in triglyceride (TG) levels in the intervention group	[6]
8	Parallel, randomised, controlled, double-blind study	Nutraceutical combination containing phytosterols, bergamot, olive oil, and vitamin K2	Evaluation of the effect of a nutraceutical combination on lipid profile and inflammatory biomarkers in individuals with hypercholesterolaemia without a clinical history of cardiovascular disease	118 individuals (mean age ± SD, 57.9±8.8 years; 49 men and 69 women) with hypercholesterolaemia	- Compared to placebo, after 6 and 12 weeks, supplementation did not significantly reduce TCH, LDL-C, TG. - No changes were found in hs-CRP, interleukin-32, interleukin-38, miR-21, miR-126, miR-146a	[45]

TCH – total cholesterol, TG – triglycerides, LDL-C – LDL cholesterol, HDL-C – HDL cholesterol, cIMT – carotid intima-media thickness, HOMA-IR – Homeostasis Model Assessment of Insulin Resistance, GGT – gamma-glutamyltransferase, hs-CRP – high-sensitivity C-reactive protein, miR-21, miR-126, miR-146a – small non-coding RNA molecules that regulate gene expression at the post-transcriptional level.

Diabetes parameters

Fogacci et al. [20] demonstrated an improvement in insulin resistance indices (HOMA-IR) after supplementation with a standardised phytocomplex from bergamot fruit. A similar effect was observed after the use of bergamot juice enriched with flavonoids and pectins, which led to a reduction in insulin resistance (HOMA-IR), blood glucose levels, and fasting insulin levels in the group receiving a high dose [6].

Dietary supplementation with a nutraceutical mixture containing bergamot and artichoke extracts also improved glycaemia in patients and healthy individuals with malnutrition [48].

However, in a study conducted by Rondanelli et al. [49] the use of bergamot phytosome did not improve diabetic parameters (glucose, insulin).

A summary of the results of studies on the effect of bergamot supplementation on diabetes-related parameters in humans is presented in Table 2.

Weight loss

The effect of bergamot on weight loss has been observed previously, both in animal and human studies.

In recent studies, including a randomised, double-blind clinical trial conducted by Cai et al. [5] evaluating the effect of CitriCholess supplementation in elderly patients with dyslipidaemia, a significant reduction in body weight, waist circumference and BMI was observed. A reduction in body fat was also observed by Fogacci et al. [20] in a group of adults with mild hyperlipidaemia after supplementation with a high dose of a standardised bergamot phytocomplex. A preparation containing 600 mg of bergamot phytosome and 100 mg of standardised artichoke leaf extract resulted in a significant reduction in waist circumference and visceral fat after 2 months of supplementation in a group of patients with mild hypercholesterolaemia, even in those who did not follow a low-calorie diet [48].

In another study, Rondanelli et al. showed that 12 weeks of bergamot phytosome supplementation in overweight individuals with mild hypercholesterolaemia resulted in a significant reduction in visceral fat [49]. In a group of obese patients, administration of bergamot juice enriched with flavonoids and pectins reduced body weight by 14.8% and body mass index by 15.9% [6].

A summary of the results of studies on the effect of bergamot supplementation on body weight reduction, waist circumference and body fat content in humans is presented in Table 3.

Table 2. The effect of bergamot supplementation on diabetes-related parameters in humans.

No.	Type of study	Form of bergamot	Main outcome measures	Participants	Findings	References
1	Clinical trial (randomised, double-blind, placebo-controlled. 12 weeks)	Phytocomplex from bergamot fruit (Endoberg/ Kalita), 350 mg and 700 mg daily	The impact of a standardised bergamot phytocomplex on insulin resistance (HOMA-IR), fasting blood glucose, and fasting plasma insulin levels in adults.	90 healthy adults (30 in each group) with metabolic syndrome characteristics	HOMA-IR decreased by 12.2 ±2.1% in the high-dose group compared to placebo ($p<0.05$); Fasting glucose decreased by 5.6% (90±7 → 85±5 mg/dL); Fasting insulin levels decreased from 18.4±3.5 to 16.4±2.4 µU/mL ($p<0.05$).	[20]
2	Randomised, double-blind, placebo-controlled study. The study lasted 90 days.	BPE-C - Bergamot juice polyphenol extract complex (ВПЕ-complex TM) in capsule form at a dose of 0/650/1300 mg/ day	Evaluation of the effectiveness of a bergamot polyphenol complex in reducing insulin resistance, improving glycaemic control, and decreasing fasting insulin levels in patients with metabolic syndrome.	52 individuals aged 40–80 years with metabolic syndrome, who had not previously received lipid-lowering therapy, were enrolled in the study. Participants were divided into three groups: low-dose BPE-C treatment (n=17), high-dose BPE-C treatment (n=18), and a control group (n=17). The study was completed by 45 participants.	Fasting glucose levels were reduced by 18.1% in the high-dose group ($p<0.05$); HOMA-IR showed a significant reduction ($p<0.05$); Fasting insulin concentrations were significantly decreased ($p<0.05$).	[6]
3	Randomised, double-blind, placebo-controlled study lasting 60 days	Preparation containing 600 mg of bergamot polyphenol phytosome and 100 mg of standardised artichoke leaf extract (Indena SpA). Control group: tablets identical in shape, colour, taste, and smell	The effect of a 600 mg phytosome formulation containing bergamot polyphenols and standardised artichoke leaf extract on fasting blood glucose, fasting insulin levels, and insulin resistance (HOMA-IR) in overweight patients with hypercholesterolaemia.	60 individuals aged 18–65 with mild hypercholesterolaemia and a BMI of 25–35 kg/m², without overt cardiovascular disease, who had previously responded poorly to bergamot supplementation.	Fasting glucose, insulin, and HOMA-IR: no significant changes in either group ($p>0.05$); the difference between the supplement and placebo groups was not statistically significant. HbA1c was significantly reduced in the control group ($p<0.05$) but not in the supplement group.	[48]
4	Randomised, double-blind, placebo-controlled study lasting 12 weeks	Study group: 2 tablets per day, containing a total of 500 mg of bergamot phytosome	The effect of bergamot phytosome supplementation on fasting blood glucose, fasting plasma insulin, and insulin resistance (HOMA-IR) in overweight and obese subjects.	64 overweight and obese individuals with mild hypercholesterolaemia.	Fasting glucose, insulin, and HOMA-IR: no significant changes in either group ($p>0.05$); the difference between the bergamot and placebo groups was not statistically significant ($p=0.99$).	[49]

HOMA-IR – Homeostasis Model Assessment of Insulin Resistance, HbA1c – glycated haemoglobin

Table 3. The effect of bergamot supplementation on body weight reduction, waist circumference, and body fat content in humans.

No.	Type of study	Form of bergamot	Main outcome measures	Participants	Findings	References
1	Randomised, double-blind, placebo-controlled study lasting 12 weeks	Study group: CitriCholess capsules twice daily (500 mg of Citrus Bergamia Risso extract)	The effect of Citrus bergamia extract supplementation on body weight, waist circumference, and body mass index (BMI) in older adults with dyslipidaemia.	98 people over 50 years of age. Study group n=48, placebo n=48	Body weight decreased by 0.604±0.939 kg in the CitriCholess group compared to an increase of 0.06±0.74 kg in placebo (p<0.01). Waist circumference was reduced by 0.60±1.349 cm in the CitriCholess group versus 0.16±1.503 cm in placebo (p=0.01). BMI decreased by 0.207±0.357 kg/m2 in the CitriCholess group compared to an increase of 0.025±0.274 kg/m2 in placebo (p=0.001).	[5]
2	Clinical trial (randomised, double-blind, placebo-controlled, 12 weeks)	Phytocomplex from bergamot fruit (Endoberg/Kalita), 350 mg and 700 mg daily	The effect of a standardised bergamot phytocomplex on waist circumference, body mass index (BMI), and body fat content in adults.	90 healthy adults (30 in each group) with metabolic syndrome characteristics	Waist circumference decreased from 87.4±3.8 to 85.2±3.3 cm in the high-dose group (−2.2 cm), but the difference was not statistically significant compared with placebo (p>0.05). BMI decreased from 26.8±1.4 kg/m2 to 26.0±1.1 kg/m2 (−0.8 kg/m2) in the high-dose group with no significant difference versus placebo (p>0.05). Percentage body fat was significantly reduced by 9.7±1.1% in the high-dose group compared to baseline (p<0.05); however, no significant difference was observed versus placebo (p>0.05).	[20]
3	Randomised, double-blind, placebo-controlled study lasting 60 days	Preparation containing 600 mg of bergamot polyphenol phytosome and 100 mg of standardised artichoke leaf extract (Indena SpA). Control group: tablets identical in shape, colour, taste, and smell	The effect of a 600 mg phytosome formulation containing bergamot polyphenols and standardised artichoke leaf extract on weight loss, waist circumference reduction, body fat content, and visceral adipose tissue (VAT) in overweight subjects with hypercholesterolaemia.	60 individuals aged 18–65 with mild hypercholesterolaemia and a BMI of 25–35 kg/m², without overt cardiovascular disease, who had previously responded poorly to bergamot supplementation.	Waist circumference was reduced by 1.355 cm (95% CI: −1.919; −0.791) in the supplement group compared to 0.448 cm in the placebo group (not statistically significant). The between-group difference was −0.907 cm (p<0.05). Body fat content was decreased by 1133 g (95% CI: −1768; −498) in the supplement group. Visceral adipose tissue (VAT) was markedly reduced in the supplement group (p<0.05) despite the absence of caloric restriction.	[48]
4	Randomised, double-blind, placebo-controlled study lasting 12 weeks	Study group: 2 tablets per day, containing a total of 500 mg of bergamot phytosome	The effect of bergamot phytosome supplementation on body weight reduction, waist circumference, body fat content, and visceral adipose tissue (VAT) in overweight and obese subjects.	64 overweight and obese individuals with mild hypercholesterolaemia.	Body weight was significantly reduced in the supplement group (69.85→68.61 kg, p=0.001) and placebo group (76.23→74.53 kg, p=0.06). Waist circumference showed no significant changes in either group (p>0.05). Body fat content was significantly decreased in the supplement group (−302.47 g, p=0.002). Visceral adipose tissue (VAT) demonstrated a marked reduction in the supplement group (−130.08 g at 30 days, p<0.0001) compared with the placebo (−29.75 g, p=0.27).	[49]
5	Randomised, double-blind, placebo-controlled study lasting 90 days.	BPE-C - Bergamot juice polyphenol extract complex (ВПЕ-complex TM) in capsule form at a dose of 0/650/1300 mg/day	Assessment of the effectiveness of a bergamot polyphenol complex on body weight reduction, body mass index (BMI) reduction, body fat content, and atherogenic index (AIP) in patients with metabolic syndrome.	52 individuals aged 40–80 years with metabolic syndrome, who had not previously received lipid-lowering therapy, were enrolled in the study. Participants were divided into three groups: low-dose BPE-C treatment (n=17), high-dose BPE-C treatment (n=18), and a control group (n=17). The study was completed by 45 participants.	Body weight decreased by 14.8% in the high-dose group. BMI was reduced by 15.9% in the high-dose group. Body fat content was significantly decreased in the high-dose group. A marked reduction in atherogenic index (AIP) was observed, with values below 0.2 in the high-dose group. The effects were dose-dependent. Appetite-regulating hormones, including leptin and ghrelin, were significantly decreased, while adiponectin levels were increased in the high-dose group.	[6]

VAT – Visceral Adipose Tissue, BMI – Body Mass Index, AIP – Atherogenic Index

Liver enzymes

Rondanelli et al. demonstrated that 12 weeks of supplementation with bergamot phytosome in overweight individuals with mild hypercholesterolaemia resulted in a significant improvement in liver enzymes (ALT, AST) [49]. Weekly use of a dietary supplement containing dry extracts of bergamot and artichoke in malnourished individuals resulted in a significant improvement in alanine transaminase (ALT) and gamma-glutamyl transferase (GGT) levels compared with placebo [19]. Supplementation of adult patients

with a standardised bergamot phytocomplex (Endoberg by AKHYNEX and Kalita by Giellepi) also reduced glutamyl transferase levels after 12 weeks compared to baseline values and placebo [20].

Anti-inflammatory markers

Fogacci et al. [20] showed in a study involving 90 participants that supplementation with a standardised bergamot phytocomplex leads to a significant reduction in inflammatory markers such as hs-CRP. Similarly, the use of a dietary supplement containing dry extracts of bergamot and artichoke in malnourished individuals resulted in a significant improvement in hs-CRP levels compared with placebo after only 6 weeks [19].

On the other hand, the use of a combination of nutraceuticals containing phytosterols, bergamot, olive fruit and vitamin K2 did not result in a significant reduction in inflammatory biomarkers such as hs-CRP, interleukin-32, interleukin-38, miR-21, miR-126, and miR-146a in patients with hypercholesterolaemia without a history of cardiovascular disease [45].

Mental health and sleep quality

Bergamot essential oil has shown sedative and anxiolytic effects comparable to those of diazepam. Inhaling bergamot oil also reduces depression-like behaviour, similarly to fluoxetine, as demonstrated in animal studies [50]. Recent studies on animal models have confirmed an improvement in depression-like behaviour in rats and have also shown protection of hippocampal neuronal plasticity as a result of the use of bergamot essential oil [9].

In humans, a significant effect of bergamot oil-based spray on alleviating mental stress, depression, and anxiety has also been observed. In a group of healthy adults using bergamot, a significant improvement in depression, anxiety, and stress scores was found [57]. Inhalation of bergamot oil vapour in healthy women reduced cortisol levels in the RWB configuration and caused an increase in high-frequency heart rate (HF), which is an indicator of parasympathetic nervous system activity, compared with groups at rest or at rest inhaling water vapour. Scores for negative emotions and fatigue also improved [59].

In another study, even a short 15-minute exposure to bergamot essential oil improved participants' positive affect of compared with the control group (by 17%) [28]. Interestingly, lavender-bergamot essential oil (La-Ber) improved sexual function, anxiety, and depression scores in postmenopausal women with sexual dysfunction even 8 weeks after the end of the study [35]. Bergamot oil used in aromatherapy also improved depressive mood in postpartum women, but did not improve sleep quality [10].

In several other studies, bergamot essential oil appeared to be a safe and inexpensive method for improving sleep quality and morning alertness. In studies involving students, when used before bedtime and after waking up in the form of a spray, it reduced feelings of sleepiness and increased feelings of freshness after getting up, and also prolonged sleep duration [57]. Bergamot oil, together with lavender and ylang-ylang oils, also improved sleep quality in cardiac rehabilitation patients compared with placebo [34].

A summary of the results of studies on the effect of bergamot on mental health and sleep quality in humans is presented in Table 4.

DISCUSSION

The results of the presented studies confirm the beneficial effect of bergamot extracts, especially those standardised for polyphenol content, on a number of metabolic parameters, with particular emphasis on the lipid profile. The most frequently observed statistically significant reductions were in total cholesterol, LDL-C, and triglyceride levels, as well as increases in HDL-C levels. These effects were particularly pronounced when high doses of the extract or preparations enriched with additional bioactive ingredients, such as pectins or flavonoids, were used [6,20]. The effectiveness of preparations such as Bergavit®, Endoberg, and BPE-C suggests that appropriate standardisation and selection of the form of supplementation play an important role in the efficacy of the intervention.

Although earlier systematic reviews and meta-analyses pointed to the limited quality and heterogeneity of the studies [30,37], more recent, better-designed studies confirm that bergamot can be a valuable adjunct in the treatment of lipid disorders, especially in patients with mild hypercholesterolaemia and metabolic syndrome. Importantly, some studies have also shown a reduction in carotid intima-media thickness (cIMT), which may indicate an anti-atherosclerotic effect [53].

With regard to diabetes-related parameters, the data are less clear. Although some studies have shown improvements in the HOMA-IR index and reductions in fasting glucose and insulin concentrations [6,20], not all studies have

Table 4. The effect of bergamot on mental health and sleep quality in humans.

No.	Type of study	Form of bergamot	Main outcome measures	Participants	Findings	References
1	Placebo-controlled, randomised, open-label, two-arm, two-period crossover study. Intervention duration: 1 week, with a 1-week washout period	Bergamot oil-based spray (30 drops of bergamot essential oil, 10 ml of absolute ethanol and 90 ml of mineral water per 100 ml – a solution with a concentration of approximately 1.5%) or placebo before bedtime and after waking up in each period.	Sleep quality and morning alertness were assessed using the Ogri-Shirakawa-Azumi Sleep Inventory (OSA-MA). Secondary outcome measures were depression, anxiety, and stress, assessed using the Depression Anxiety Stress Scale-21 (DASS-21).	48 university students	In the group using bergamot: - significant improvement in 'sleepiness after waking up', 'refreshment after getting up' and 'length of sleep', - significant improvement in depression, anxiety and stress scores.	[57]
2	Randomised, placebo-controlled, two-arm study	Research group (n = 29) – bergamot oil aroma/ control group (n = 31) – pure water aroma	The effect of aromatherapy intervention using bergamot oil on depressive mood and sleep quality in postpartum women.	60 women staying at a postnatal care centre	Significantly lower depressive mood in the experimental group compared with the control group.	[10]
3	Randomised, double-blind crossover trial comparing treatment with placebo Duration: 5 nights	Cotton balls soaked in a mixture of lavender, bergamot, and ylang-ylang or a placebo were placed next to the beds of the subjects.	The effect of aromatherapy intervention consisting of a mixture of Lavandula x intermedia (Lavandin Super), Citrus bergamia (bergamot) and Cananga odorata (ylang-ylang) on sleep quality.	42 adult patients undergoing rehabilitation after cardiac hospitalisation	Statistically significantly lower mean global Pittsburgh Sleep Quality Index (PSQI) score, significantly better sleep quality, significantly less need to get up to use the toilet, and fewer sleep problems due to cold in the intervention group compared with placebo.	[34]
4	Random cross-sectional study	Volunteers were subjected to three experimental configurations (rest (R), rest + steam (RW), rest + steam + bergamot oil (RWB)) for 15 minutes each.	The primary objective was to obtain initial clinical evidence of psychological and physiological effects. The secondary objective was to achieve a basic understanding of the relevant pharmacological processes.	41 healthy women	Cortisol levels in the RWB configuration were significantly lower, and high-frequency heart rate, an indicator of parasympathetic nervous system activity, increased compared with the R and RW configurations. Results in terms of negative emotions and fatigue also improved.	[59]
5	Controlled, randomised study Duration: three sessions per day for eight weeks. Eight Mindfulness-Based Intervention (MBI) intervention sessions.	Participants were randomly assigned to 4 groups: Aromatherapy–Routine Care (Aroma-RC), MBI–Placebo (MBI-P), Aromatherapy–MBI (Aroma-MBI) or Routine Care–Placebo (RC-P). 2–3 drops of La-Ber or a similar placebo. Results were evaluated 8 weeks after the intervention.	Assessment of the impact of lavender-bergamot essential oil (La-Ber) and Mindfulness-Based Intervention (MBI) on sexual function, anxiety and depression scores in postmenopausal women with sexual dysfunction.	132 postmenopausal women	Improvement in sexual function in the Aroma-MBI and MBI-P groups compared with the RC-P group.	[35]
6	Pilot observational study. Duration: 15 minutes	Aromatherapy with a diffuser containing bergamot oil	The study assessed the effect of bergamot essential oil inhalation on mental health and well-being, measured using the Positive and Negative Affect Schedule, in a mental health treatment centre.	57 patients treated at a mental health treatment centre in Utah, USA (50 women aged 23–70).	Fifteen minutes of exposure to bergamot essential oil improved participants' positive affect compared to the control group (by 17%).	[28]

confirmed these effects [49]. This may be due to differences in the study populations (e.g. age, BMI, degree of insulin resistance), the duration of the intervention, and the form and bioavailability of the preparations used. It should also be noted that the improvement in glycaemic parameters was usually secondary to weight loss and improvement in the lipid profile, which may indicate an indirect mechanism of action.

The effect of bergamot on weight loss and fat reduction, especially visceral fat, has been confirmed in several independent randomised, placebo-controlled studies [5,20,49]. These effects appear to be independent of dietary intervention and may be related to thermogenic action and effects on lipid metabolism. In addition, the beneficial effect on liver enzymes (ALT, AST, GGT) indicates the potential use of bergamot in the

prevention and treatment of non-alcoholic fatty liver disease [19,49].

The effect of bergamot on inflammatory markers, such as hs-CRP, seems promising, especially when using preparations enriched with other plant ingredients, such as artichoke extract [19,48]. The lack of effects in studies of complex nutraceutical preparations [45] may be due to interactions between ingredients or low bioavailability of active compounds.

Despite the growing number of clinical studies, certain limitations should be noted. Most studies are characterised by a relatively short duration (6–12 weeks), small sample sizes, and a lack of long-term observation of metabolic and safety effects. In addition, the variety of bergamot formulations used and the lack of dose standardisation make it difficult to compare results between studies.

In light of the above, supplementation with bergamot extract may be a valuable adjunct to the treatment of lipid, metabolic, and inflammatory disorders, especially in patients with mild hypercholesterolaemia and metabolic syndrome. Nevertheless, further research is needed to confirm these observations. In particular, multicentre, randomised clinical trials with longer follow-up periods are desirable to assess the durability of the effects and the safety of long-term use of bergamot. Another important direction is to compare different forms of preparations, including standardised extracts, phytosomes, and food products, in order to identify the form with the highest bioavailability and efficacy. Bergamot-based preparations may have potential applications in military pilots, a professional group exposed to factors known to adversely affect lipid metabolism, including chronic stress, circadian rhythm disruption, and sustained cognitive and physical demands. These occupational conditions are recognised contributors to the development of metabolic disturbances, including dyslipidaemia. Clinical evidence indicating beneficial effects of standardised Citrus bergamia extracts on total cholesterol, LDL-C, triglycerides, inflammatory markers, and endothelial function suggests that bergamot supplementation could be a supportive element within preventive strategies in aviation medicine. Given its favourable safety profile and good tolerability, bergamot may be of interest as an adjunctive option in individuals presenting with mild lipid abnormalities, particularly when conventional pharmacological interventions are limited or not immediately indicated. However, targeted clinical studies specifically addressing military aviation personnel are required to substantiate these potential benefits.

It is also worth considering diverse clinical populations, such as people with type 2 diabetes, metabolic syndrome, non-alcoholic fatty liver disease, or older adults. The use of more advanced biochemical markers, such as lipoprotein subfractions, insulin resistance indices, adipokine concentrations, and inflammation biomarkers, may contribute to a better understanding of the effects of bergamot at the metabolic level. Another interesting area is the analysis of bergamot's interaction with commonly used drugs, especially statins and antidiabetic drugs, as well as the potential effects of combination therapy with other bioactive substances, such as flavonoids, artichoke, or prebiotics. In addition, basic research aimed at understanding the molecular mechanisms of action, such as the effects on gene expression, regulation of the gut microbiota, or endothelial and mitochondrial function, could significantly expand our knowledge of the therapeutic potential of bergamot in the context of metabolic disorders. Data from preclinical studies and earlier clinical trials indicate that bergamot essential oil may have a beneficial effect on mental health and sleep quality. Studies on animal models confirm the anxiolytic and antidepressant effects of bergamot, comparable to diazepam and fluoxetine [9,50]. This suggests that the active ingredients in bergamot may affect neurotransmitter pathways associated with mood regulation, such as GABA and serotonin, and support neuroplasticity, particularly in the hippocampus.

The latest results of human studies also confirm the health-promoting effects of bergamot in the context of stress reduction, mood improvement, and alleviation of symptoms of depression and anxiety. Studies by Waku et al. [57] conducted among students showed that using a spray containing bergamot oil before bedtime and after waking up improved sleep quality and reduced levels of depression, anxiety, and stress. A subjective improvement in morning alertness was also observed, which may have practical implications for improving cognitive and mental functioning.

Short-term inhalation of bergamot oil, as shown in studies by Han et al. [28] and Watanabe et al. [59], resulted in a significant improvement in positive emotions, reduced fatigue and cortisol levels. The increase in parasympathetic nervous system activity indicates the relaxing effect of bergamot, which may be particularly beneficial in healthy individuals exposed to chronic stress.

Interestingly, in a study by Mojtehedi et al. [35], the use of aromatherapy with a mixture of lavender and bergamot (La-Ber) in combination with mindfulness techniques brought long-term benefits in postmenopausal women: not only did anxiety and depression scores improve, but sexual function improved as well. This may indicate a more complex and multidirectional effect of these oils on the central nervous system and endocrine system.

However, not all studies have shown an effect on sleep quality. For example, in a study by Chen et al. [10], although bergamot oil reduced depressive mood in postpartum women, no improvement in sleep parameters was observed. This may suggest that the effects of bergamot on sleep depend on the clinical context, the form used (pure oil vs. blend), and any coexisting psychophysical problems.

In contrast, McDonnell et al. [34] showed that the use of a blend of oils (bergamot, lavender, and ylang-ylang) in cardiac rehabilitation patients improved sleep quality, suggesting the potential for combination therapy in hospital settings.

Despite the positive effects demonstrated in many studies, important limitations should be noted. First of all, most of the available studies concern short-term interventions, often with small sample sizes and variable methodological quality. Differences in the method of administration, concentration, and combinations with other oils (e.g. lavender or ylang-ylang) make it difficult to clearly attribute the observed effects to bergamot alone. In many studies, the influence of the placebo effect and the expectations of participants, which can be particularly strong in the case of olfactory interventions, were not controlled.

Nevertheless, the available data allow bergamot oil to be considered a promising natural option for supporting mental health and sleep quality, especially in mild states of tension, mood disorders, and during convalescence. Due to its good tolerance and low risk of side effects, it may complement traditional therapies, particularly for individuals who prefer non-pharmacological methods.

Although the results to date indicate a beneficial effect of bergamot oil on mental health and sleep quality, further research is needed, especially long-term studies. It will be crucial to determine the durability of the effects and the optimal dose and form of administration.

It is also worth expanding our understanding of neurobiological mechanisms using modern brain imaging techniques (e.g. fMRI, EEG). Research involving broader population groups, including people with mental disorders and different age profiles, remains an important area.

Research into the potential interactions of the oil with psychotropic drugs and an assessment of its use in the prevention of stress and insomnia are also recommended. Future work should also take into account real-life everyday conditions in order to better assess the real effectiveness of aromatherapy interventions.

CONCLUSIONS

Bergamot has multifaceted therapeutic potential, including beneficial effects on lipid metabolism, cardiovascular function, liver homeostasis, and mental health. The best-documented effect is improvement in the lipid profile, especially in individuals with mild hypercholesterolaemia not treated with statins, which highlights its role as an effective adjuvant in the treatment of dyslipidaemia.

In addition, bergamot supplementation may reduce insulin resistance, glycaemia, and body weight, and has anti-inflammatory and hepatoprotective effects. Its effectiveness depends on the standardisation of the preparation, the dose, and the duration of use, with the best results after at least 8–12 weeks.

In terms of mental health, bergamot essential oil has anxiolytic and antidepressant properties, lowering cortisol levels and improving sleep quality and well-being, especially when used in aromatherapy, particularly in combination with other oils.

Due to its properties supporting both metabolic and mental health, bergamot may be particularly useful in high-stress environments that require maximum mental and physical fitness, such as military aviation. For pilots and flight personnel exposed to chronic stress, circadian rhythm disturbances, and physical and cognitive overload, the use of natural supportive interventions can be a valuable complement to conventional methods of prevention and treatment.

Despite promising results, further high-quality clinical studies are needed to precisely determine the mechanisms of action, optimal doses, and long-term safety of bergamot preparations. Bergamot represents a promising component of complementary therapy for metabolic and psychosomatic disorders, but it should be integrated with conventional treatment.

AUTHORS' DECLARATION

Study Design: Patrycja N. Dadyńska, Mateusz Bartkowiak, Natasza Bolesławska-Król, Alicja Drzewiecka, Elżbieta Janda, Izabela Bolesławska, Sławomira Drzymała-Czyż. **Statistical analysis:** Patrycja N. Dadyńska, Mateusz Bartkowiak, Natasza Bolesławska-Król, Alicja Drzewiecka, Elżbieta Janda, Izabela Bolesławska, Sławomira Drzymała-Czyż. **Data Collection:** Patrycja N. Dadyńska, Mateusz Bartkowiak, Natasza Bolesławska-Król, Alicja Drzewiecka, Elżbieta Janda, Izabela Bolesławska, Sławomira Drzymała-Czyż. **Manuscript Preparation:** Patrycja N. Dadyńska, Mateusz Bartkowiak, Natasza Bolesławska-Król, Alicja Drzewiecka, Elżbieta Janda, Izabela Bolesławska, Sławomira Drzymała-Czyż. The Authors declare that there is no conflict of interest.

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