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EXPLORING THE HEALTH BENEFITS OF MUESLI AND SELENIUM: A REVIEW

***Maija Gertsone, Asnate Ķirse-Ozoliņa**
Latvia University of Life Sciences and Technologies, Latvia
*Corresponding author's e-mail: maijagertsone@gmail.com

Abstract
Regular breakfast consumption is associated with lower risks of cardiovascular disease, especially for those who consume more than 25 grams of dietary fiber daily. Systematic reviews show that breakfast cereals enriched with oats, barley, and fruits can effectively reduce cholesterol levels and lower the risk of diabetes and heart disease due to their fiber and bioactive compounds. Additionally, selenium plays a crucial role in the diet by supporting immune function, reproductive health, and reducing the risk of chronic diseases. Notably, selenium was chosen for this study because no muesli products currently exist that are specifically fortified with selenium. This study explores the health benefits of muesli and selenium through a review of literature from 2020 to 2025 using databases like Google Scholar, ScienceDirect, and EBSCOhost. The research highlights potential benefits of selenium-rich muesli, such as lower obesity rates, improved metabolism, and better thyroid health. A total of 63 articles were reviewed, reinforcing the significance of a nutritious diet in preventing cardiovascular diseases (CVD) and coronary artery disease (CAD). The paper encourages awareness and consumption of selenium-rich muesli to enhance overall health and well-being. The study highlights the significance of dietary choices in promoting better public health outcomes and the role of nutrition education in promoting healthier eating habits. Additionally, the results indicate that incorporating such nutrient-dense foods into daily diets could result in long-term health improvements and lower healthcare costs associated with managing chronic diseases.
Keywords: muesli health benefits, muesli nutrition, selenium and thyroid function, selenium and autoimmunity, selenium deficiency.

Introduction

Muesli is composed of a mix of cereals, nuts, and dried fruits, and has gained popularity as a nutritious breakfast option due to its potential health benefits. Research indicates that the soluble fibers found in muesli, particularly beta-glucan from oats and barley, may enhance satiety and contribute to heart health by lowering cholesterol levels (Hughes & Grafenauer, 2021; Santos et al., 2022). As dietary patterns evolve, muesli is emerging as a favored choice among health-conscious consumers, often promoted for its rich nutrient profile and versatility in meal preparation (Gréa et al., 2025).

In addition to the benefits associated with whole grains and dietary fibers, selenium - a vital micronutrient - plays a significant role in human health. Selenium contributes to various biological processes, including immune function and thyroid hormone metabolism (Hong & Diamond, 2020; Minich, 2022). However, selenium deficiency is a widespread issue, affecting populations in both developing and developed countries (Zhang et al., 2023; Azevedo et al., 2023). Understanding the interrelationship between muesli consumption and selenium bioavailability is critical for maximizing dietary health benefits.

This review specifically chose to compare selenium due to the absence of commercially available muesli products that are high in this essential micronutrient. Despite selenium's known benefits in supporting thyroid function and reducing thyroid autoimmunity, there is currently a gap in the market for muesli formulations enriched with selenium. By focusing on this nutrient, the review aims to explore the potential health benefits that a newly developed selenium-rich muesli could provide.

Materials and Methods

Monographic method was used for this study. Relevant scientific literature was gathered to investigate the health benefits of muesli and selenium consumption. Comprehensive searches were conducted using databases such as Google Scholar, ScienceDirect, and EBSCOhost. The literature review is based on published studies from the last 5 years, emphasizing the most recent studies. The selection of publications was based on the following criteria:

Language: Only articles published in English were considered.

Focus: Studies needed to address the health effects of muesli and selenium specifically, with a particular emphasis on articles that discussed the fortification of muesli with selenium.

Availability: Only publications for which the full text was accessible were included.

Despite targeted queries for articles focusing on the fortification of muesli with selenium, no studies were found that specifically addressed this topic. Most existing literature concentrated on the nutritional benefits of individual grains or general dietary sources of selenium, rather than muesli as a fortified product.

Initially, a total of 121 publications were identified through the search. After applying the inclusion criteria, 63 articles met the necessary requirements for detailed analysis in this literature review.

The search terms utilized and corresponding results are documented in Table 1, providing clarity on the keywords that guided the literature selection process.

This structured approach enables the review to thoroughly gather and present the latest research on the nutritional advantages of muesli and selenium. By doing so, it deepens our understanding of their health implications, especially given the identified gap in the literature concerning muesli fortification. This detailed examination not only highlights the potential benefits but also underscores the need for further exploration in this area, paving the way for informed discussions and future research.

Table 1
Search terms used and number of papers identified

Search terms and number of papers identified	*Number of papers identified*
'Muesli health benefits'	6
'Muesli and cardiovascular disease risk'	5
'Muesli consumption and BMI'	4
'Muesli nutrition'	10
'Selenium and thyroid function'	6
'Selenium and autoimmunity'	7
'Selenium deficiency'	10
'Selenium deficiency in Latvia'	3
'Selenium bioavailability'	6
'Selenium supplementation'	6

Results and Discussion

Muesli nutrition

Many people around the world base their daily diets on grains. Grains are plant seeds that mostly fall under the legume, cereal, and pseudocereal botanical categories. In the human diet, they provide micronutrients like vitamins and minerals as well as macronutrients like proteins, fats, and carbohydrates (Carcea, 2020).

Muesli, a Swiss dish made from different cereals, nuts, and dried fruits, is added to dairy products and is being researched for its potential to increase satiety. Muesli prepared from rye or oats may be regarded as a source of soluble fibers like beta-glucan (Santos et al., 2023).

Oat groats have a protein level of 13–20%. About 30% of the oat embryo is made up of proteins. Antioxidant substances such tocols, phenolic compounds, and sterols are other trace amounts of oats that are linked to positive health effects. Tocopherols and tocotrienols, which together form tocols, are the primary contributors to vitamin E activity (Paudel et al., 2021).

Oats have been shown to contain several phenolic compounds, including avenanthramides (AVAs), p-hydroxybenoic acid, vanillic acid, tricin, apigenin, luteolin, kaempferol, quercetin, ferulic acid, caffeic acid, protocatechuic acid, syringic acid, p-coumaric acid, sinapic acid, tricin, apigenin, luteolin, and caffeic acid (Paudel et al., 2021).

Beta glucan, a beneficial and chemically comparable polysaccharide, is present in both barley and oats. Depending on the type, barley has 4–10% w/w β-glucan and oats 6–8% (Hughes & Grafenauer, 2021). It is composed of a linear branched chain of D-glucose monosaccharides joined by a combination of β (1 → 3) and β (1 → 4) links and is one of the main constituents of soluble fiber. Known for several nutritional and functional qualities, including its ability to decrease cholesterol and prevent diabetes, it is thought to be the main active ingredient in oats (Paudel et al., 2021).

The research by Gréa et al. (2025) highlights significant trends in the Nutri-Score classification of breakfast cereals in Germany. It reveals an increase in fat content, particularly in children's muesli (39.0%), compared to other breakfast cereal categories, while non-children's muesli demonstrated a reduction in sugar content (9.2%). The study suggests that reducing saturated fat can notably decrease negative points in Nutri-Score ratings. Furthermore, substituting palm oil with healthier alternatives, such as sunflower oil, could effectively enhance the nutritional profile of mueslis. This emphasizes the importance of mindful ingredient choices in improving the healthfulness of breakfast cereals (Gréa et al., 2025).

When creating new muesli, a variety of nutrient-rich ingredients can be included to enhance both flavor and health benefits, e.g., nuts and seeds.

Hazelnuts: A great source of healthy fats, especially monounsaturated and polyunsaturated fatty acids, hazelnuts contain important lipids like palmitic, stearic, linoleic, and α-linolenic acids, the latter being a precursor for omega-3 fatty acids (Poșta et al., 2022).

Walnuts: Renowned for their high monounsaturated fatty acid content, walnuts are an excellent source of omega-3 fatty acids and antioxidants. They help in reducing cholesterol and oxidative stress (Bell et al., 2025).

Sesame Seeds: High in oil content (57–63%), sesame seeds are rich in protein and minerals such as iron and calcium. Their lignans, sesamin and sesamolin, contribute to antioxidant stability (Orngu & Mbaeyi-Nwaoha, 2022).

Flaxseeds: With around 41% fat and a high content of α-linolenic acid, flaxseeds are a valuable source of dietary fiber and phenolic compounds (Abbasi et al., 2022).

Chia Seeds: These seeds are rich in dietary fiber (30–34 g per 100 g), providing both soluble and insoluble fibers, as well as important minerals like calcium and phosphorus (Agarwal et al., 2023).

Sunflower Seeds: Containing about 51.46 g of total lipid per 100 g, along with protein, carbohydrates, and fiber, sunflower seeds are an excellent source of choline and betaine (Petraru et al., 2021).

Pumpkin Seeds: A great source of minerals like phosphorus and magnesium, pumpkin seeds are rich in trace minerals, making them a valuable addition to muesli (Marcel et al., 2021).

Matcha: Exceptionally rich in antioxidants, particularly catechins, with epigallocatechin gallate (EGCG) being the most significant one. These antioxidants are essential for combating oxidative stress and reducing inflammation within the body (Monfared et al., 2022).

Cacao: Integrating cacao into muesli not only enhances flavor but significantly boosts its nutritional profile, making it an even healthier breakfast option (Carmona-Rojas et al., 2022). Integrating these ingredients into muesli not only enhances its nutritional value but also offers a wider range of flavors and textures, creating a nutritious and satisfying breakfast option (Andrejaš et al., 2020).

Muesli and weight management

Regular consumption of muesli is associated with lower body mass index and a lower risk of obesity, especially for products rich in fiber (Santos et al., 2022). The effect of fiber and grain constituents can be explained by controlling the intestinal microbiota and preventing the growth of pathogenic bacteria for instance, avenanthramides from whole oats can be efficiently used by the gut microbiota, generating bioactive metabolites and preventing obesity (Zhang et al., 2020).

The findings from Liu & Cai (2023) study showed association between muesli consumption and improved health outcomes, particularly in the context of weight management. The genetically predicted intake of muesli was significantly linked to the reduction in body mass index, indicating its potential role in maintaining a healthy weight. Additionally, the suggestive associations with lower levels of LDL cholesterol and hemoglobin A1c further reinforce the idea that muesli may be beneficial not only for weight management but also for overall metabolic health (Liu & Cai, 2023).

The consumption of muesli and cereals is associated with several beneficial effects, including reductions in body weight and improvements in adiposity markers. Additionally, these foods may influence glyco-metabolic gastrointestinal hormones, mitigate oxidative stress, and promote genomic adaptations (Tang et al., 2024).

Health effects of muesli

Whole grains offer a substantial chance to prevent and treat increased cholesterol and reduce the risk of CVD (Hughes & Grafenauer, 2021). Muesli is one of the current trends in cereal foods, as people's lifestyles are changing due to the fast pace of life, but it is important to get all the nutrients (Chow et al., 2024). Recent studies have shown that eating breakfast is associated with a reduced incidence of cardiovascular disease. Regular daily breakfast intake is associated with lower total and cardiovascular mortality, especially when consuming fiber >25 g per day (King & Xiang, 2021). Some foods, such as oatmeal, barley, rye, psyllium, chia seeds, goji berries, apples, oranges and various berries, are effective in reducing low-density lipoprotein (LDL) levels (Kenneth & Feingold, 2024). Oats have been shown to improve gut flora and promote immunomodulation, which are both good for human health. Consumption of oats also helps prevent conditions including dermatitis, atherosclerosis, and some types of cancer (Paudel et al., 2021).

Two systematic reviews of studies that included nutritional analyses of breakfast cereals concluded that they help lower cholesterol levels, improve bowel function, and reduce the risk of diabetes and cardiovascular disease (Santos et al., 2022). Diets that include plant-based foods rich in fruits, whole grains, and limiting red meat, especially processed foods, reduce the risk of coronary artery and cardiovascular disease (WHO, 2021). It is still unclear whether specific foods have a direct effect on the risk of cardiovascular disease (Yang et al., 2023). Can we eat one food every day, such as muesli, and reduce the risk of coronary artery disease? A study conducted in Europe showed that regular muesli consumption was statistically negatively associated with the risk of coronary artery disease. The association between muesli and reduced risk of CVD was observed in population cohort studies (Park et al., 2024).

A large-scale longitudinal study found that consumption of breakfast cereals, bran cereals, and oat cereals did not demonstrate a significant association with a reduced risk of diabetes. However, muesli emerged as a potential protective factor against both diabetes and cardiovascular diseases. This suggests that muesli may offer unique health benefits that warrant further exploration (Tang et al., 2024).

It has been demonstrated that consuming 3 g of beta glucan daily significantly reduces blood cholesterol levels and circulating LDL cholesterol, two important risk factors for cardiovascular disease (Hughes & Grafenauer, 2021). The advantages of eating more whole grain meals on a regular basis are well established; Marshall et al. (2020) state that for every 16 g increase (one serving), the risk of cardiovascular disease is reduced by 9% (Marshall et al., 2020).

Health benefits of a muesli that is high in selenium

A muesli high in selenium offers numerous health benefits, particularly in promoting cardiovascular health and enhancing immune function. Selenium is a vital trace mineral that plays a crucial role in antioxidant activity, helping to neutralize free radicals and reduce oxidative stress, which is linked to various chronic conditions, including heart disease (Méplan & Hughes, 2020). Studies suggest that adequate selenium intake may significantly lower the risk of coronary artery disease (Sun et al., 2021), while enhancing thyroid function (Gärtner & Köhrle, 2022). Additionally, selenium's role in immune response has been well-documented, with research indicating that it may improve the body's ability against infections (Bell et al., 2024). While there has not yet been a muesli specifically focused on adding selenium, it is planned to fortify wheat grains by soaking them in selenium-containing solutions. Dūma & Kārkliņa demonstrated that wheat grains can be effectively fortified with the microelement selenium by soaking them in sodium selenate solutions (Dūma & Kārkliņa, 2006). Their findings revealed a remarkable increase in total selenium content, showing an 81.5x increase when grains were soaked in the highest concentration of 200 mg L^{-1} sodium selenate solution. This method presents a viable approach for enhancing the selenium content in wheat grains.

By incorporating ingredients high in selenium such as Brazil nuts, sunflower seeds, and whole grains, consumers can benefit from the essential properties of selenium while enjoying a delicious and nutritious breakfast option (Jones & Poutanen, 2020).

Selenium requirements and sources

The World Health Organization (WHO) recommends an intake of 55 μg day^{-1} of selenium for adults, with an upper limit of 400 μg day^{-1} (Zhang et al., 2023). Meanwhile, selenium mostly generates the immune-boosting and antioxidant benefits, along with some anticarcinogenic effects, at a dosage of 150–200 μg day^{-1}. The tolerable upper intake level (UL) is set at 400 micrograms per day for adults. Consumption of selenium above this level, especially over a long period, can lead to toxicity (Minich, 2022). Maternal selenium requirements also increase during pregnancy and lactation, reaching 70 μg day^{-1} in pregnant women. Studies have shown that this amount of selenium intake is sufficient for the effective functioning of selenoenzymes, but the levels necessary for the regulation of autoimmunity have not yet been determined. Blood selenium levels mainly depend on recent dietary intake and selenium form ingested (Veisa et al., 2021).

Cereals are the main source of selenium; however, their selenium content is relatively low, ranging from 0.01 to 0.55 μg g^{-1}. Selenium content ranges from 0.08 to 0.7 μg g^{-1} in animal foods and less than 0.1 μg g^{-1} in vegetables and fruits. Brazil nuts are the richest dietary source of selenium, with selenium levels of up to 1920 μg 100 g^{-1}. To achieve the daily value of 55 mcg: 1 Brazilian nut (providing about 68-91 mcg) is sufficient to meet or exceed the daily requirement. Other foods such as oysters (154 μg 100 g^{-1}), tuna (108 μg 100 g^{-1}), chia seeds (100 μg 100 g^{-1}), and sunflower seeds (100 μg 100 g^{-1}) are also rich sources of selenium (Godos et al., 2022).

Soil is the main source of selenium in plants. If the total selenium content of the soil is below 0.1 mg kg^{-1}, it is considered a significant selenium deficiency in the soil, from 0.2–0.3 mg kg^{-1} is a low selenium content, and soil with a content of more than 0.4 mg kg^{-1} is considered a good source of selenium (Zhang et al., 2023).

Selenium bioavailability

In soils, the bioavailability of selenium (Se) is influenced by its chemical forms as well as the soil conditions. The primary abiotic factors that affect this include soil pH, redox potential, clay content, and the presence of organic matter (Kushwaha et al., 2021).

Soil microbes are the key biotic factor influencing selenium (Se) bioavailability in soils. The microbes most commonly associated with enhancing plant Se uptake include various fungi, such as arbuscular mycorrhizal fungi and endophytic fungi, as well as a range of bacterial groups. The bacteria that contribute to Se accumulation in crop tissues are referred to as selenobacteria (Feng et al., 2023).

The bioavailability of different forms of selenium (Se) in soil varies by plant, and selenium uptake by plants is also affected by soil pH, microbial activity, and organic matter. As much as 90% of the selenium present in the human body is absorbed as selenomethionine, which comes from sources such as selenium-enriched yeast, selenite, and selenate (Winther et al., 2020). The total amount of selenium in the human body is approximately 3–20 mg (Zhang et al., 2023).

Selenium is ingested from food and is present in the human body in the natural organic forms of selenocysteine and selenoprotein. They are stored in various organs and tissues: 30% in the liver, 30% in the muscles, 15% in the kidneys, 10% in the plasma and 15% in other organs. The concentration of selenium in the liver reflects the level of absorption in the intestine. The liver synthesizes selenoprotein P (SELENOP), which enters the bloodstream and delivers selenium to other tissues and organs (Zhang et al., 2023).

The importance of selenium in the body

Selenoproteins are essential for the metabolism of thyroid hormones, DNA synthesis, reproduction, and defense against infection and oxidative damage (Hong & Diamond, 2020). Selenium is involved in immune-cell function, redox, anti-inflammatory, anti-carcinogenic, and antioxidant processes. It also regulates thyroid hormone metabolism (Kobayashi et al., 2021). Selenium plays a key role in eliminating free radicals and shielding tissues and cells from harm caused by peroxide. Therefore, low levels of selenium in the environment may have an impact on the body's selenium levels (Li et al., 2024).

Selenium has anti-inflammatory, immunostimulating, and antioxidant properties (Joshi et at., 2022). Numerous selenoproteins have a role in controlling antioxidant activity. Selenium has a major function in controlling many inflammatory processes inside the body as a cofactor of enzymes involved in antioxidant protection (Kieliszek, 2021). Inflammatory skin conditions including psoriasis and atopic dermatitis are linked to an inadequate selenium level in the body (Jun et al., 2020). This explains why it is so crucial to monitor your blood serum selenium levels and incorporate foods high in selenium in your diet.

In the anti-inflammatory response in periapical dental tissues, authors discovered that selenium utilized for intracanal medicine might enhance the healing benefits of calcium hydroxide (Espaladori et al., 2020). According to Ceyhan et al. (2021), selenium showed a protective effect against oxidative damage caused by dental amalgam (Ceyhan et al., 2021).

Selenium deficiency

Selenium deficiency has been linked to an increased risk of several chronic diseases with inflammatory pathogenesis, such as cardiovascular disorders (Gröber &

Holick, 2021). Smokers also have reduced selenium levels, potentially because of increased oxidative stress (Yan et al., 2020). One of the main causes of Keshan disease (endemic cardiomyopathy) is a selenium deficit (Li et al., 2024). Children and women of reproductive age are the primary populations affected by Keshan illness. The illness persists even if its incidence is low nowadays (Hou et al., 2021). Iodine deficiency may worsen due to selenium deficit, which might raise the risk of congenital hypothyroidism in newborns. In addition to having very low plasma levels of thyroxine (T4) and triiodothyronine (T3) and very high levels of thyroid stimulating hormone (TSH), people with this illness also manufacture inadequate amounts of thyroid hormone (Hong & Diamond, 2020).

Numerous studies have already found links between low selenium and higher rates of thyroid, and viral infections as well as breast, prostate, and gastrointestinal malignancies (Zhang et al., 2020). People in some nations that eat a lot of vegetables that are cultivated in low-selenium regions have the risk of becoming deficient. Some regions of China have the lowest selenium intakes in the world, with soil selenium levels extremely low and a big percentage of the population eating mostly vegetarian food (Yang et al., 2025).

Because hemodialysis eliminates some selenium from the blood, patients on long-term hemodialysis frequently have much lower selenium concentrations than healthy people. Individual selenium status, however, also affects whether selenium concentrations in hemodialysis patients are adequate (Azevedo et al., 2023).

Low selenium concentrations are common in HIV-positive patients, possibly because of malabsorption or insufficient selenium consumption (Martinez et al., 2021). According to observational research, people with HIV who have decreased selenium levels are more likely to develop cardiomyopathy (Golin et al., 2022).

Selenium deficiency in Latvia

The findings from the study conducted in Latvia suggest a significant connection between selenium (Se) levels and the severity of COVID-19, indicating that acute patients exhibit notably lower concentrations of Se and its transport protein, selenoprotein P, compared to those recovering from the virus. The decreased selenium levels in acute patients, alongside elevated markers of oxidative stress, such as 4-hydroxynonenal (4-HNE) adducts, imply a compromise in antioxidant defenses during the acute phase of the illness (Šķesters et al., 2023).

The analysis of dietary habits among phenylketonuria (PKU) patients in Latvia reveals critical insights into their nutritional status, specifically concerning selenium levels. Despite the adequate selenium intake reported via food diaries for the majority of PKU patients across various age groups, it is concerning that 11% of those in the 13–18 age group exhibited inadequate serum selenium levels. This indicates that, while intake may be sufficient on paper, actual absorption and status may still be compromised (Lubina et al., 2023).

For example, during the pregnancy, serum selenium levels in the first trimester in Latvia were lower (101.5 $\mu g\ L^{-1}$) compared to certain countries, including the United States (151 $\mu g\ L^{-1}$), Japan (140.2±12.4 $\mu g\ L^{-1}$), Nigeria (107.4±15.8 $\mu g\ L^{-1}$), and Finland (106±15 $\mu g\ L^{-1}$). However, results for pregnant women were higher than those reported in other countries like Germany (89±1 $\mu g\ L^{-1}$), Serbia (63 $\mu g\ L^{-1}$), Finland (59 $\mu g\ L^{-1}$), and Poland (53.4±8.0 $\mu g\ L^{-1}$). Notably, around one-third (30.1%) of pregnant women in Latvia had selenium levels below 80 $\mu g\ L^{-1}$, indicating selenium deficiency (Veisa et al., 2021).

Selenium status

Selenium supplementation has shown effectiveness in viral diseases. Furthermore, it has been demonstrated that a lack of selenium is linked to a greater incidence of viral genome mutation in a number of RNA virus-induced viral illnesses, including SARS-CoV, HIV, Ebola virus, and influenza virus (Hiffler & Rakotoambinina, 2020). Numerous studies have evaluated the connection between body selenium levels and COVID-19 incidence, severity, and death. People who live in regions with low levels of selenium appear to be more at risk of viral diseases. Additionally, some research has looked at the relationship between soil selenium levels and the severity and prevalence of COVID-19 (Liu et al., 2021).

Table 2 presents data on selenium consumption from various food sources and corresponding blood concentration levels in different countries.

Table 2

Blood levels and consumption of selenium foods in various parts of the world

Country	*Daily intake (µg)*[1]	*Blood/serum (µg/liter)*[2]	*Source*
China	2-6990	5-7800	(Minich, 2022)
USA	94-132	~127	(Klein et al., 2023)
Australia	52-90	82-180	(Tinggi & Perkins, 2022)
New Zealand	25-77	~111	(Tinggi & Perkins, 2022)
Germany	38-47	89-98	(Minich, 2022)
Finland until 1984	~40	~69	(Minich, 2022)
Finland after 1984	~80	~109	(Minich, 2022)

[1]Adults should consume 55 µg of selenium each day (Zhang et al., 2023).
[2]Normal selenium concentration in adult human blood serum is between 110 and 165 mcg/L (Blazewicz et al., 2024).

The amount of selenium in human serum and daily consumption varies significantly between nations. Long-term improvements in population health and disease prevention were achieved with the introduction of dietary supplements containing selenium in areas of Europe (Germany and Finland) and Central Asia (China) where selenium consumption was inadequate before 2020 (Minich, 2022). Selenium blood serum levels in China vary significantly, ranging from 5 to 7800 μg L^{-1}. This variation is largely due to differences in soil selenium content across different regions. Selenium deficiency is observed not only in third world countries, but modern and highly developed countries, and it is important to prevent the deficiency in a timely manner (Lei et al., 2023).

Although this review provides valuable insights into the health benefits of muesli and selenium, several limitations must be acknowledged. First, the study is based on secondary data from existing literature and does not include original empirical analysis. Second, due to the narrative nature of the review, no statistical or meta-analytical methods were applied to quantify the effects. Additionally, variations in selenium bioavailability depending on food source, soil composition, and individual absorption were not deeply explored. Therefore, while the findings suggest promising health benefits, further clinical and population-based research is necessary to validate and generalize these conclusions.

Conclusion

1. The formulation of a selenium-enriched muesli leverages the bioactive properties of selenium, an essential trace element known for its role in antioxidant defense and immune function modulation. Such a product would provide a significant contribution to daily selenium intake, aligning with recommendations from health authorities regarding micronutrient consumption.
2. Incorporating a variety of nutritionally dense ingredients, such as whole grains, nuts, and seeds, facilitates not only a balanced macronutrient profile but also enhances the availability of selenium and other synergistic micronutrients. Selenium is a key nutrient for immune function and thyroid health, yet many are deficient.
3. The review highlights a concerning prevalence of selenium deficiency globally, which is linked to numerous health issues, including cardiovascular disorders, autoimmune diseases, and increased susceptibility to viral infections.
4. Despite promising findings, inconsistencies in current literature regarding muesli's effects on body weight and composition warrant additional research.

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