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Selenium in Muesli: Nutritional Content, Consumer Awareness, and Public Health Implications in Latvia

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Abstract: Selenium is an essential trace element for antioxidant defense and immune health, but intake in Latvia is low due to selenium-poor soils. This study evaluated selenium content in muesli products available in Latvia and assessed consumer awareness to support the development of high-selenium muesli. From 102 identified cereals, 28 met the inclusion criteria. Selenium content, estimated from ingredient lists, ranged from 5.5 to 11.2 µg 100 g^{-1}, contributing a mere 3-7% of the recommended daily intake per serving. Notably, no products contained Brazil nuts, a primary selenium source. Analysis revealed a significant negative correlation between selenium levels and total sugar content (ρ = -0.604, p < 0.001). A survey of 1,729 respondents indicated moderate awareness of soil deficiencies (60.1%), yet revealed limited knowledge regarding specific health claims and personal selenium status; 37.3% could not identify selenium-rich foods. These findings demonstrate that current muesli products provide insufficient selenium, highlighting a clear opportunity for functional food reformulation and targeted consumer education to address public health gaps.

Key words: Breakfast cereals, health claims, micronutrient deficiency, selenium.

1. Introduction

Selenium is an essential trace element required for the synthesis of selenoproteins, which play fundamental roles in antioxidant defense, immune regulation, and thyroid hormone metabolism. Incorporated as selenocysteine into at least 25 knowns human selenoproteins, selenium contributes to the activity of enzymes such as glutathione peroxidases and thioredoxin reductases that protect cells from oxidative stress and maintain redox homeostasis [1]. Selenium is also crucial for the proper function of iodothyronine deiodinases, which regulate the activation and conversion of thyroid hormones, thereby influencing metabolic processes and energy balance [2]. Emerging evidence further highlights selenium's role in modulating immune responses and inflammatory pathways, with both inadequate and excessive intake being associated with adverse health outcomes [3]. These findings underscore the importance of maintaining adequate selenium status to support metabolic health and overall physiological function.

Celiac disease and women's health are two contexts in which adequate selenium intake is particularly important. Individuals with celiac disease may be at increased risk of micronutrient deficiencies, including selenium, due to impaired absorption and the reliance on gluten-free products often based on low-selenium grains such as rice and corn [4]. Women, who have a higher prevalence of thyroid disorders, also require sufficient selenium to support thyroid hormone metabolism, antioxidant defense, immune function, and reproductive health [5]. Therefore, the development of gluten-free muesli formulations enriched with naturally selenium-rich ingredients represents a nutritionally justified strategy to support vulnerable groups and improve overall selenium intake in the population.

Despite selenium's recognized importance for human health, consumer awareness of selenium and

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its dietary sources is generally low, and research indicates widespread knowledge gaps across different populations. Studies from Europe show that many individuals are unfamiliar with the role of selenium or its presence in common foods: a survey of adults in Spain found that awareness of selenium as an essential micronutrient was limited, with a substantial proportion unable to identify foods rich in selenium or understand its health implications [6]. Similarly, research in China demonstrated that while general nutrition knowledge was moderate, specific understanding of trace elements such as selenium was poor, with many respondents unable to link selenium to its physiological roles or dietary sources [7]. A survey of German consumers found that many people were unfamiliar with selenium and that providing information about its health effects increased acceptance of selenium‑biofortified foods, suggesting gaps in baseline knowledge [8]. Together, the literature highlights that selenium is a “hidden” nutrient in public awareness, reinforcing the need for improved nutrition education and clearer communication about selenium‑rich foods in dietary guidance and food labeling.

Selenium status varies widely across Europe, largely due to geographic differences in soil selenium concentrations, which influence the selenium content of locally produced foods. Northern and Western European countries, including the United Kingdom, Germany, and the Nordic states, generally exhibit lower soil selenium levels compared with parts of North America, resulting in lower dietary selenium intake and serum selenium status among populations [9]. Figure 1 shows an overview of the transfer of selenium from the environment to humans: selenium present in soil can enter water systems and accumulate in crops or be consumed by livestock, which in turn provides selenium to humans through plant- and animal-based foods, illustrating the key role of soil selenium in determining dietary intake [10]. Recent European biomonitoring data indicate that mean serum selenium concentrations often fall below optimal ranges (70-120 μg L^{-1}) in several countries, particularly in the Baltic region, where low soil levels limit selenium accumulation in grains and vegetables [11]. In Latvia specifically, limited national data suggest that a substantial proportion of the population, especially women,

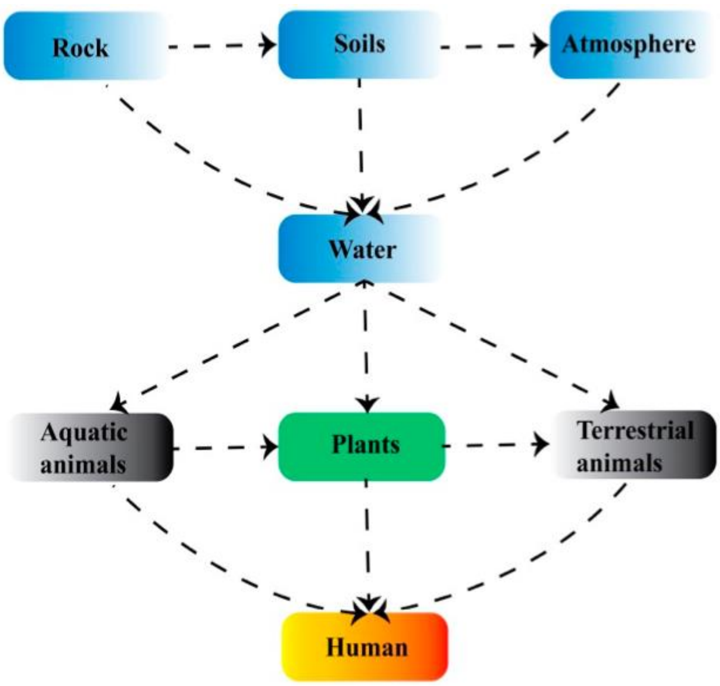

Fig. 1 The main pathways for selenium to enter the human body [10].

displays serum selenium concentrations below this reference range, with higher prevalence of lower status among older adults and individuals consuming diets low in selenium‑rich foods [12]. Low serum selenium has been associated with compromised antioxidant defenses and altered thyroid hormone metabolism, emphasizing the public health significance of monitoring and addressing selenium deficiency in affected regions. These patterns support the rationale for assessing selenium content in commonly consumed foods like muesli and for promoting dietary strategies to enhance population selenium intake.

Currently, there is limited published data specifically addressing the average selenium content of commercially available muesli products, as most research focuses on individual cereals or raw ingredients rather than finished breakfast cereal mixtures. Selenium content in cereal-based products is known to vary considerably depending on the type of grain used and the selenium concentration of the soil in which it was grown [13]. However, comprehensive evaluations of selenium levels in ready-to-eat muesli products are insufficient in the scientific literature. Given the lack of product-specific data, this study systematically evaluated muesli products available on the Latvian market to determine their potential contribution to dietary selenium intake and their value as sources of this essential trace element, while also assessing consumer awareness and attitudes toward selenium and related health claims to support the development of consumer-approved high-selenium muesli.

2. Materials and Methods

2.1 Sample Selection and Nutritional Analysis

A total of 28 muesli representing 11 different brands (including *Fibera, Graci, Rimi, Smalkais Muslis,* and *Alpen*) were selected for analysis. Product labels were systematically reviewed to estimate selenium content based on declared ingredients. The muesli products were sourced from the online retail platforms of *Rimi, Maxima, Lidl, Lats, Top,* and *Dabas Stacija,* chosen for their broad assortment of breakfast cereals. Data collection was conducted between December 2025 and February 2026. Inclusion criteria comprised muesli products without added oils or added sugars, while products containing these ingredients were excluded [14]. Of the 102 products initially identified, 28 met the inclusion criteria and were included in the final analysis. Selenium content of each muesli product was calculated in the app Cronometer using the ingredient list; selenium content was compared to reference intakes (RI), which corresponds to 55 µg/day for adults according to Regulation (EU) No 1169/2011 [15]. If the ingredient list did not provide product weight or percentages per 100 g, the manufacturer was contacted to obtain an accurate ingredient distribution, which was then used to calculate the selenium content.

2.2 Consumer Survey

An online survey was designed to gather data on consumer preferences, selenium awareness, and health-related perceptions concerning intake from breakfast cereal and muesli products. A structured questionnaire consisting of 10 questions was created using Google Forms. The questions were designed to assess the following aspects: Demographic information, including age and education level; Awareness of selenium deficiency in Latvian soil and blood serum levels; Selenium sources and health claims.

The target population included Latvian consumers aged 18 to 74 years. Data collection occurred over the month of March 2025, from March 1st to March 31st. The study received ethical approval from the Latvian University of Life Sciences and Technologies Research Ethics Committee (approval No. 2025/3). In total, 1,729 individuals participated in the study, comprising 1,427 women and 302 men. The invitation to participate in the study and the link to the survey were published on the social networking platforms *Facebook, Instagram, WhatsApp* and via email.

2.3 Statistical Analysis

The collected data were analyzed using the *R-Studio* program to perform statistical analyses. Descriptive statistics were employed to summarize demographic information and muesli consumption habits. Statistical significance was determined at a p-value of less than 0.05. Graphical visualization and preparation of tables for reporting the experimental results were performed using *Microsoft Excel*. Additionally, to explore the relationship between selenium content and macronutrients in the muesli products, Pearson's correlation (to quantify linear associations) and Spearman's rank correlation (to quantify monotonic associations, robust to nonlinearity) were calculated.

3. Results and Discussion

3.1 Selenium Content of Muesli Products

In the analysis of all the muesli ingredient lists provided, no Brazil nuts (*Bertholletia excelsa)* were included as a listed ingredient. Brazil nuts are known to be the richest natural dietary source of selenium, with values often exceeding ~28-49 mg kg^{-1} (2800-4900 µg 100 g^{-1}), depending on geographic origin [16], far higher than other ingredients in muesli. The products analyzed contained nuts such as hazelnuts, almonds, and peanuts, as well as seeds like sunflower seeds, pumpkin seeds, and linseeds, but none of these provide selenium at levels comparable to Brazil nuts. While some products mentioned the potential presence of "other nuts" as a cross-contamination warning, Brazil nuts were not explicitly listed, meaning that none of the analyzed muesli would have a significantly elevated selenium content from this source. Consequently, the calculated selenium levels reflect only contributions from oats, wheat, seeds, and other minor ingredients, which are comparatively low in selenium.

Table 1 presents the selenium content of 28 commercially available muesli products, expressed both per 100 g and per typical 30 g serving. Selenium levels per 100 g ranged from 5.7 µg in "Alpen Chocolate Muesli" to 11.2 µg in "Buckwheat Crispy Breakfast Flakes Bio" (average 8.2 µg), while per 30 g portion they ranged from 1.9 µg to 3.7 µg, with most products providing ~2.4-2.9 µg per portion (average 2.7 µg). Products with higher proportions of buckwheat or nuts generally contained more selenium per portion. Overall, a single serving contributes only 3-7% of the recommended daily selenium intake (55 µg/day) according to Regulation (EU) No 1169/2011 [15].

The analyzed muesli was classified as single-cereal (n = 12; 9 oat-based, 3 buckwheat-based) and multi-cereal (n = 16; containing 2 or more grains: wheat, barley, oats, rye, corn, rice, or triticale). Selenium content per 100 g ranged from 6.4 to 11.2 µg in buckwheat muesli (average 8.7 µg), 7.5 to 10.7 µg in oat muesli (average 8.7 µg), and 5.7 to 10.1 µg in multi-cereal muesli (average 7.9 µg). Overall, the results indicate that selenium levels were relatively similar across categories, with buckwheat and multi-cereal products showing slightly higher maximum values, reflecting the influence of cereal type and composition on selenium content. These findings are consistent with previous research: a study comparing selenium levels in 27 gluten‑free cereal products found that selenium varied widely depending on the grain base, from 0.9 to 24.5 µg 100 g^{-1} [17]. Products based on less commonly used cereals such as oats, amaranth, teff, and quinoa had much higher selenium (average ~10.8 µg 100 g^{-1}) than those based on traditional gluten‑free grains like corn, rice, or buckwheat (~2.8 µg 100 g^{-1}). This supports the observation that grain composition influences selenium content in muesli.

3.2 Selenium and Sugar

Table 1 Selenium content of analyzed muesli products.

Product name	Selenium amount (µg 100 g^{-1})	Selenium amount (µg 30 g^{-1})
Buckwheat Crispy Breakfast Flakes Bio	11.2	3.7
Smalkais Muslis with Seeds	10.7	3.5
Muesli Rimi Smart with Dried Fruits	10.1	3.3
Functional Muesli Graci Thin	9.8	3.2
Organic Muesli Salling Eko with Seeds and Nuts	9.6	3.2
Cereal Mix Fibera Nuts	9.2	3.0
Smalkais Muslis with Protein	8.9	2.9
Smalkais Muslis with Apples	8.9	2.9
Chocolate Oat Muesli (Gluten-Free) Organic	8.8	2.9
Muesli Nut Graci in a Cylinder	8.8	2.9
Muesli Rimi with Nuts and Fruits	8.7	2.9
Sprout Buckwheat Mueslis with Cranberries Organic	8.5	2.8
Rimi Whole Grain Muesli with Chocolate and Strawberries	8.3	2.7
Oat Muesli Protein, Unsweetened Bio	7.9	2.6
Oat Muesli with Fruit, Unsweetened, Gluten-Free Bio	7.8	2.6
Smalkais Muslis with Strawberries	7.8	2.6
Alpen Muesli with Fruits and Seeds	7.6	2.5
Smalkais Muslis with Cherries	7.6	2.5
Muesli Fibera with Tropical Fruits	7.6	2.5
Smalkais Muslis with Berries	7.5	2.5
Smalkais Muslis with Fruits	7.5	2.5
Muesli Graci with Passion Fruit	7.4	2.4
Granola Fibera with Strawberry Pieces	7.3	2.4
Smalkais Muslis with Mango	7.2	2.4
Muesli Graci with Rye Bread Flavor	6.8	2.2
Whole Grain Muesli Rimi with Dates, Goji Berries and Quinoa	6.5	2.1
Sprout Buckwheat Mueslis with Coconuts Organic	6.4	2.1
Alpen Chocolate Muesli	5.7	1.9

Although selenium does not directly determine the sugar content of foods, it plays an important role in glucose metabolism and oxidative stress regulation once consumed. In the body, selenium is incorporated into selenoproteins, such as glutathione peroxidases, which protect cells from oxidative damage caused by postprandial glucose spikes. Adequate selenium intake has been associated with improved insulin sensitivity and glycemic control, whereas low selenium status may contribute to oxidative stress and impaired glucose metabolism [2, 18]. Recent population data also indicate that blood selenium levels are linked to markers of insulin resistance, although the relationship is complex and may vary by dose and baseline selenium status [3, 19].

Across the analyzed muesli products, total sugars varied widely from 0.8 to 22.0 g 100 g^{-1}, indicating substantial differences in formulation (Fig. 2). Products with the highest selenium concentrations (≈ 9-11 µg 100 g^{-1}) were found both among low-sugar (< 2 g 100 g^{-1}) and moderate-to-high sugar (≥ 6 g 100 g^{-1}) products. Similarly, muesli with lower selenium levels (≈ 5.7-6.8 µg 100 g^{-1}) often contained higher sugar contents (14-22 g 100 g^{-1}), largely reflecting the presence of dried fruits, sweetened components, or chocolate. Selenium and total sugars show a strong, statistically significant negative relationship. The Pearson correlation was $r = -0.737$ with $p = 7.8 \times 10^{-6}$, meaning products with higher total sugars tend to have notably lower selenium. The Spearman correlation was also significantly negative at $\rho = -0.604$ with $p = 0.000672$. In practical terms, the fitted line implies roughly 0.15 µg 100 g^{-1} lower selenium per + 1 g sugar (about 1.5 µg 100 g^{-1} lower per + 10 g sugar) on average in this dataset.

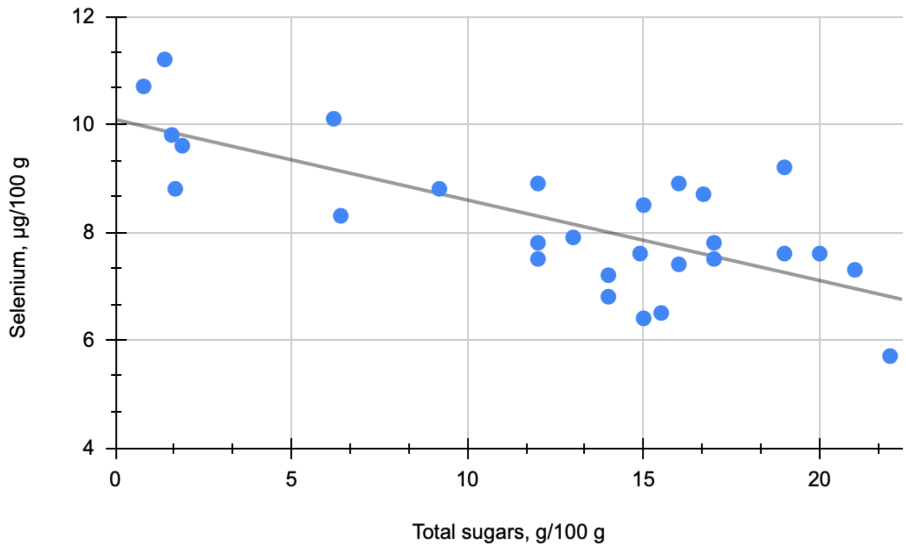

Fig. 2 Relationship between selenium content and total sugars in muesli products.

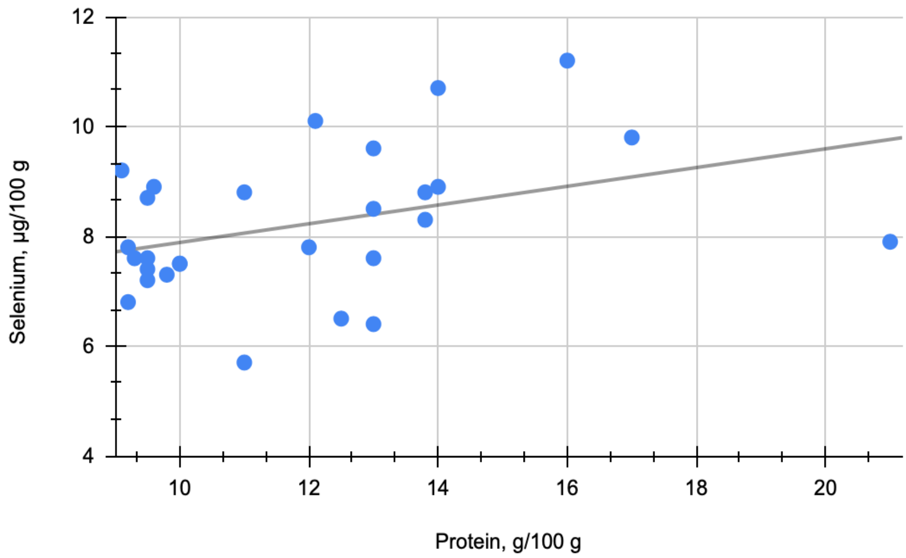

Fig. 3 Relationship between selenium content and protein in muesli products.

3.3 Selenium and Protein

Selenium interacts closely with protein metabolism because it is an essential component of selenoproteins, a unique class of proteins that incorporate the amino acid selenocysteine into their structure and function. Selenoproteins, such as glutathione peroxidases and selenoprotein P, play critical roles in antioxidant defense, redox homeostasis, and thyroid hormone metabolism, all of which influence overall protein turnover and utilization in the body [20]. Adequate selenium intake supports proper protein synthesis and reduces oxidative stress that would otherwise damage proteins [1]. Population research indicates a potential synergistic effect between dietary selenium and higher protein intake in reducing mortality risk, underscoring the role of selenium in supporting protein-related metabolic processes as part of a balanced diet [21]. These mechanisms emphasize why foods with both adequate selenium and protein, such as cereal products with seeds and nuts, contribute to nutritional quality beyond their individual macronutrient content.

Protein content varied between 9.1 and 21.0 g 100 g-1. Products with the highest selenium levels (> 10 µg 100 g-1) did not consistently correspond to the highest protein content, and products with lower selenium (≈ 5.7-7.5 µg 100 g-1) exhibited a broad range of protein (9.1-13.0 g 100 g-1) (Fig. 3). The analysis found a very weak negative linear association between selenium µg 100 g-1 and fat g 100 g-1 with Pearson r = -0.195 and p = 0.319, and essentially no monotonic association with Spearman ρ = -0.056 and p = 0.776. The scatter plot reflected this, with only a slight downward slope and lots of spread, and the estimated effect size was small in practice (roughly 0.76 µg 100 g-1 lower selenium per + 10 g 100 g-1 fat).

3.4 Selenium and Fiber

Selenium and dietary fiber are both important for metabolic health, but their relationship is primarily complementary rather than directly causative. Fiber-rich foods, such as oats, buckwheat, and whole grains, often provide moderate amounts of selenium, especially when combined with seeds and nuts, which are naturally selenium-rich. While the fiber content of a food does not directly increase selenium levels, high-fiber cereals can influence the bioavailability and absorption of selenium. Some studies suggest that dietary fiber may slow digestion and modulate nutrient absorption, potentially affecting the release of selenium in the gastrointestinal tract [22]. Moreover, both selenium and fiber contribute to antioxidant defense and metabolic regulation: selenium through its incorporation into selenoproteins, which reduce oxidative stress, and fiber by promoting healthy gut microbiota and improving glycemic control [23]. In the context of muesli, the combination of selenium-containing ingredients and high fiber provides dual benefits, supporting both micronutrient intake and digestive health, without implying that higher fiber content directly elevates selenium levels in the product.

Fiber content varied between 4.6 and 14.1 g 100 g^{-1} (Fig. 4). Products with the highest selenium levels (> 10 µg 100 g^{-1}) generally had moderate to high fiber content (6.2-11.0 g 100 g^{-1}), whereas products with lower selenium (≈ 5.7-7.5 µg 100 g^{-1}) also displayed a wide range of fiber (7.4-14.1 g 100 g^{-1}). The analysis found a very weak negative linear association between selenium µg 100 g^{-1} and fat g 100 g^{-1} with Pearson r = -0.195 and p = 0.319, and essentially no monotonic association with Spearman ρ = -0.056 and p = 0.776. The scatter plot reflected this, with only a slight downward slope and lots of spread, and the estimated effect size was small in practice (roughly 0.76 µg 100 g^{-1} lower selenium per + 10 g 100 g^{-1} fat).

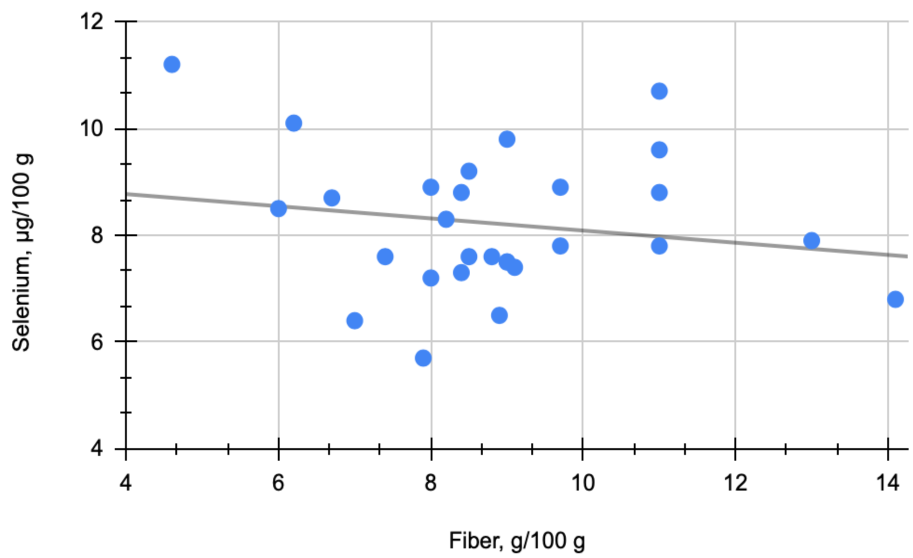

Fig. 4 Relationship between selenium content and fiber in muesli products.

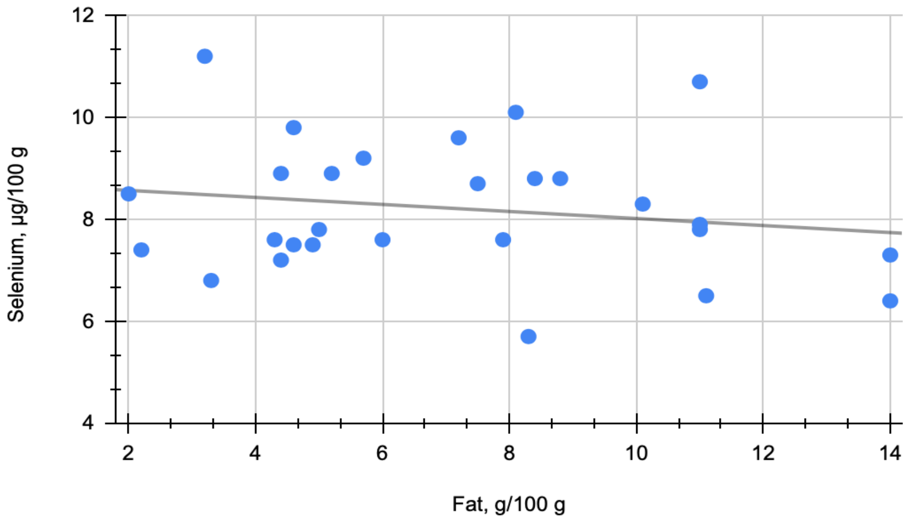

Fig. 5 Relationship between selenium content and fat in muesli products.

3.5 Selenium and Fat

Selenium and dietary fat are related primarily through antioxidant protection and metabolic functions, rather than fat content directly determining selenium levels in foods. Selenium, incorporated into selenoproteins such as glutathione peroxidases, protects polyunsaturated fatty acids (PUFAs) from oxidative damage, maintaining the integrity of fats in the diet and in the body [22, 23]. Adequate selenium intake may also influence lipid metabolism, as some studies indicate that selenium status is associated with serum lipid profiles, including HDL-cholesterol and triglycerides [2]. However, the amount of fat in a food product does not inherently affect its selenium content; rather, foods that are naturally high in fat, such as nuts and seeds, may also be selenium-rich due to the nutrient composition of the ingredient. In the context of muesli, ingredients such as almonds, Brazil nuts, sunflower seeds, and pumpkin seeds provide both healthy fats and selenium, creating a nutritionally synergistic effect that supports antioxidant defense and overall metabolic health, without implying a direct causal relationship between fat content and selenium concentration [24].

Fat content varied widely from 2.0 to 14.0 g 100 g^{-1} (Fig. 5). Products with higher selenium levels (> 10 µg 100 g^{-1}) showed both low-to-moderate fat (3.2-4.6 g 100 g^{-1}) and higher fat content (11.0 g 100 g^{-1}), reflecting differences in the presence of nuts, seeds, or chocolate. For fat, the relationship is consistently weak and not statistically significant with Pearson r ≈ -0.178 and $p \approx 0.365$, and Spearman ρ ≈ -0.108 and $p \approx 0.586$, which means fat content doesn't meaningfully predict selenium in this sample.

3.6 Demographic Characteristics of Survey Respondents

In a survey conducted among 1,729 respondents, the demographic breakdown revealed that 1,427 participants were women, accounting for approximately 82.5% of the total, while 302 were men, representing about 17.5% (Table 2). This gender distribution highlights a significant predominance of women respondents in the survey's sample population. Respondents were categorized by age groups, the majority of respondents fell within the 25-34 years category, with 777 individuals, closely followed by the 18-24 years group consisting of 218 participants. The 35-44 years age group had 245 respondents, while the 45-54 years group included 129 individuals. With 263 respondents aged 55-64 years, participation continued to decline in the older segments, with 97 aged 65-74 years. This data indicates a significant concentration of younger participants, particularly among those aged 18 to 34, while the older demographics show notably lower engagement.

The questionnaire results highlighted a diverse spectrum of educational attainment among respondents. Notably, 103 individuals reported having a primary education, indicating a modest representation in this category. The secondary education level was reported by 143 participants, showcasing a slightly higher engagement among those who completed their secondary schooling. However, the most significant portion of respondents belonged to the higher education category, with an impressive 1,483 individuals indicating they had pursued higher education.

3.7 Respondents' Awareness of Selenium

Responses to the question regarding selenium deficiency in Latvia reveal a significant perception among the population. Out of a total of 1,729 respondents, an overwhelming 1,039 individuals (approximately 60%) agreed with the statement that Latvia, like many Northern European countries, faces a selenium deficiency in the soil, which affects crop and livestock products, as well as the general diet (Table 3). In contrast, only 104 respondents disagreed, reflecting a minority that does not share this concern. A considerable number of participants, 586 (around 34%), indicated that they are not informed about the issue, suggesting a gap in knowledge or awareness regarding selenium levels in their environment and diet. To the question: "Do you know your selenium level in your blood?" out of 1729, 353 individuals (20.4%) indicated that they are aware of their selenium levels, while a substantial majority of 1,376 individuals (79.6%) reported that they do not know their selenium levels. Among those who reported knowing their selenium status (n = 353), most participants had normal blood serum selenium levels (241 individuals, 68.3%), 111 participants (31.5%) had low selenium levels, and only 1 participant (0.3%) reported elevated selenium levels.

This suggests that even in populations where a portion of individuals monitor their selenium, suboptimal intake remains a concern. Low selenium levels can have implications for antioxidant defense, thyroid function, and immune response, emphasizing the importance of monitoring dietary sources of selenium. These findings also underscore the relevance of selenium-rich foods, such as cereals, seeds, and nuts, in the diet. Given that most participants were unaware of their selenium status, educational initiatives promoting awareness of selenium intake and its food sources may help prevent deficiencies. Furthermore, these results align with previous studies showing that a large part of the general population does not monitor trace element intake, which could lead to deficiencies despite the availability of selenium-rich foods [22, 23].

Table 2 Demographic characteristics of survey respondents.

Variable	Category	Number of respondents	% of total respondents
Gender	Women	1,427	82.5
	Men	302	17.5
Age group	18-24	218	12.6
	25-34	777	44.9
	35-44	245	14.2
	45-54	129	7.5
	55-64	263	15.2
	65-74	97	5.6
Education	Primary	103	6.0
	Secondary	143	8.3
	Higher	1,483	85.7

Table 3 Data on selenium awareness in Latvia.

Question	Answers	n = 1,729 (100%)
Do you agree with the statement that in Latvia, like many other Northern European countries, there is a selenium deficiency in the soil, and as a result, also in crop and livestock products and the usual diet?	Yes	1,039 (60.1%)
	No	104 (6.0%)
	I am not informed	586 (33.9%)
Do you know your selenium level in your blood?	Yes	353 (79.6%)
	No	1,376 (20.4%)

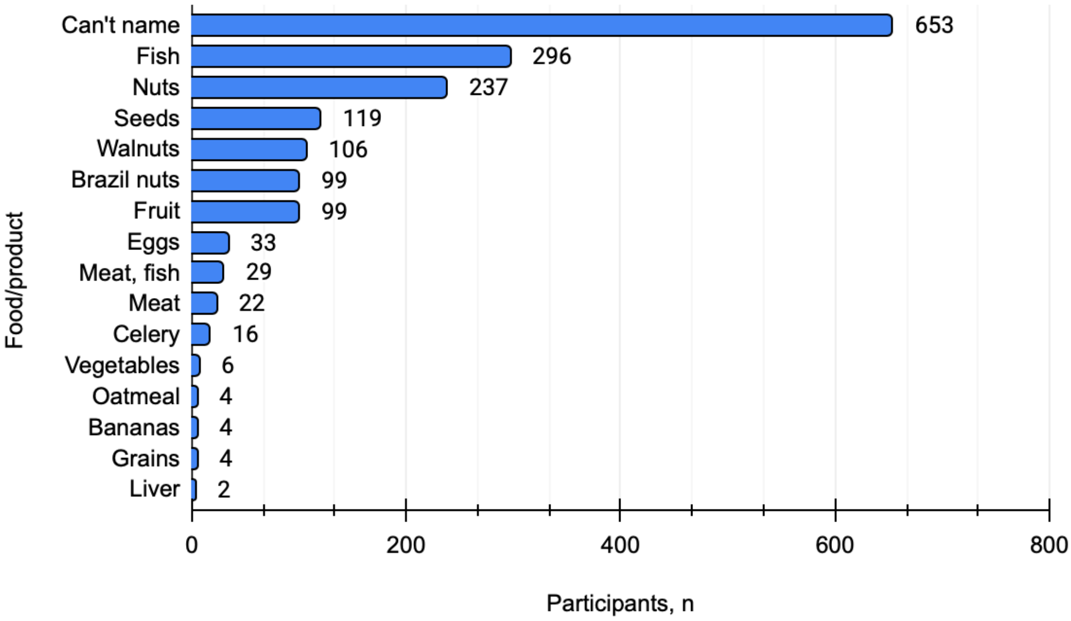

Fig. 6 Listed high selenium foods.

A survey asked participants to name foods that are high in selenium, and 1,749 individuals provided responses (Fig. 6). The results revealed considerable variation in knowledge: a substantial portion of respondents, 37.3%, could not identify any selenium-rich foods, highlighting a clear gap in public awareness regarding dietary sources of this essential micronutrient. Among those who could name foods, fish emerged as the most frequently mentioned selenium source, followed by various nuts and seeds. Brazil nuts, which are particularly rich in selenium, were identified by only a small proportion of participants. Other foods cited included eggs, meat, dairy products, and some grains and vegetables. These findings underscore the need for targeted nutritional education campaigns to improve public knowledge of selenium-rich foods and promote dietary choices that support adequate selenium intake from a nutritional perspective, these findings indicate that while widely known selenium-rich foods, such as fish, are commonly recognized, less obvious sources, including seeds, nuts, and certain whole grains, are often overlooked, which may contribute to inadequate selenium intake in the general population. Improving awareness of these sources could help bridge the gap between actual selenium intake and recommended reference intakes, supporting antioxidant defense, thyroid function, and overall metabolic health [20].

The next survey question assessed whether consumers pay attention to health claims when making purchasing decisions. Out of 1,729 respondents, 1,437 individuals (83.2%) reported that they notice health claims, while 292 participants (16.8%) indicated that they do not. This suggests that health claims are a highly visible and influential component of food packaging for most consumers. The high level of attention may reflect growing public interest in nutrition and functional foods, as well as the role of labels in guiding healthier dietary choices. From a marketing and public health perspective, this finding underscores the potential value of including scientifically validated health claims, such as those related to selenium content, on products [25]. Since a large proportion of consumers actively engage with health claims, labeling foods with selenium could increase awareness of this essential micronutrient and potentially encourage the selection of selenium-rich foods, which may help address suboptimal intake observed in the population. These results align with previous studies indicating that nutrition and health claims significantly influence consumer perceptions and purchasing decisions, especially for products positioned as functional or fortified foods [26].

Figure 7 illustrates consumers' awareness of health claims related to selenium. The most frequently recognized claim was that selenium contributes to the normal function of the immune system, selected by 983 respondents (56.8%), indicating that immune health is the benefit most strongly associated with selenium in consumers' perceptions. Claims related to the maintenance of healthy nails were identified by 741 respondents (42.9%), protection of cells from oxidative stress by 708 respondents (41.0%), and maintenance of normal hair condition by 603 respondents (34.9%), suggesting moderate awareness of selenium's antioxidant and integumentary roles. In contrast, selenium's contribution to normal thyroid function was less frequently recognized, with only 390 respondents (22.6%) selecting this claim, despite thyroid health being one of selenium's well-established physiological functions. Notably, 246 participants (14.2%) indicated that they did not know which health claims apply to selenium, highlighting persistent gaps in consumer knowledge.

The final survey question assessed consumer attitudes toward the inclusion of health claims on products with elevated selenium content. A substantial majority of respondents supported this approach, with 1,603 participants (92.7%) indicating that it would be beneficial to include such health claims, while only 126

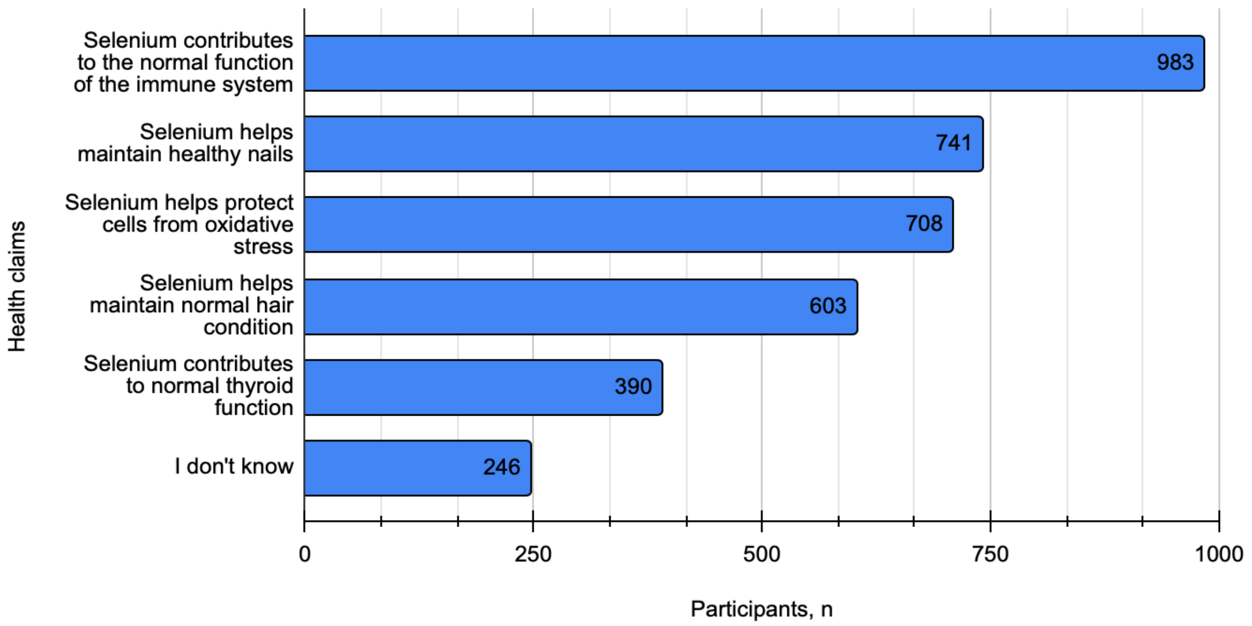

Fig. 7 Which of these health claims do you think apply to selenium?

respondents (7.3%) disagreed. This strong level of agreement highlights a clear consumer demand for transparent and informative labeling related to selenium content. From a product development perspective, these findings suggest that incorporating scientifically substantiated selenium health claims on muesli packaging could enhance consumer understanding and confidence in their purchasing decisions. Moreover, given the previously identified gaps in consumer knowledge regarding selenium-rich foods and selenium-related health benefits, the use of clear, evidence-based health claims may serve as an effective educational tool. For future muesli development, these results support the strategic inclusion of approved selenium health claims to improve product communication, align with consumer expectations, and potentially contribute to more informed dietary choices.

4. Conclusion

The present study demonstrates that commercially available muesli products in the Latvian market contain relatively low levels of selenium, contributing only about 3-7% of the adult reference intake (55 µg/day) per 30 g serving. This indicates that muesli, in its current formulation, cannot be considered a significant dietary source of selenium. The absence of selenium-rich ingredients, particularly Brazil nuts, likely explains these low values, highlighting a clear opportunity for product reformulation to enhance nutritional quality. In addition, a significant inverse relationship was observed between selenium content and total sugar levels ($p = 0.000672$), suggesting that products with higher sugar content tend to have lower selenium concentrations. This finding points to a broader nutritional imbalance in some commercially available muesli products, where higher sweetness may be associated with reduced micronutrient density. The consumer survey revealed that although 60.1% of respondents are aware of selenium deficiency in Latvian soils, there is a marked lack of knowledge regarding dietary selenium sources, with a substantial proportion unable to identify selenium-rich foods. Furthermore, most participants (79.6%) were unaware of their own selenium status, indicating limited personal monitoring of this essential micronutrient. Despite these gaps, consumers showed strong attention to health claims and high support (92.7%) for selenium-related claims on food packaging, demonstrating the potential effectiveness of nutritional labelling as a communication tool.

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