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Evaluation of Nutritional Profiles of Breakfast Cereals in Latvia

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Abstract. Muesli consumption in Latvia has increased due to convenience and perceived health benefits, but improvements in total sugars, fat, and fiber content are needed to make it an optimal breakfast option. This study aimed to analyze the range and nutritional composition of breakfast cereal available in Latvian online stores. A total of 102 products from 24 brands were analyzed, including 28 mueslis, 64 granolas, and 10 flakes and puffs. Products were classified by formulation: muesli (no added oil), granola (added oil and sweeteners), and flakes and puffs (cereal flour as main ingredient). Nutritional values were compared with reference intake (RI) for adults. Granola was the most energy-dense (448 kcal/100 g) with the highest fat (16.9 g/100 g) and total sugars (18.1 g/100 g), while muesli had moderate energy (369 kcal/100 g), lower fat (7.1 g/100 g), and higher protein (11.9 g/100 g) and fiber (8.9 g/100 g) content. Flakes and puffs were high in carbohydrates (74.9 g/100 g) and total sugars (15.9 g/100 g) but lower in fiber (5.8 g/100 g) and protein (8.9 g/100 g). All products met EU criteria for high-fiber foods, though a 30 g serving provided only 10-11% of daily intake. Grain choice influenced nutrient content, with pseudo-cereals such as buckwheat (17.6 g/100 g fiber) and amaranth (13.0 g/100 g fiber) enhancing nutritional value. Only 28 of the 102 analyzed breakfast cereal products, comprising muesli, flakes and puffed cereals, and granola, met the established criteria for true muesli, highlighting the need for careful product evaluation when selecting cereal products.

Key words: muesli nutritional analysis, breakfast cereals, granola, nutrition claims.

Introduction

The average per capita consumption of breakfast cereal products worldwide was 1.6 kg in 2020, with the segment generating \$62,763 million in global revenue and projected to grow at an annual rate of 4.1% through 2025 (Santos *et al.*, 2022). This growth underscores a pressing need to enhance the nutritional value of breakfast cereal, especially regarding sugar, salt, and fat content.

Muesli has emerged as a popular grain food trend, primarily due to shifting lifestyles and an increasing demand for nutrient-rich options. Previous studies in Slovakia revealed that key motivators for purchasing breakfast cereal include taste, health benefits, and energy, with a significant part of the population indicating intentions to increase their consumption (Predanócyová *et al.*, 2022). Furthermore, research shows that regular breakfast consumption is associated with a reduced risk of cardiovascular diseases and mortality, particularly when daily fiber intake exceeds 25 g (King & Xiang, 2021).

Previous research has shown that breakfast cereals represent a highly diverse food category and often carry voluntary label information such as nutrition and health claims or gluten-free declarations (Angelino *et al.*, 2019). An analysis of 371 breakfast cereal products available on the Italian market revealed differences in energy and macronutrient composition, with muesli and cereal bars showing the highest energy, total fat, and saturated fat contents per 100 g. Comparisons between products with and without nutrition or health claims, as well as gluten-free declarations, indicated only minor nutritional differences. Although most products met national targets for sugar and salt content, some products with such claims still exceeded recommended levels, indicating that label claims do not necessarily reflect overall nutritional quality (Angelino *et al.*, 2019). These findings highlight that label claims alone are not reliable indicators of overall nutritional quality and underline the importance of critically evaluating nutritional information on food labels.

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Table 1

Classification of Categories

Category	Description of Types
Flakes and puffs	Consists of cereals produced from toasted, puffed, or popped grain flours, or from flakes derived from corn, wheat, oats, and/or rice, with oil included in the ingredient list, that undergo thermal processing (e.g., puffing, flaking, or extrusion) to create expanded ready-to-eat products. May be enriched with micronutrients.
Muesli	Consists of raw or dry-toasted cereals, usually made from rolled oats and not containing added oils, with optional inclusion of dried fruit, nuts, seeds, coconut, and/or chocolate.
Granola	Primarily composed of rolled oats combined with added sweeteners and oils, then oven-baked until crisp and golden brown, forming clustered pieces, and may include dried fruits, nuts, seeds, coconut, and/or chocolate.

Source: Croisier et al., 2021; Woods & Walker, 2007.

Muesli, granola, and flakes and puffs are similar breakfast options that contain oats or other cereals, but they differ in their preparation methods (Table 1) (Croisier et al., 2021; Woods & Walker, 2007). Muesli and granola are mixtures of oats, various grains, nuts, and dried fruits. Granola contains sweeteners, which are usually not added to muesli, such as honey or agave syrup and oils like vegetable, rapeseed, sunflower, or palm oil to help bind the ingredients together during heat treatment. The preparation of flakes and puffs are more complex, starting with the grinding of raw materials, primarily cereal grains into flour as the main ingredient, and ending with thermal processing.

A single serving of muesli often provides a low percentage of the recommended daily dietary fiber intake (Santos et al., 2022). In Latvia, the average consumption of breakfast cereal products was

3.03 kg per household member in 2019 (National Statistical System of Latvia, 2020). With around 100 breakfast cereals available in Latvian supermarkets, differing significantly in nutritional value and added ingredients, this study aims to analyze the range and nutritional composition of breakfast cereal available in Latvia.

Materials and Methods

In total, 102 samples from 24 different brands like *Herkules*, *Graci*, *Rimi*, *The Beginnings*, and *Axa* were analyzed, including 28 mueslis, 64 granolas, and 10 flakes and puffs. Breakfast cereals were sourced from the online stores of *Rimi*, *Maxima*, *Lidl*, *Lats*, *Top*, and *Dabas Stacija*, which were selected due to their wide assortment of breakfast cereals. Data collection was conducted from December, 2025, to January,

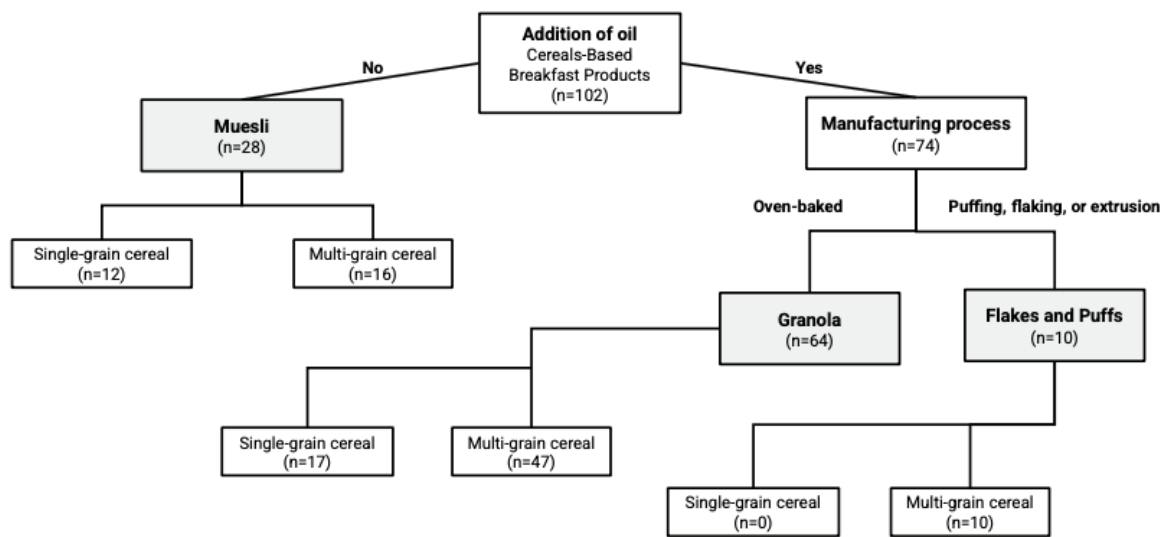


Fig. 1. Characteristics of cereals-based breakfast products used in the research.

2026. All products that were identified through a comprehensive search using the term ‘muesli’ across multiple online retail platforms were included in the study, ensuring that the dataset represented the full range of commercially available products marketed under this category. A broad range of brands, price categories, and product formulations were included to ensure that the diversity of the Latvian market was adequately represented.

Breakfast cereals were classified according to their formulation, specifically based on whether the product contained added oil and whether it was oven-baked or produced via puffing, flaking, or extrusion. (Fig. 1.). Products without added oil were classified as muesli. Based on the manufacturing process, oven-baked products were classified as granola, while products produced by puffing, flaking, or extrusion were classified as flakes and puffed cereals (Croisier *et al.*, 2021).

The nutritional value (macronutrients and energy value) of each muesli product was calculated using the ingredient list to compare if it corresponds to the values shown on the label according to Regulation (EU) No 1169/2011. ‘Fineli’ food composition database was used for the reference of nutrients in breakfast cereals. Nutritional and health claims on the label were analyzed according to Regulation (EC) No 1924/2006. Dietary reference values for adults were used to compare the quality and ratio of nutrients in breakfast cereals (EFSA, 2017). Nutritional properties of breakfast cereals were described, and the findings were displayed using the mean and range for calories, total fat, saturated fats, carbs, sugars, fiber, protein, and salt. The various muesli product types were analyzed by grouping them into the macronutrient classes and compared to recommended daily allowance of nutrients for adults.

Descriptive statistics were used to summarize cereal product characteristics, including nutritional composition, with results reported as means, standard deviations (SD), and where relevant medians and min–max ranges. Prior to group comparisons, distributional assumptions were evaluated using the Shapiro–Wilk test for within-group normality and Levene’s test (median-centered) for homogeneity of variances. Differences in nutrient composition among cereal product categories (muesli, granola, and flakes and puffs) were evaluated using one-way analysis of variance (ANOVA); where assumptions were potentially violated, robustness checks were performed using Welch’s ANOVA (variance-robust) and the Kruskal–Wallis test (nonparametric). When overall group differences were detected, Tukey’s honestly significant difference (HSD) post hoc test was applied to identify which category pairs differed

while controlling the family-wise error rate. To quantify the magnitude of category effects, effect sizes were calculated for ANOVA models using eta-squared (η^2) and omega-squared (ω^2). Statistical significance was assessed using a two-sided threshold of $p < 0.05$. All statistical analyses were performed using RStudio IDE, while graphical visualization and preparation of tables for reporting results were conducted using Microsoft Excel.

Results and Discussion

Table 2 presents the characterization of the breakfast cereals included in the study according to their main cereal ingredients. A total of 102 breakfast cereal products were analyzed, including single-grain cereals ($n = 29$) and multi-grain cereal formulations ($n = 73$). Single-grain cereal products were predominantly oat-based. Among these, 15 products contained conventional oats, while 13 products were formulated with gluten-free oats. Only one product was based on spelt, indicating limited diversity within the single-grain cereal category. Multi-grain cereal products demonstrated considerably greater ingredient complexity. Oats were the most frequently used cereal ingredient, present in 64 products, followed by wheat ($n = 53$) and corn ($n = 36$). Barley ($n = 14$) and rice ($n = 14$) were included less frequently, while rye ($n = 5$) appeared only in a small number of products. Gluten-free oats were present in two multi-grain cereal products. Multi-grain formulations consisted of various cereal combinations. The most common were oat-wheat ($n = 17$) and corn-wheat-oat ($n = 16$), followed by oat-corn-wheat ($n = 8$). In addition to traditional cereals, 11 multi-grain cereal products contained added pseudocereals, most commonly buckwheat ($n = 5$) and quinoa ($n = 5$), with amaranth included in one product.

Notably, single-grain formulations were most commonly observed in muesli products, where oats were typically used as the main cereal ingredient. In contrast, more complex multi-grain ingredient combinations were more frequently observed in flake and puff cereals, reflecting the greater level of processing and formulation diversity in these product categories.

When compared with data from the Portuguese study, notable similarities and differences in muesli formulation patterns can be observed (Castro *et al.*, 2025). In both studies, cereals dominated product composition, however, the Portuguese market showed a much higher prevalence of single-grain cereal products, particularly those based on corn and wheat, whereas the present study identified a clear predominance of multi-grain cereal formulations. While oats were the primary cereal ingredient in the

Table 2

Sample characterization of the different breakfast cereals analyzed

Product groups by main ingredients	Breakfast Cereals (n=102)
Single-grain cereal	29
Oats	15
Gluten-free oats	13
Spelt	1
Multi-grain cereal	73
Oat, wheat	17
Corn, wheat, oat	16
Oat, corn, wheat	8
Oat, wheat, barley	5
Corn, oat, rice (flour)	5
Wheat, triticale, spelt, quinoa	3
Oat, barley, corn, buckwheat	3
Oat, rice	3
Oat, wheat, rice, barley	2
Corn, oat (flour)	2
Oat, spelt, quinoa	2
Oat, rye, wheat, corn	2
Gluten-free oats, corn, rice	2
Oat, barley, buckwheat, amaranth	1
Rice, corn, buckwheat, amaranth	1
Corn, wheat (flour)	1

current dataset, especially within both single- and multi-grain cereal products, the Portuguese study reported a comparatively lower representation of oat-based products and a stronger reliance on corn and wheat as main ingredients. These differences may be explained by regional consumer preferences and market trends, with the current dataset showing a stronger emphasis on oat-based and multi-grain products, likely linked to perceived health benefits and fiber content.

The price of breakfast cereals varied considerably depending on their country of origin (n=9) (Fig. 2.). One-way analysis of variance (ANOVA) confirmed that country of origin had a statistically significant effect on product price ($F = 3.53$, $p < 0.0013$). Average prices ranged from 6.64 to 18.90 EUR/kg, with Denmark priced at 6.64 EUR/kg ($n = 1$), the United Kingdom averaging 6.69 EUR/kg ($n = 10$, $SD = 3.11$), and Italy

showing the highest observed value (18.90 EUR/kg, $n = 1$). Among countries with a larger number of products, Latvia and Poland showed substantial within-country variability, with mean prices of 13.50 EUR/kg (range 5.97-21.55 EUR/kg, $n = 34$, $SD = 4.64$) and 10.53 EUR/kg (range 4.99-20.59 EUR/kg, $n = 30$, $SD = 5.09$), respectively. Muesli from Germany and the Czech Republic averaged 13.05 EUR/kg (range 5.97-19.00 EUR/kg, $n = 10$, $SD = 4.51$) and 10.03 EUR/kg (range 5.97-19.00 EUR/kg, $n = 7$, $SD = 4.76$), while Ukrainian products were generally more affordable (9.47 EUR/kg, range 7.97-9.97 EUR/kg, $n = 8$, $SD = 0.93$). Although the ANOVA result supports meaningful between-country price differences, assumption checks indicated non-normality in several country groups and unequal variances (Levene $p < 0.045$), suggesting some caution in interpretation; nevertheless, post-hoc testing indicated at least one

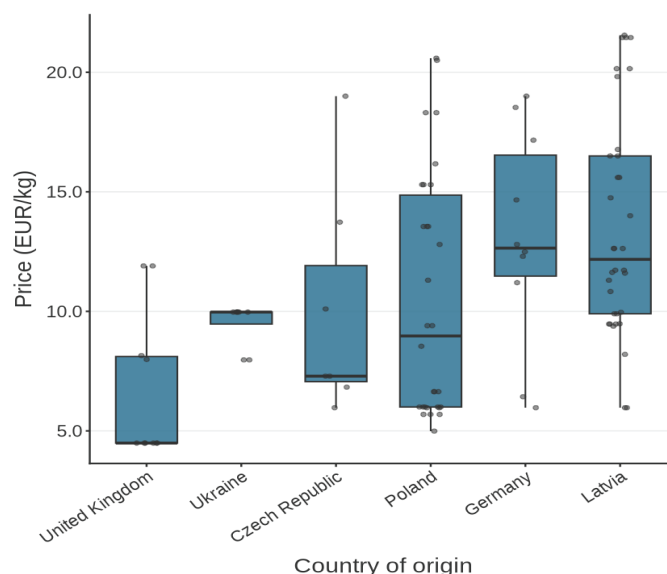


Fig. 2. Average price of breakfast cereal per kilogram by country of origin.

clear difference, with Latvian products priced higher than those from the United Kingdom (Tukey-adjusted $p < 0.0017$). Considering that a typical portion of muesli is approximately 30 g (EUFIC, 2019), the estimated cost per serving ranges from roughly 0.20 to 0.57 EUR, depending on the country of origin, highlighting that despite differences in retail price per kilogram, muesli remains a relatively inexpensive and cost-effective breakfast option. The observed price differences likely reflect factors such as production costs, brand positioning, and local market conditions, with products from Southern Europe (e.g., Italy) tending to command the highest prices per kilogram.

The nutrient composition of Flakes and Puffs, Muesli, and Granola per 100 g is presented in Figure 3, showing energy (A), total sugars (B), fat (C), and protein (D) contents for each cereal type.

Nutritional comparison of energy content (kcal/100 g) across cereal categories showed strong differences: granola had the highest values (mean 447.6 ± 26.6 , range 383–525, $n = 64$), muesli was lower (mean 369.7 ± 27.9 , range 329–443, $n = 28$), and flakes and puffs were intermediate (mean 381.9 ± 22.2 , range 357–431, $n = 10$) (Fig.3A). Overall group differences were statistically significant by one-way ANOVA ($F = 95.14$, $p < 0.001$), confirmed by Welch ANOVA ($F = 92.56$, $p < 0.001$) and Kruskal–Wallis ($H = 64.06$, $p < 0.001$); the category effect was large ($\eta^2 \approx 0.658$; $\omega^2 \approx 0.649$), and Tukey post-hoc testing showed granola differed significantly from both muesli and flakes and puffs ($p < 0.001$), whereas muesli and flakes and puffs did not differ significantly ($p < 0.429$). These differences align with results from other nutrition surveys: an Italian market study observed significant

variation in energy content among cereal types, with products like muesli showing higher median energy values compared to bran or puffed cereals (median up to ~ 443 kcal/100 g) and overall considerable variability between types (Angelino *et al.*, 2019).

Across 102 products, average sugar content differed by cereal category (Fig. 3B), with granola showing the highest mean sugar (18.13 ± 6.57 g/100g, $n=64$), flakes and puffs intermediate (15.89 ± 8.35 g/100g, $n=10$), and muesli lowest (12.51 ± 6.42 g/100g, $n=28$). Assumption checks indicated unequal normality across groups driven mainly by muesli (Shapiro $p < 0.012$), while variances were not meaningfully different (Levene $p < 0.711$). Despite the mild normality issue, results were consistent across tests, showing a significant overall category effect by one-way ANOVA ($F = 6.84$, $p = 0.00166$), Welch ANOVA ($F = 7.14$, $p = 0.00396$), and Kruskal–Wallis ($H = 13.60$, $p = 0.00111$), with a moderate effect size ($\eta^2 \approx 0.121$) and ($\omega^2 \approx 0.103$). Tukey post-hoc comparisons found granola significantly higher in sugar than muesli mean difference about 5.61 g/100g, $p < 0.0011$, while flakes and puffs did not differ significantly from either group after adjustment. Overall, the observed differences indicate that total sugar content is strongly influenced by cereal category and processing methods. The presence of added sugars, degree of processing, and inclusion of sweetened ingredients play a key role in determining sugar content, emphasizing the importance of cereal type when evaluating the nutritional quality of breakfast products.

Fat content varied strongly by cereal category (Fig. 3C), with granola having the highest fat (16.89 ± 5.17 g/100g, range 9.2–34, $n=64$), muesli notably

lower (7.08 ± 3.36 g/100g, range 2.0-14, $n=28$), and flakes and puffs lowest (4.18 ± 4.19 g/100g, range 1.0-15, $n=10$). Normality checks indicated departures from normality for granola and flakes and puffs (Shapiro $p < 0.01$), but variances were not detectably different across groups (Levene $p \approx 0.359$). Despite the normality issue, all inferential approaches agreed on a clear category effect: classic one-way ANOVA ($F = 62.92$, $p < 0.001$), Welch ANOVA ($F = 71.99$, $p < 0.001$), and Kruskal–Wallis ($H = 61.37$, $p < 0.001$)

were all highly significant, and the effect size was large ($\eta^2 \approx 0.560$, $\omega^2 \approx 0.548$). Tukey post-hoc testing showed Granola was significantly higher in fat than Muesli (mean difference ≈ 9.81 g/100g) and Flakes and Puffs (mean difference ≈ 12.71 g/100g), while Muesli and Flakes and Puffs were not significantly different after adjustment. These results align with previous market analyses, which have found that granola and cluster-type cereals tend to have significantly higher total fat than other breakfast cereal

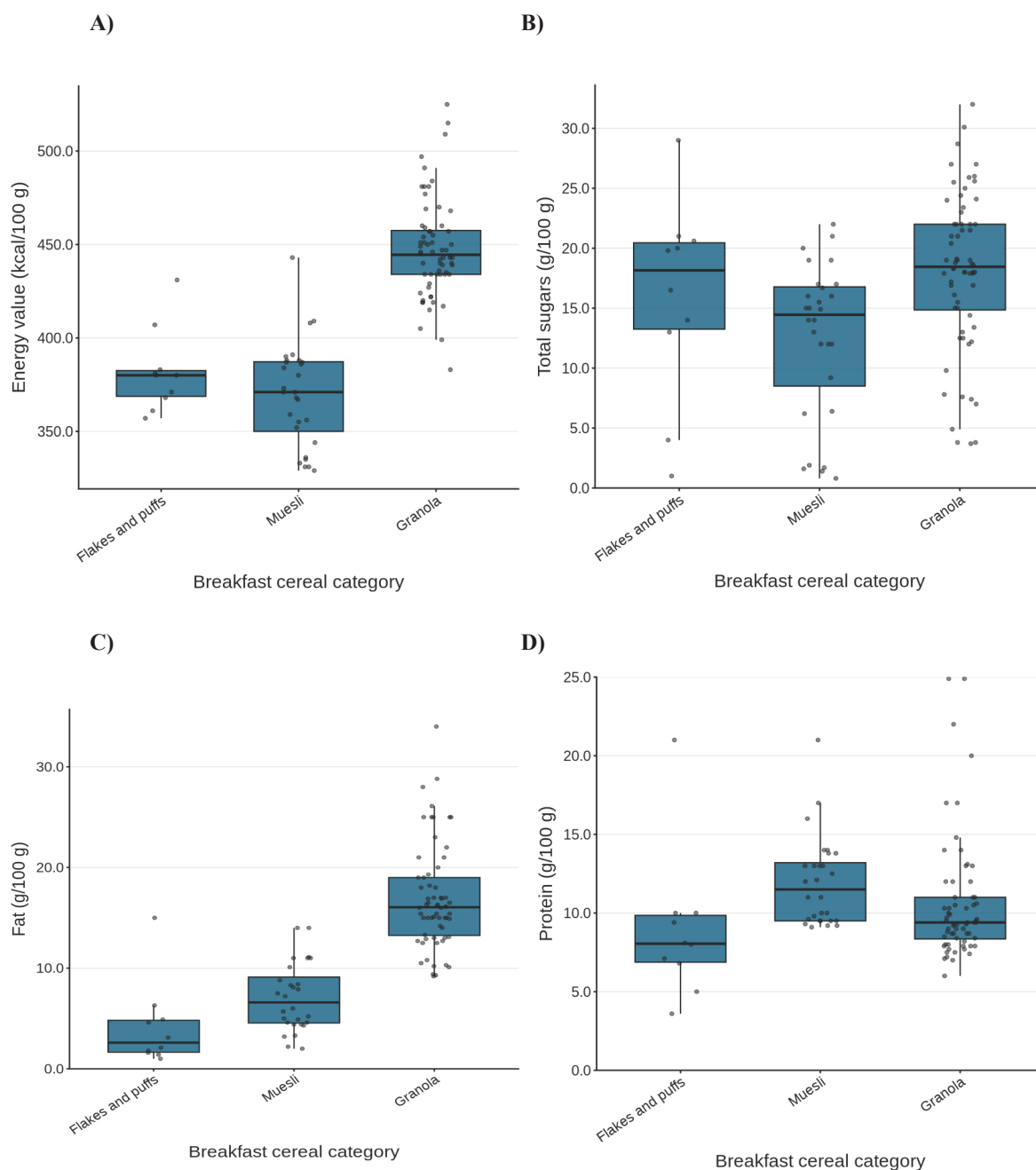


Fig. 3. Nutrient profile of flakes and puffs, muesli, and granola (per 100 g):
(A) energy; (B) total sugars; (C) fat; (D) protein.

categories, including muesli and flaked products, and that fat content varies substantially across cereal types (Croisier *et al.*, 2021).

Muesli had the highest average protein content (11.9 ± 2.84 g/100 g) with a range of 9.1–21.0 g/100 g, reflecting the inclusion of protein-rich ingredients such as nuts, seeds, and whole grains (Fig. 3D). Granola products showed slightly lower average protein levels (10.6 ± 3.95 g/100 g, 6.0–24.9 g/100 g), consistent with their varied formulations that also incorporate protein-dense components but often higher sugar and fat content. Flakes and puffs had the lowest average protein content (8.9 ± 4.73 g/100 g, 3.6–21.0 g/100 g), likely due to their reliance on processed grains with fewer protein-rich ingredients. ANOVA and Welch were not significant at 0.05 ($F = 2.64$, $p = 0.076$; Welch $F = 2.72$, $p = 0.087$), the ANOVA-style effect size was small ($\eta^2 \approx 0.0506$, $\omega^2 \approx 0.0312$), Tukey found no significant pairwise differences (all reject = False), but the nonparametric test did detect an overall distribution difference (Kruskal–Wallis $H = 14.34$, $p = 0.00077$) consistent with strong non-normality in all groups. Similarly, surveys of commercial breakfast cereals in European markets show a wide range of protein content across cereal types, highlighting that product category and recipe composition are key determinants of protein levels (Robert *et al.*, 2024). Overall, protein content is strongly influenced by cereal type and formulation, with muesli achieving the highest protein levels among the categories analyzed.

The coverage of a nutrient by one serving (30 g) of breakfast cereal in relation to Reference Intakes was used to calculate the quantity of nutrients required for adults (Fig 4.). A 30 g portion size was used as a reference serving in line with common industry practice, reflecting typical consumption patterns and allowing standardized comparison of nutritional values across breakfast cereal products (EUFIC,

2019). Dietary guidelines recommend a daily intake of at least 25 g of fiber, with cereal products being one of the main dietary sources (Eufic, 2023). In the present study, a single 30 g serving of muesli provided between 0.7–5.1 g of dietary fiber. On average, granola contributed the highest fiber amount per serving (2.67 g), followed by muesli (2.46 g), while flakes and puffs provided the lowest fiber content (1.74 g per serving) (Fig. 4A). Although granola and muesli offer a higher fiber contribution, even the highest average values supply only about 10–11% of the recommended daily intake per serving. These findings suggest that while cereal-based products can meaningfully contribute to daily fiber intake, relying on a single serving is insufficient to meet recommendations, emphasizing the importance of portion size, product choice, and overall dietary diversity.

According to the RI for energy and selected nutrients for adults, a minimum daily intake of 50 g of protein is recommended (EU No 1169/2011). In this study, a 30 g serving of cereal products provided relatively small amounts of protein. Muesli had the highest average protein content (3.57 g per serving), followed by granola (3.18 g per serving), while flakes and puffs provided the lowest amount (2.67 g per serving) (Fig. 4B). These values correspond to only 5.3–7.1% of the recommended daily protein intake, indicating that cereal products contribute modestly to daily protein requirements and should be complemented with other protein-rich foods in a balanced diet, with the main protein source of this breakfast meal most likely coming from added milk or yoghurt. Moreover, when protein intake is evaluated against European reference standards, the overall coverage of recommended values is low. This is further emphasized when considering national dietary guidelines in Latvia, which recommend that protein should provide approximately 10–20% of total daily

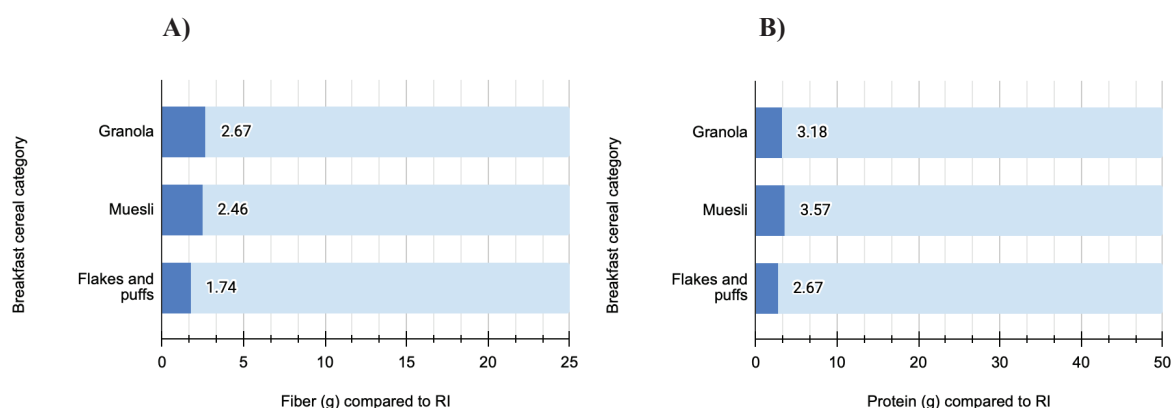


Fig. 4. Nutrient coverage of one serving of muesli category in comparison to reference intake: (A) fiber; (B) protein.

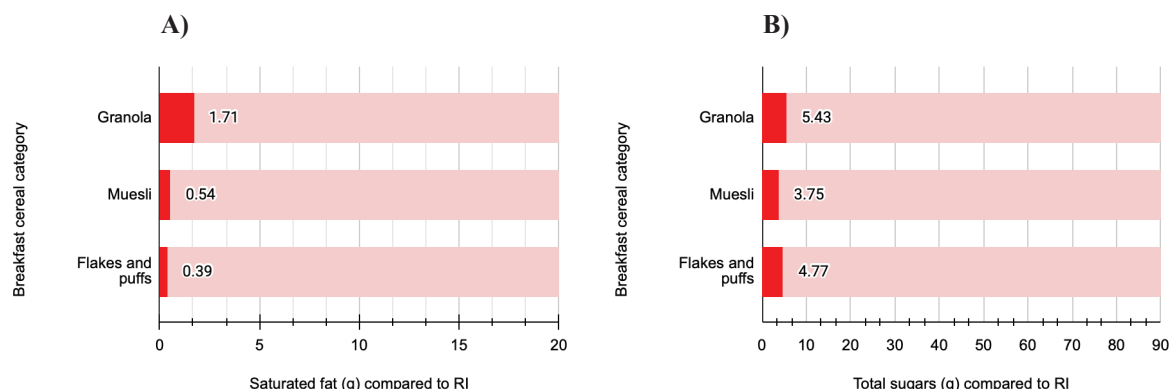


Fig. 5. Nutrient coverage of one serving of muesli category in comparison to maximum recommended intake: (A) saturated fat; (B) total sugars.

energy intake, corresponding to about 100 g of protein per day for adults consuming 2000 kcal (SPKC, 2017); under this criteria, the relative protein contribution of cereal products would be even lower.

It is recommended that saturated fatty acids provide no more than 20 g per day for adults consuming 2000 kcal (EU No 1169/2011). Saturated fat content of a 30 g serving of cereal products was low across all categories when compared with Maximum Recommended Intake (MRI). Granola contained the highest average amount (1.71 g per serving), followed by muesli (0.54 g), while flakes and puffs had the lowest saturated fat content (0.39 g per serving) (Fig. 5A). Even the highest value represented less than 8.5% of the MRI, indicating that these products are not a major source of saturated fat in the diet. This is a favorable nutritional characteristic, as low saturated fat intake is associated with a reduced risk of cardiovascular disease, and it suggests that muesli and related cereal products can be safely included in a balanced diet without substantially increasing saturated fat intake.

According to the MRI for Energy and Selected Nutrients for adults, the daily intake of total sugars should not exceed 90 g per day (EU No 1169/2011). A 30 g serving of cereal products contributed the following amounts of sugar: granola provided the highest average content (5.43 g per serving), followed by flakes and puffs (4.77 g) and muesli (3.75 g per serving) (Fig. 5B). These values correspond to roughly 4-6% of the maximum recommended daily sugar intake per serving, indicating that a single portion of cereal products contributes moderately to daily sugar intake. Granola products contribute the most sugar among the categories analyzed, while muesli offers the lowest contribution. This highlights that cereal product choice and portion size are important considerations for managing total sugar intake in the diet.

The proportion of products meeting EU nutrition claim criteria varied markedly among cereal categories (Fig. 6). Although manufacturers already displayed selected nutrition claims on product packaging, predominantly “low sugar” and “high fiber,” these were limited in scope. Therefore, a comprehensive assessment of all potential nutrition claims was conducted in accordance with Regulation (EC) No 1924/2006. Furthermore, to enable a more detailed characterization of nutritional variability within the breakfast cereal category, compliance with nutrition claim criteria was systematically evaluated across individual product groups: muesli, granola, and flakes/puffs. According to this regulation, products may be labeled low in fat if they contain ≤ 3 g fat/100 g, low in saturated fat if saturated and trans fats are ≤ 1.5 g/100 g, low in sugars if sugars are ≤ 5 g/100 g, and low in sodium/salt if sodium is ≤ 0.12 g/100 g. High-fiber claims require ≥ 6 g fiber/100 g or ≥ 3 g/100 kcal, while source of protein and high protein claims require $\geq 12\%$ and $\geq 20\%$ of energy from protein, respectively (European Commission, 2020).

Flakes and puffs most frequently met low fat (5/10; 50%) and low saturated fat (9/10; 90%) criteria, reflecting their lower lipid content, whereas granola products rarely qualified for these claims (0/64; 0% and 4/64; 6%, respectively) due to added oils. Low sugar claims were uncommon across all categories (Muesli 5/28; 18%, Granola 3/64; 5%, Flakes and Puffs 2/10; 20%), indicating widespread sugar inclusion. In contrast, high-fiber criteria were met by most muesli (27/28; 96%) and granola (60/64; 94%) products, compared with 5/10 (50%) of flakes and puffs. Sources of protein claims were most common in muesli (19/28; 68%), while high protein claims were rare across all categories (Muesli 2/28; 7%, Granola 2/64; 3%, Flakes and Puffs 1/10; 10%). Overall, muesli products most consistently met favorable nutrition claim criteria, whereas granola was limited by high fat

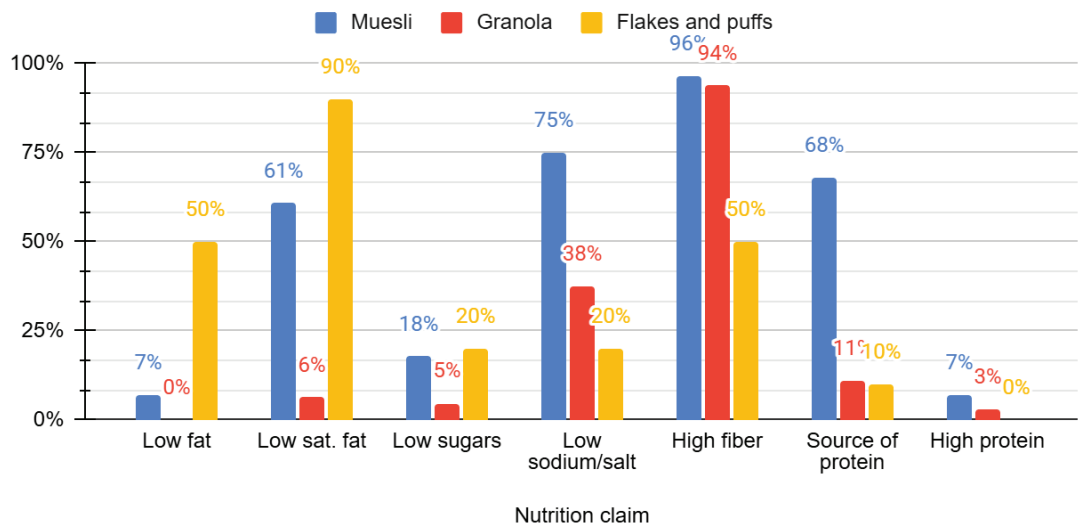


Fig. 6. Proportion of muesli, granola, and flakes and puffs products meeting nutrition claim criteria per 100 g.

content and flakes and puffs showed a more variable profile driven mainly by low-fat characteristics. The Portuguese cereal typology study parallels our findings in several ways: only a minority of flakes and puffs exhibit favourable nutritional quality, similar to our observation that many granolas and flavored products fail to meet multiple positive nutrition claims. In both datasets, fiber-related claims and higher nutritional quality were linked to whole grain or multi-grain cereal products. Unflavored

cereals more often carried nutrient claims such as low fat or low sugar, whereas flavored products tended to emphasize fiber or fat-free claims, a pattern consistent with our results showing muesli frequently meeting claim criteria compared with granola (Castro *et al.*, 2025). The study’s finding that single-grain or pseudo-cereal formulations often have better Nutri-Scores supports our conclusion that formulation type strongly affects overall nutritional quality, underscoring the importance of ingredient

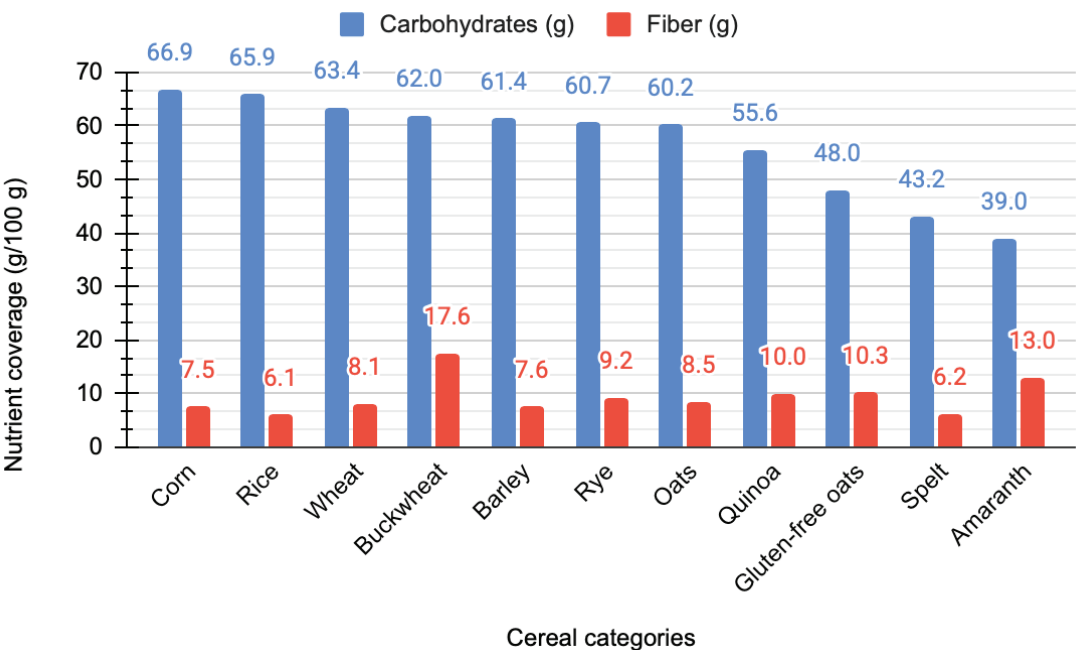


Fig. 7. Comparison of carbohydrate and fiber content across breakfast cereal types, with indication of cereal ingredients in the ingredient list.

composition and product classification when evaluating different breakfast cereals.

The carbohydrate content varied among the cereal and pseudo-cereal grains analyzed (Fig. 7), with corn (66.9 g) and rice (65.9 g) showing the highest levels, and amaranth (39.0 g) the lowest. Intermediate carbohydrate values were observed for wheat (63.4 g), buckwheat (62.0 g), barley (61.4 g), rye (60.7 g), oats (60.2 g), quinoa (55.6 g), gluten-free oats (48.0 g), and spelt (43.2 g). These results are consistent with literature reports indicating that cereal grains and pseudo-cereals are predominantly carbohydrate sources, typically ranging from ~48–82% of dry weight depending on species and processing conditions (Khan & Liu, 2024).

In contrast, fiber content showed greater variability across the analyzed grains, with buckwheat (17.6 g), quinoa (10.0 g), and gluten-free oats (10.3 g) exhibiting higher levels compared with rice (6.1 g), corn (7.5 g), and spelt (6.2 g). Rye (9.2 g) and oats (8.5 g) also demonstrated notable fiber content, likely reflecting higher bran fractions and the presence of soluble fibers such as β -glucans, which have been associated with improved lipid profiles and reduced cardiovascular risk in intervention studies (Khan *et al.*, 2024).

These findings highlight the importance of evaluating cereal nutrient composition when assessing the nutritional quality of breakfast cereals and guiding product development. In particular, understanding the variability in fiber content among grains is essential for the formulation of muesli products with enhanced cardiometabolic benefits. Grains rich in dietary fiber, especially those containing soluble fibers, may be preferentially selected to support cardiovascular health outcomes (Khan & Liu, 2024).

These findings broadly align with previous compositional analyses, which have demonstrated that pseudo-cereals like buckwheat, quinoa, and amaranth can contain substantial dietary fiber and complex carbohydrates relative to traditional cereal grains, and that whole grain cereals such as rye and oats are also important fiber sources (Khan & Liu, 2024). The observed variability in carbohydrate and fiber content across grain types underscores the importance of grain selection in dietary planning, particularly for strategies aimed at optimizing glycemic response and gut health through increased intake of complex carbohydrates and dietary fiber.

Conclusions

Study shows clear differences in both labeling and nutritional quality among cereal-based breakfast products. Although 102 products were identified online using the term “muesli,” only 28 met the

criteria for true muesli, while many contained added oils and sugars. Among the product groups, muesli had the most balanced nutritional profile, with moderate energy (369 kcal/100 g), lower fat (7.1 g/100 g), and higher protein (11.9 g/100 g) and dietary fiber (8.9 g/100 g) compared with granola and flakes and puffs. Granola was the most energy-dense product (448 kcal/100 g), mainly due to its high fat (16.9 g/100 g) and sugar content (18.1 g/100 g), while flakes and puffs were high in carbohydrates (74.9 g/100 g) and sugars (15.9 g/100 g) but lower in fiber (5.8 g/100 g) and protein (8.9 g/100 g). All product types met the requirements for a high-fiber claim, but a typical 30 g serving provided only about 10–11% of the recommended daily fiber intake. Results also show that grain choice strongly affects nutritional quality, as the use of pseudo-cereals such as buckwheat (17.6 g fiber/100 g) and amaranth (13.0 g/100 g), as well as whole grains like rye (9.2 g/100 g), can significantly improve fiber content and overall product quality.

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