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Variability of declared protein content in commercial oatmeal products with emphasis on protein-fortified formulations

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Abstract

Oatmeal is widely consumed as a convenient and nutritious food product, while protein-enriched formulations are increasingly marketed to consumers seeking higher protein intake. This study assessed the variability in declared protein content among commercially available oatmeal products, with particular emphasis on protein-enriched variants. A total of 64 oatmeal products were collected from retail markets in Šabac, Serbia, including oat flakes, instant oatmeal with various additives, and protein-fortified variants. Nutritional label data were analyzed using descriptive statistics to assess central tendency, dispersion, and distribution characteristics. Oat flakes exhibited relatively uniform protein content (mean 13.64 g/100 g) with low variability, indicating a consistent nutritional profile. Instant oatmeal products with various

additives demonstrated moderate protein content (mean 10.38 g/100 g) and relatively stable distribution. In contrast, protein-enriched oatmeal products showed substantially higher protein levels (mean 23.65 g/100 g) but also greater heterogeneity, reflecting differences in formulation and protein sources. Analysis of labelled protein content per serving revealed that fortified products can provide significantly higher protein intake compared to conventional formulations, potentially contributing meaningfully to daily protein requirements. A wide range of protein sources was identified, including animal-derived ingredients (milk proteins, whey protein concentrates, collagen) and plant-based proteins (pea protein isolate, date powder). Considerable variability exists in protein content across oatmeal product categories. Protein-fortified formulations offer enhanced nutritional value and may significantly contribute to daily protein intake, emphasizing the importance of formulation strategies and transparent labelling in the development and selection of oatmeal products.

Keywords: daily intake; instant oatmeal; nutritional labelling; protein.

INTRODUCTION

Instant oatmeal is one of the most widely consumed breakfast options worldwide due to its convenience, quick preparation, and favorable nutritional profile. This product is made from oat grains (*Avena sativa* L.) that are pre-cooked, chopped, and rolled into thin flakes, significantly reducing preparation time compared with traditional forms such as steel-cut or rolled oats while maintaining most of the grain's nutrients. Oats are rich in complex carbohydrates, proteins, dietary fiber, vitamins, and minerals, making them an excellent choice for a balanced diet [1]. Beyond their

nutritional value, instant oatmeal may also influence satiety and energy intake. Randomized studies indicate that consuming oatmeal at breakfast can increase feelings of fullness and reduce subsequent energy intake compared to other cereal-based breakfasts, suggesting a potential role in weight management [2,3]. Numerous studies have shown that diets rich in oats and oat-based products, including instant oatmeal, provide health benefits, particularly due to their high content of beta-glucans, a type of soluble dietary fiber [4,5]. Beta-glucans are associated with lowering LDL cholesterol, improving blood glucose regulation, and supporting cardiovascular health [6,7].

Oats (*Avena sativa* L.) are recognized not only for their high fiber content but also for their relatively high-quality protein, which is higher than that found in many other cereal grains such as rice or wheat. Oat proteins are primarily composed of globulins (70-80%), followed by prolamins (4-14%), albumins (1-12%), and a minor fraction of glutelins (<10%) [8,9]. Oat protein shares structural similarities with soy glycinin and shows strong potential as a novel functional ingredient in food processing. Furthermore, globulin—the predominant fraction, comprising approximately 70-80% of oat protein—demonstrates greater thermal stability than most other plant proteins [10]. Oat proteins are generally considered safe for gluten-free diets due to the low immunological activity of avenins [11]. While oats contain all the essential amino acids, their protein is limited in lysine, which is often the first limiting amino acid in cereal-based diets. This means that, although oat protein contributes substantially to daily protein intake, it is not a complete protein source when consumed alone. Combining oats with other protein sources, such as dairy, legumes, or nuts, enhances the amino acid balance and overall protein quality [12,13].

This systematically evaluated the declared protein content of commercially available oatmeal products and assessed variability among different product categories, including conventional oat flakes, instant oatmeal with various additives, and protein-enriched formulations. Particular emphasis is placed on identifying differences in declared protein levels per 100 g and per serving, as well as examining the contribution of added protein sources of both animal and plant origin. In addition, the study aims to analyze the role of formulation strategies in enhancing the nutritional value of oatmeal products, with a focus on protein enrichment and its potential impact on dietary protein intake. By comparing products with diverse ingredient compositions, this research seeks to highlight the extent of heterogeneity within the market and to evaluate how these differences may influence consumer choices and

nutritional adequacy. The findings are expected to contribute to a better understanding of the relationship between product formulation, nutritional labelling, and overall dietary significance.

MATERIALS AND METHODS

A total of 64 oatmeal products were collected from supermarkets in Šabac, Serbia, in January 2026, including 10 packs of oat flakes (100% oat), 44 packs of instant oatmeal products with various ingredients, and 10 packs supplemented with various sources of protein. Duplicate products were identified and removed before the evidence of declared data. For each product, the declared protein content (per 100 g and per recommended portion), the net mass of the pack, and the oat content (%) were recorded. All numerical data processing, calculation and graphical presentation were performed using Microsoft Office Excel. Data distribution was assessed using descriptive statistics, including skewness and kurtosis. The results are presented as a range (interval) to reflect the observed variability adequately. Due to non-normality and heterogeneity of variances, inferential analysis was limited to descriptive statistics.

RESULTS AND DISCUSSION

Labelled protein content in oat flakes

Based on the given sample (n = 10) of oat flakes (Figure 1), a descriptive statistical analysis of the observed variable was performed. The arithmetic mean is 13.64, while the median is 14, indicating that the data are slightly concentrated around the central value. The mode is 14, which further confirms that the most frequently occurring value is around this point. The variability of the data is low, with a minimum value of 11 and a maximum value of 15, resulting in a range of 4. The standard deviation is approximately 1.19, indicat-

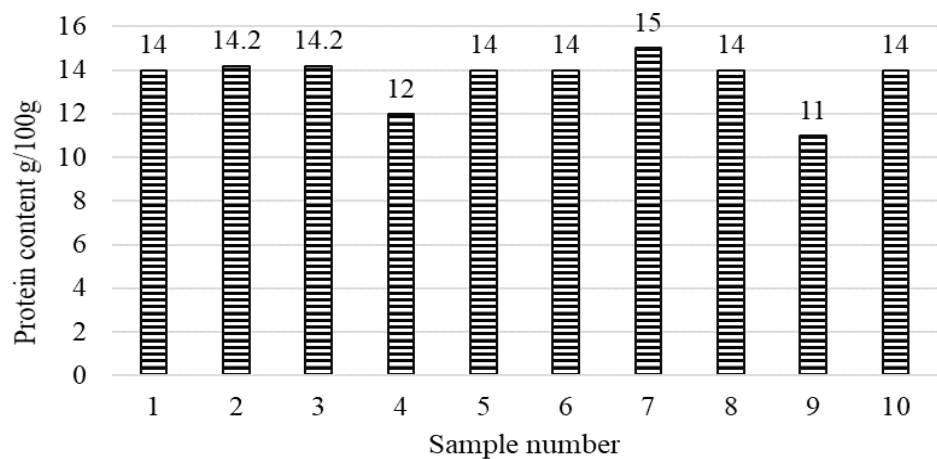


Figure 1. Labelled protein content (g/100g) in oat flakes.

ing a small dispersion of values around the mean. The distribution shows a slight left skew due to the presence of lower values (11 and 12), while most observations are clustered around 14. The 95% confidence interval for the mean is approximately 12.79 to 14.49, suggesting that the true population mean is expected to lie within this range. Overall, the results suggest a homogeneous dataset with a stable central tendency and limited variability.

Labelled protein content in oatmeals with added sources of proteins

A descriptive statistical analysis was performed on the declared protein content per 100 g in instant oatmeal products with added protein ingredients (n = 10) (**Figure 2**). The mean protein content was 23.65, with a median of 24.99, indicating slight negative skewness (skewness = -1.23). The dataset is multimodal, with modes at 18, 23, and 26.3, suggesting the presence of distinct product subgroups with different declared protein levels. The variability was moderate (SD = 3.213; range = 8.3), reflecting heterogeneity across products. Values ranged from 18 to 26.3. Kurtosis (0.16) indicates a distribution close to normal in terms of tail heaviness, without pronounced outliers. The 95% confidence interval for the mean (23.648 ± 2.298) indicates moderate uncertainty given the small sample size. Overall, the distribution reflects a heterogeneous product group rather than a single uniform formulation profile.

The dataset (n = 10) of declared protein content per suggested portion in oatmeals with added sources of proteins (**Figure 2**) exhibits a mean value of 17.28 (standard error = 1.45), indicating the average level of

the observed variable. The median is 19.99, which is higher than the mean, suggesting a negatively skewed distribution. This is confirmed by the skewness coefficient (-0.88), indicating that lower values are pulling the mean downward. The mode (14.72) is lower than both the mean and median, further supporting the presence of asymmetry. Measures of dispersion show a standard deviation of 4.59 and a range of 11.14 (minimum = 9.90; maximum = 21.04), indicating moderate variability within the dataset. The quartile analysis provides additional insight into the distribution. The first quartile (Q1) is 14.72, the median (Q2) is 19.99, and the third quartile (Q3) is 20.80. This indicates that 50% of the observations fall between 14.72 and 20.80, with a clear concentration of values toward the upper end of the scale. The relatively narrow interquartile range suggests that the central portion of the data is fairly compact despite the overall range. Furthermore, the kurtosis value (-0.97) indicates a platykurtic distribution, meaning the data are flatter than a normal distribution and exhibit fewer extreme values. Finally, the 95% confidence interval for the mean (±3.28) suggests that the true population mean is likely to lie between 14.00 and 20.56, reflecting moderate precision given the sample size.

Labelled protein content in instant oatmeals with various additives

The dataset of protein content per 100 g in instant oatmeals with various additives included 45 observations ranging from 8.0 to 14.3 (**Figure 3**). The mean value was 10.38, closely aligned with the median of 10.0, indicating an approximately symmetric distribution with a slight positive skew. Variability was moderate (stand-

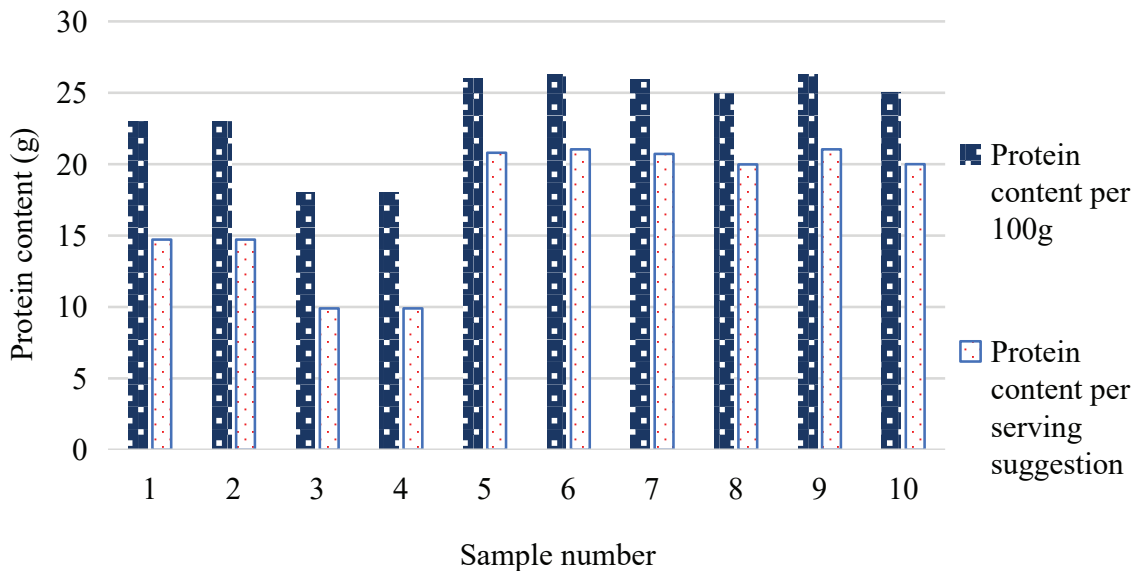


Figure 2. Protein content (g/100g and g/serving portion) in instant oatmeal products with added sources of proteins.

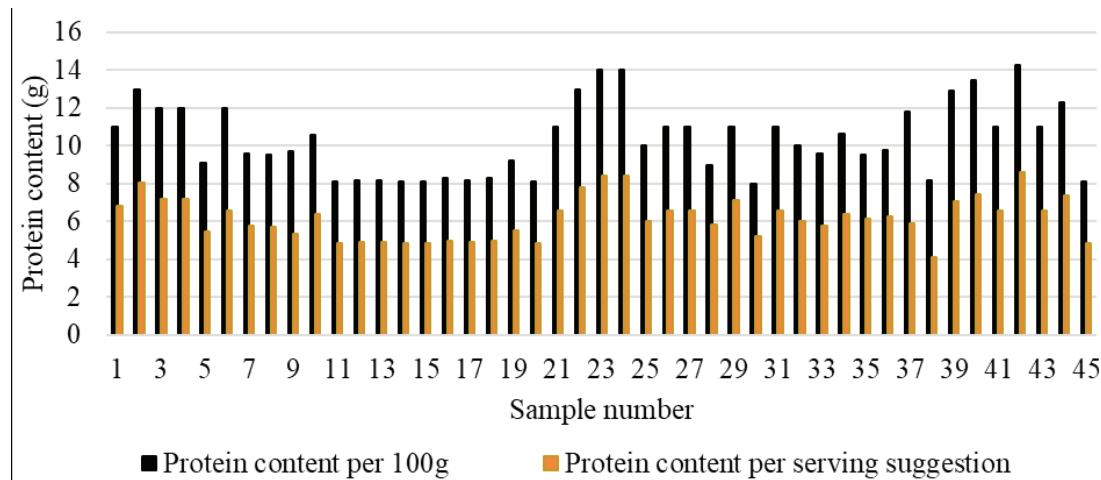


Figure 3. Protein content g per 100 g and per serving suggestion in instant oatmeal products.

ard error = 1.88; variance = 3.55), with a limited range of 6.3, suggesting relatively clustered values without extreme outliers. Skewness was mildly positive (~0.42), while kurtosis was negative (~ -0.87), indicating a flatter-than-normal distribution with light tails. The 95% confidence interval for the mean was ± 0.57 , indicating a relatively precise estimate of the population mean given the sample size. Overall, the data show moderate dispersion and near-symmetry, with minor heterogeneity driven by a small number of higher observations.

The descriptive statistics for protein content per suggested portion in instant oatmeals with various additives indicate a moderate level of central tendency, with a mean of 6.19 and a median of 6.12, suggesting a relatively balanced distribution (**Figure 3**). The slight positive skewness (0.37) points to a mild right-tailed asymmetry, indicating that higher values are somewhat more dispersed, although the difference between the mean and median remains minimal. The dataset’s variability is moderate, as reflected by a standard deviation of 1.11 and a range of 4.48 (from 4.10 to 8.58). Furthermore, the negative kurtosis (-0.55) sug-

gests a platykurtic distribution, indicating flatter tails and a lower likelihood of extreme outliers compared to a normal distribution. The quartile analysis provides additional insight into the distribution. The first quartile (Q1) is approximately 5.09, the median (Q2) is 6.12, and the third quartile (Q3) is approximately 6.96. This results in an interquartile range (IQR) of approximately 1.87, indicating that the central 50% of the data is moderately dispersed around the median. The slightly greater distance between Q2 and Q1 compared to Q2 and Q3 is consistent with the observed mild positive skewness. Overall, the dataset demonstrates a relatively stable distribution with moderate variability, slight right skewness, and no substantial presence of extreme values.

Variety in added protein sources

As presented in **Table 1**, additional protein sources included both animal-derived ingredients, such as unspecified milk proteins, whey protein concentrates, and freeze-dried beef collagen, as well as plant-based proteins, including date powder and pea protein isolate.

Table 1. Some of the ingredients in oatmeal products include added sources of protein.

No.	Ingredients
1.	Milk protein, whole milk powder, dehydrated vanilla pieces 0.1%
2.	Milk protein, whole milk powder, chocolate pieces 1.5%
3.	Date powder 14%, cocoa powder 2.5%, freeze-dried sour cherry pieces
4.	Date powder 14%, freeze-dried banana 1.8%, cocoa powder 2.5%
5.	Whey protein concentrate 19%, freeze-dried raspberries 1.19%
6.	Whey protein concentrate 19%, coconut flour 5.25%
7.	Whey protein concentrates 19%, freeze-dried strawberries 0.82%, green tea 0.75%
8.	Freeze-dried beef collagen 13.2%
9.	Whey protein concentrate 19%, cocoa mass 1.25%
10.	Pea protein isolate 12%, cocoa mass 3.3%

Among sports nutrition supplements, whey protein (WP) is particularly known for its rapid digestion and high-quality amino acid profile, which largely explains its widespread use in athletic contexts. Despite a considerable number of studies examining its physiological effects, important gaps remain in understanding its exact mechanisms related to exercise performance, recovery processes, and immune function. Furthermore, clearer evidence is still required to define optimal intake amounts, timing strategies, potential risks or side effects, and future research directions [14]. The different variants of WPC are commercialized at different levels of protein (w/w) via 35, 50, 60 and 80% [15].

Incorporating protein supplements derived from collagen-rich beef materials is advisable as a source of functionally active amino acids that support bone health. Such ingredients can be utilized in the formulation of specialized and personalized fortified foods aimed at particular groups, including individuals affected by collagen-related disorders. Additionally, these products may offer preventive benefits and contribute to maintaining and improving the musculoskeletal system across the general population [16].

Plant-derived proteins found in foods like oats, pulses, and various nuts supply essential amino acids along with beneficial bioactive constituents, and they typically contain less saturated fat and no dietary cholesterol compared to animal-based sources. Research suggests that regular consumption of these proteins is linked to enhanced heart health, a lower likelihood of developing chronic conditions, and more favorable metabolic indicators [17]. Derived from field peas, pea protein isolate (PPI) is a highly concentrated protein fraction that typically contains more than 90% protein and is mainly composed of globulin proteins such as legumin and vicilin. It also exhibits several favorable functional properties, including good water solubility, thermal stability, and strong emulsifying and foaming capacities [18].

In date powder, the predominant constituent is total dietary fibre (TDF), accounting for 66.0 ± 1.4 g/100 g, followed by total sugars at 18.7 ± 0.8 g/100 g, protein content at 6.8 ± 0.7 g/100 g, moisture at 5.7 ± 1.0 g/100 g, ash at 1.7 ± 0.3 g/100 g, and total fat at 1.2 ± 0.7 g/100 g. Nutritionally, date fruits are regarded as rich carbohydrate sources, with carbohydrates making up approximately 60% to 80% of their overall composition, including both naturally occurring sugars and dietary fibre fractions [19,20]

In oats meal products with added protein sources, the content of proteins from oat origin was in the interval 58.1-64.7 g/100 g (**Figure 4**).

In oats meal products with various ingredients, the content of proteins from oat origin was in the interval 47-87 g/100 g (**Figure 5**). Some of the ingredients presented in labelled content more than 1% were: sweetened cranberry, raspberry pieces, dried apple pieces, raisins, chicory root, white, chocolate-like product pieces, chia seeds, freeze-dried plum, chocolate pieces, white chocolate, quinoa, chocolate drops, hazelnut, etc.

The observed variability in protein content across oatmeal product categories can be primarily attributed to differences in formulation strategies, ingredient composition, and the degree of protein fortification applied during processing. Conventional oat flakes demonstrated relatively stable protein levels, reflecting minimal processing and limited modification of the native protein content of oats. In contrast, instant oatmeal products with added ingredients showed lower protein values, which may be explained by the dilution effect of carbohydrate-rich additives such as sugars, dried fruits, and flavoring agents.

Protein-fortified oatmeal products exhibited substantially higher protein content, but also greater variability, indicating the absence of standardized fortification practices across manufacturers. This heterogeneity likely reflects the use of different protein sources,

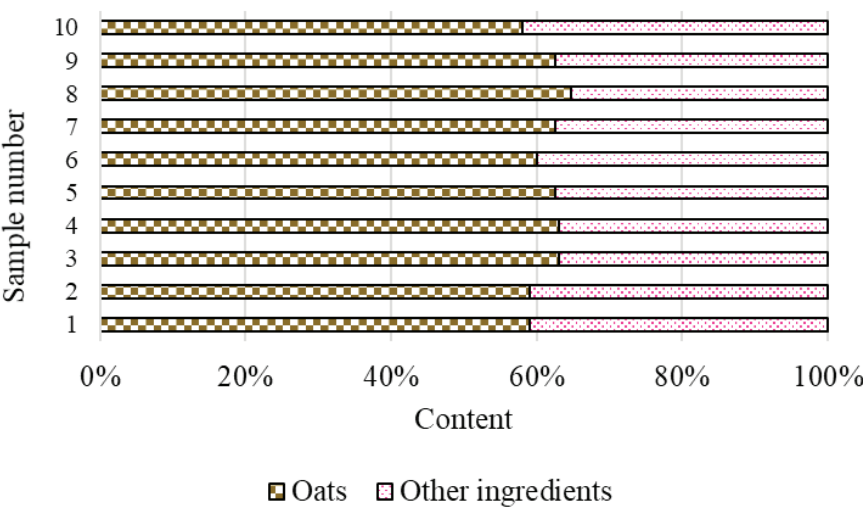


Figure 4. Oats content in instant oatmeal with added protein sources.

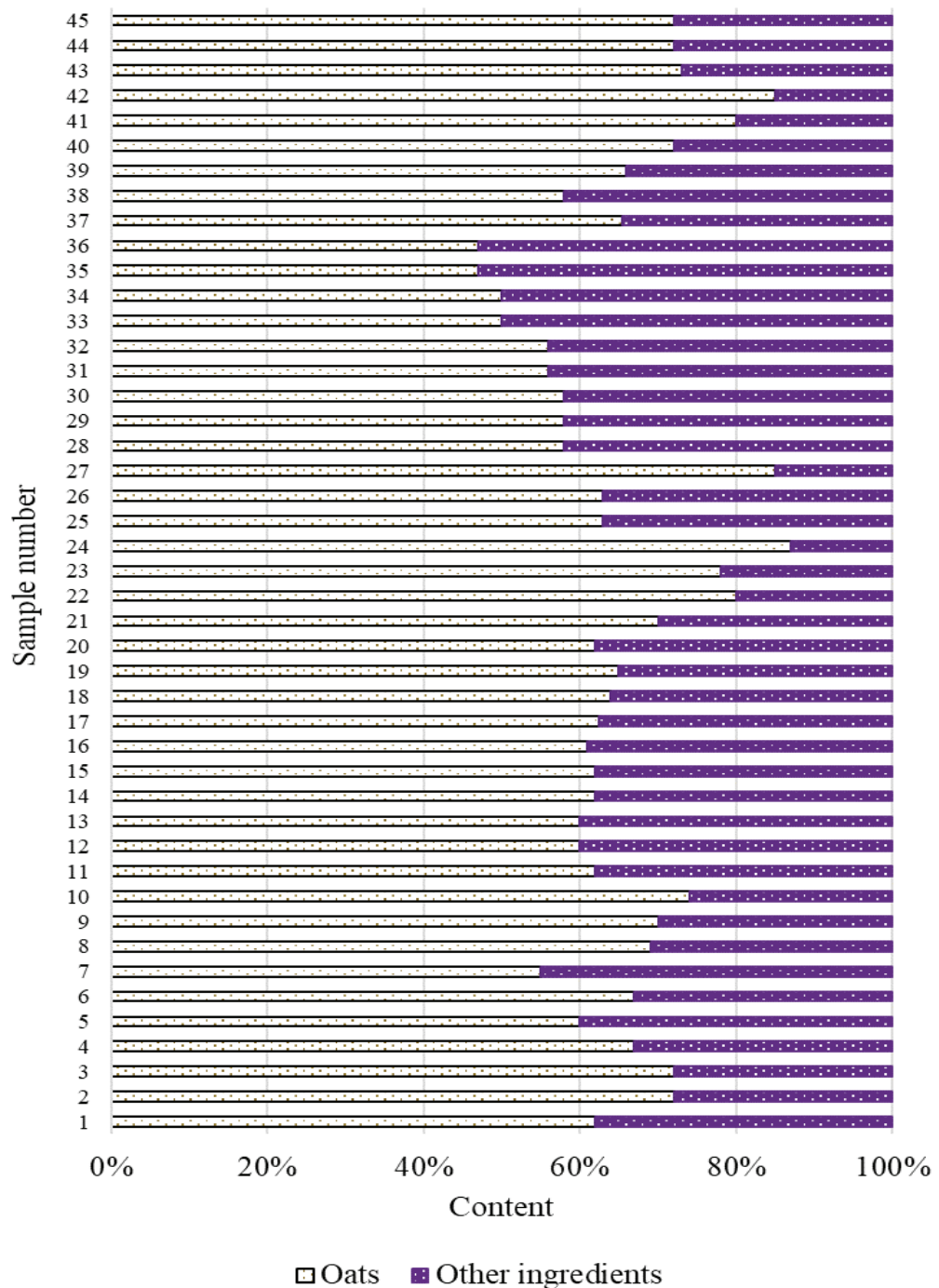


Figure 5. Oats content in instant oatmeal with various ingredients.

including milk proteins, whey protein concentrates, collagen, and plant-derived isolates such as pea protein. Each of these ingredients differs in protein concentration, digestibility, amino acid composition, and functional properties, which directly influence the final nutritional profile of the product.

From a nutritional standpoint, protein-enriched oatmeal formulations may represent a convenient strategy to increase daily protein intake, particularly in populations with elevated requirements, such as older adults, physically active individuals, or those with in-

creased satiety demands. However, the actual nutritional benefit depends not only on total protein content but also on protein quality, amino acid balance, and overall dietary context. In this regard, plant-based proteins such as pea protein contribute favorable functional and nutritional properties, while dairy-derived proteins such as whey protein offer higher biological value and faster digestibility. Collagen, although widely used in fortified products, lacks certain essential amino acids and therefore should not be considered a complete protein source.

Daily protein intake

Diets with elevated protein content, along with foods fortified with protein, have seen a rise in popularity because of their proposed role in influencing hunger regulation, caloric consumption, body weight management, and overall body composition. This increasing interest has also prompted discussion about the adequacy and precision of existing protein intake recommendations. While potential adverse health effects have been suggested in various contexts, a substantial number of these claims lack robust scientific backing, and several are not supported by current empirical findings [21].

Based on the Scientific Opinion on Dietary Reference Values for protein [22], dietary surveys indicate that average protein intake across European populations ranges from about 67 to 114 g/day in adult men and from 59 to 102 g/day in adult women, which corresponds to roughly 12–20% of total energy intake for both sexes. When expressed per kilogram of body weight, available estimates are more limited but generally range from 0.8 to 1.25 g/kg/day in adults. The Recommended Dietary Allowance (RDA) is defined as the average daily level of nutrient intake that is sufficient to meet the requirements of nearly all (97–98%) healthy individuals within a given sex and life-stage group, where life stage includes age and, when relevant, pregnancy or lactation [23]. In contrast, the Population Reference Intake (PRI) represents the level of intake considered adequate for almost all individuals in a population group (Table 2). It is derived on the assumption that individual requirements are normally distributed and that variability between individuals is

ity. Research evidence suggests that long-term protein consumption in healthy adults can safely reach up to about 2 g/kg BW/day, while in well-adapted individuals, a tolerable upper range of up to 3.5 g/kg BW/day has been suggested. At the same time, sustained intake above 2 g/kg BW/day has been linked to potential adverse effects on renal, digestive, and vascular function and is therefore generally discouraged. The nutritional value of protein is determined not only by total intake but also by its quality. In this context, sufficient consumption of high-quality protein sources, especially those derived from animal foods such as lean meats and dairy products, is considered important for supporting normal growth, development, and overall physiological health [25].

Since the examined oatmeal products are typically consumed as a breakfast meal, protein intake was evaluated based on the recommended serving size provided in the sachet. However, the dataset (N = 10) contained 14.00 g and 20.56 g of protein per suggested portion, but protein content per suggested portion in instant oatmeals with various additives ranged from 4.10 to 8.58. So, protein-fortified products contained higher protein content than conventional oatmeal products per recommended single portion. Phillips *et al.* [26] proposed that consuming about 0.4–0.6 g of protein per kilogram of body weight per meal, roughly 30–40 g, is required to fully optimize muscle protein synthesis in older adults. However, the majority of independently living older individuals in the Netherlands fall short of these recommended per-meal protein levels, especially during breakfast and lunch. On average $\pm$ SD, protein intake amounts to 11 ± 7 g at breakfast

Table 2. Population reference intake for proteins [21,23].

Population reference intake (PRI)
Adults (including older adults) – 0.83 g per kg of body weight per day
Pregnant women – additional intake of 1 g, 9 g and 28 g per day for the first, second and third trimester, respectively, is proposed in addition to the PRI for non-lactating women
Breastfeeding women – additional intake of 19 g per day during the first 6 months of lactation and 13 g per day thereafter is proposed in addition to the PRI for non-lactating women

known; accordingly, the PRI is calculated as the Average Requirement (AR) plus two standard deviations (SD), which is expected to cover the needs of approximately 97.5% of the population [24].

According to short-term nitrogen balance studies, the current Recommended Dietary Allowance (RDA) for protein in healthy adults with low physical activity levels is established at 0.8 g per kilogram of body weight (BW) per day. To optimise functional outcomes such as skeletal muscle protein synthesis and strength, higher intakes have been proposed, approximately 1.0 g/kg BW/day for low activity, 1.3 g/kg BW/day for moderate activity, and 1.6 g/kg BW/day for high activ-

and 18 ± 10 g at lunch [27]. Compared to our findings, these protein intakes are possible by consuming even one carefully chosen sachet of oatmeal products.

It is also important to emphasize that the nutritional impact of these products should be interpreted cautiously due to the reliance on labelled data rather than laboratory-verified protein measurements. Labelling accuracy may vary between manufacturers and jurisdictions, and discrepancies between declared and actual nutrient content have been reported in processed food products. Additionally, this study did not assess protein bioavailability or digestibility, which are critical factors in determining true nutritional value.

Another limitation of the present study is the geographical restriction to a single retail market, which may limit the generalizability of the findings. Product availability, formulation practices, and regulatory standards may differ across regions, potentially influencing protein content variability. Furthermore, the relatively small number of products within certain subcategories may reduce the statistical power of between-group comparisons.

Despite these limitations, the findings provide a relevant overview of current market trends in oatmeal product formulation and highlight the increasing role of protein fortification in cereal-based foods. The results suggest a growing diversification of product strategies aimed at enhancing nutritional value, but also underline the need for greater standardization in labelling practices and clearer communication of protein quality to consumers.

CONCLUSIONS

The results demonstrate clear differences in protein content among oatmeal product categories, with protein-enriched formulations offering substantially higher levels compared to conventional instant products and oat flakes. While traditional oat-based products provide a stable and nutritionally consistent protein contribution, their protein content per serving remains relatively modest. In contrast, the inclusion of additional protein sources – both animal- and plant-derived – significantly improves the overall protein profile, although it introduces variability depending on ingredient composition and formulation approaches. From a nutritional perspective, protein-fortified oatmeal products can play a meaningful role in supporting daily protein intake, particularly when consumed as a convenient breakfast option. This is especially relevant for population groups with increased protein requirements, such as older adults or physically active individuals. However, the observed heterogeneity suggests the need for careful product selection and clearer labeling to ensure that consumers can make informed dietary choices. Overall, the study emphasizes the growing potential of oatmeal as a functional food platform for protein enrichment, while also highlighting the importance of balancing protein quantity with quality and overall nutritional composition.

COMPETING INTERESTS

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

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

D. D-M.: Conceptualisation, Methodology, Investigation, Data Curation, Visualization, Writing – original draft; G.J.: Investigation, Data Curation, Writing – review & editing.

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Varijabilnost deklarisanog sadržaja proteina u komercijalnim proizvodima od ovsene kaše sa posebnim osvrtom na formulacije obogaćene proteinima

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Kratak sadržaj

Ovsena kaša je popularna za konzumaciju kao praktičan i nutritivno vredan prehrambeni proizvod, dok se formulacije obogaćene proteinima sve češće plasiraju potrošačima koji teže većem unosu proteina ishranom. Ova studija procenila je varijabilnost deklarisanog sadržaja proteina među komercijalno dostupnim proizvodima od ovsene kaše, sa posebnim fokusom na varijante obogaćene proteinima. Ukupno 64 proizvoda od ovsene kaše prikupljeno je iz maloprodajnih objekata u Šapcu, Srbija, uključujući ovsene pahuljice, instant ovsene kaše sa različitim dodacima i proteinski obogaćene formulacije. Podaci sa nutritivnih deklaracija analizirani su primenom deskriptivnih statističkih metoda radi procene mera centralne tendencije, disperzije i karakteristika raspodele. Obične ovsene pahuljice pokazale su relativno ujednačen sadržaj proteina (srednja vrednost 13,64 g/100 g) uz malu varijabilnost, što ukazuje na konzistentan nutritivni profil. Instant ovsene kaše sa različitim dodacima imale su umeren sadržaj proteina (srednja vrednost 10,38 g/100 g) i relativno stabilnu raspodelu vrednosti. Nasuprot tome, proizvodi od ovsene kaše obogaćeni proteinima pokazali su značajno viši sadržaj proteina (srednja vrednost 23,65 g/100 g), ali i veću heterogenost, što odražava razlike u formulacijama i izvorima proteina. Analiza deklarisanog sadržaja proteina po porciji pokazala je da obogaćeni proizvodi mogu obezbediti znatno veći unos proteina u poređenju sa konvencionalnim formulacijama, čime potencijalno značajno doprinose dnevnim potrebama za proteinima. Identifikovan je širok spektar izvora proteina, uključujući sastojke životinjskog porekla, poput mlečnih proteina, koncentrata proteina surutke i kolagena, kao i biljne izvore proteina, uključujući izolat proteina graška. Ukupno posmatrano, postoji značajna varijabilnost u sadržaju proteina među različitim kategorijama proizvoda od ovsene kaše. Formulacije obogaćene proteinima nude unapređenu nutritivnu vrednost i mogu značajno doprineti dnevnom unosu proteina, naglašavajući značaj strategija formulacije i transparentnog deklarisanja u razvoju i izboru proizvoda od ovsene kaše.

Ključne reči: dnevni unos; instant ovsena kaša; deklarisanje nutritivnih vrednosti; proteini.