NAUKI INŻYNIERSKIE I TECHNOLOGIE
Journal of Food and Engineering Sciences

Nauki Inżynierskie i Technologie
Journal of Food and Engineering Sciences
Year 2025, Vol. 41
ISSN 2449-9773
journals.ue.wroc.pl/niit

Analysis of Phosphate Content of Cola Drinks and an Attempt to Estimate the Phosphate Intake with These Drinks by Young Adults – A Pilot Study

Gabriela Haraf

Wroclaw University of Economics and Business

e-mail: gabriela.haraf@ue.wroc.pl

ORCID: 0000-0002-9398-228X

Jan Dziurbiel

Wroclaw University of Economics and Business

e-mail: 181453@student.ue.wroc.pl

Quote as: Haraf, G., & Dziurbiel, J. (2025). Analysis of Phosphate Content of Cola Drinks and an Attempt to Estimate the Phosphate Intake with These Drinks by Young Adults – A Pilot Study. *Nauki Inżynierskie i Technologie. Journal of Food and Engineering Sciences*, *41*, 1-12.

DOI: 10.15611/nit.2025.41.01

JEL: L15, L66

Abstract

Aim: This study was designed as a pilot to determine the orthophosphate (PO_4^{3-}) content of cola drinks available in Poland on the Wrocław market, attempt to estimate the amount of phosphorus (P) in soft drinks consumed by young adults (18-35 years old) and examine their level of knowledge about sources of PO_4^{3-} in the diet and the potential harm of their excess.

Methodology: The analysis of cola drinks was performed using Merck's rapid reflectometer test. Asurvey was also conducted via the Google Forms platform.

Results: The analysis of cola drinks showed that the PO_4^{3-} content varied from 125 to 875 mg/l. The survey showed that the respondents have limited knowledge of the harmfulness of excess P and its presence in food. Declared consumption of cola drinks ranged from 250 to 9,000 ml/week. Coca-Cola Zero and the classic Coca-Cola were the most frequently chosen beverages. The average P intake of young adults with these beverages amounted from 23 to 267 mg/day.

Implications and recommendations: According to scientific reports, the stated daily intake of P should not cause health problems. Nevertheless, its daily intake should be monitored, especially for people with health issues such as kidney disease or hypoparathyroidism.

Originality/value: Monitoring the PO_4^{3-} content in processed foods is important due to the increasing popularity of this type of food and the assessment of the health risks associated with excess P in diet.

Keywords: orthophosphates, phosphorus, beverages, food additives, minerals

1. Introduction

The addition of phosphates to food products has become a topic of interest due to its potential health implications, particularly for individuals with chronic kidney disease (Kaczkan et al., 2018) or hypoparathyroidism. Phosphate additives are widely used in processed foods to improve various qualities, and their presence in the market is increasing due to the popularity and convenience of processed foods (Calvo & Uribarri, 2017). Phosphate additives include buffers, sequestrants, acidulants, bases, flavours, cryoprotectants, gel accelerants, dispersants, nutrients, precipitants, and anticaking agents, which are crucial in maintaining the quality and stability of various food products, including baked goods, processed cheese, meats, and beverages (Lampila, 2013).

Unprocessed foods typically contain organic phosphate, which is less efficiently absorbed by the human gastrointestinal tract. Organic phosphates are found in animal and plant-based foods, but their bioavailability varies. For instance, plant-based phosphates are often bound in phytate form, which humans cannot digest due to the lack of the enzyme phytase, resulting in lower absorption rates (Kalantar-Zadeh et al., 2010; Watanabe et al., 2018). Consequently, the intake of natural phosphate from unprocessed foods does not significantly elevate serum phosphate levels (McCarty & DiNicolantonio, 2014; Ritz et al., 2012).

In contrast, inorganic phosphate additives, commonly found in processed foods, are highly bioavailable and almost entirely absorbed by the intestines (Benini et al., 2011; Calvo & Uribarri, 2017; Picard et al., 2023). The high absorption rate of inorganic phosphates can lead to elevated serum phosphate levels. High dietary phosphorus intake can disrupt the hormonal regulation of phosphate, calcium, and vitamin D, contributing to disordered mineral metabolism and bone loss, which can lead to osteoporosis and increased fracture risk (Calvo et al., 2014; Calvo & Uribarri, 2013; Uribarri & Calvo, 2013a, 2013b; Vorland et al., 2017). Higher phosphorus intake was linked to a higher risk of developing type 2 diabetes in a large cohort study (Mancini et al., 2017). Excessive phosphorus intake can lead to renal calcification, renal tubular injury, and impaired kidney function, particularly concerning for individuals with chronic kidney disease, but it also poses risks to the general population (Chang & Anderson, 2017). Dietary phosphorus content should also be controlled in people with hypoparathyroidism (Guarnotta et al., 2017).

Cola drinks, particularly Coca-Cola and Pepsi, are among the most popular beverages globally. Coca--Cola drinks are consumed worldwide in large quantities. It is estimated that more than 1.9 billion servings of Coca-Cola-branded drinks, among others Diet Coke, Coke Zero and Caffeine-Free Coke, are consumed worldwide every day (The Coca-Cola Company, 2024b). Global sales of fizzy (carbonated) soft drinks produced by The Coca-Cola Company grew by 2% in 2023 compared to the previous year (The Coca-Cola Company, 2024a). In some countries, consumption of Coca-Cola beverages is particularly high – each Mexican consumes on average around 160 litres of Coca-Cola per year, which is a huge consumption (The Economic Times, 2024). These figures underline cola drinks' dominant position in the soft drinks market and its widespread presence the diets of consumers worldwide. Cola drinks are also very popular in Poland, where he Brand Loyalty Index 2023 indicated that in the beverage category, Coca-Cola and Pepsi were the brands most frequently chosen by Poles between 2021 and 2023 (Business Insider, 2023).

Dark colas and sodas contain high amounts of inorganic phosphates used as additives. There is considerable variation in phosphate content among different beverages. Currently, food manufacturers are not required to include the phosphorus content on product labels (Regulation (EU) No 1169/2011,

2011). Some studies have shown higher phosphorus content in products containing phosphate additives than the values listed in nutrition databases for these foods and beverages (Krekel et al., 2016; León et al., 2013; Moser et al., 2015; Sherman & Mehta, 2009). Monitoring the phosphate content in soft drinks is also essential due to the recommendations of the EFSA Panel on Dietetic Products, Nutrition and Allergies on the need to develop tools allowing for the quantification of phosphorus-based additives used in some carbonated beverages (EFSA, 2015). In connection with the above, the study aimed to determine the content of orthophosphates in cola drinks popular and available in Poland on the Wrocław market and to attempt to estimate the consumption of these food additives with soft drinks by young adults. Instrumental analysis was performed using a fast reflectometric method. The amount of drinks consumed by young adults was determined based on the results of survey questionnaire studies. The survey also contained questions to determine the level of knowledge of its participants on the sources of phosphates in the diet, as well as the potential effects of their excess in the body.

2. Materials and Methods

2.1. The Orthophosphates Contents Analysis in Cola Drinks

The study included cola drinks from various manufacturers. The content of orthophosphates (PO_4^{3-}) (sourced exclusively from food additives) was determined in the following products: Coca-Cola and its variants (Coca-Cola Zero, Coca-Cola Cherry, Coca-Cola without caffeine, Coca-Cola Lime), various Pepsi flavours (Classic, Pepsi Max, Pepsi Mango, Pepsi Ananas), Carrefour Classic Cola, ON Lemon Kola, Dr Pepper Cherry, Kong Strong Cuba Libre energy drink with Cola, Polo Cocta, Dr Pepper, Candycan Fireball, as well as Freeway Cola and its sugar-free variety. The drinks were purchased in large shops in Poland in Wrocław (Carrefour, Auchan, Lidl, Biedronka, and POLOmarket). The content of orthophosphates in cola beverage samples was analysed using the Reflectoquant plus Phosphate test (no. 1.17942.0001) from Supelco (Bellefonte, Pennsylvania, USA) with a detection range of 0.1 – 5.0 mg/l PO_4^{3-}. The principle of determination is that in a sulfur solution, orthophosphate ions react with molybdate ions to form molybdophosphoric acid, which is then reduced to phosphomolybdate blue (PMB), determined using an RQflex 10 PLUS reflectometer (Merck Group, Darmstadt, Germany).

The drinks were degassed by exposing them to ultrasound in an ultrasonic bath for 10 minutes. After degassing, a 1 ml sample was taken from each drink and diluted with distilled water to a volume of 500 ml in a measuring flask, and then the solution was thoroughly mixed. Following the instructions for the test used (Supelco no. 1.17942.0001), reagents included in the test were added to 5 ml of the diluted drink. The pure solution of the drink was the reference sample. The analysis was performed in triplicate ($n = 3$). The mean orthophosphates (PO_4^{3-}) contents of the cola drinks were calculated, and a one-way ANOVA analysis of variance was carried out. Tukey's test at $\alpha \leq 0.05$ was used to assess the significance of differences.

2.2. Survey Research

The anonymous survey was conducted via the Google Forms platform from September to December 2023. The selection of respondents was random and participation in the survey was voluntary, with 124 persons taking part. The survey questionnaire consisted of nine single-choice and multiple-choice questions. Data were collected on the respondents' age, education and place of residence to characterise the study population. Two questions were designed to determine the respondents' level of knowledge about sources of phosphorus in their diet and the potential harm of an excess of this mineral. The next questions were focused on preferences, frequency, and the quantity of beverages consumed. The results of the analysis of the phosphate content of cola drinks (indicated by the respondents as the most frequently consumed by them) and the respondents' answers regarding the amount of cola drinks consumed were used to estimate the amount of phosphate supplied with these drinks.

3. Results and Discussion

3.1. Orthophosphates Contents Analysis in Cola Drinks

The results of the study are shown in Table 1. The data showed that phosphates (PO_4^{-3}) amounts ranged from 125 mg/l for Dr Pepper Cherry to 875 mg/l for Classic Carrefour Cola. When converted to phosphorus (P) content, the values varied from 40 to 280 mg P/l. Popular carbonated drinks such as Coca-Cola and its variants, Pepsi and Dr Pepper, had varying phosphate levels, typically from 425 to 675 mg PO_4^{-3}/l. Of the sugar-free variants, Freeway Cola Zero was characterised by a lower amount of added phosphates than Coca-Cola Zero and Pepsi Max. It was observed that the fruit-flavoured variants contained significantly fewer orthophosphates than the classic ones. Caffeine-free Coca-Cola and Lime contained significantly less of them than the classic Coca-Cola. Pepsi Mango and Pineapple were found to have less phosphate than their classic flavour versions, i.e. Pepsi and Pepsi Max. Similarly, for Dr Pepper, the fruit-flavoured variant of Dr Pepper Cherry had significantly less phosphate content. The phosphate content of Dr Pepper Cherry was the lowest of all the drinks tested and five times lower than that of the popular classic drinks Coca-Cola and Pepsi.

Table 1. Results of the analysis of the phosphate content of cola drinks (mean ± SD)

Beverage	Producer	Phosphate content (PO_4^{-3}) [mg/l]	Phosphorus content (P) [mg/l]
Classic Carrefour Cola	Carrefour	875^{a} ± 28.4	280 ± 9.1
Kong Strong Cuba Libre (rum with	Lidl	850^{ab} ± 20.0	272 ± 6.4
Candy Can Fireball	Candy Can	700^{bc} ± 26.0	224 ± 8.3
Coca-Cola	The Coca-Cola Company	675^{bcd} ± 28.4	216 ± 9.1
Pepsi Max (sugar-free)	Pepsi Co	675^{bcd} ± 28.4	216 ± 9.1
Coca-Cola Cherry	The Coca-Cola Company	625^{cde} ± 30.8	200 ± 9.8
Coca-Cola Zero	The Coca-Cola Company	625^{cde} ± 28.4	200 ± 9.1
Pepsi	Pepsi Co	625^{cde} ± 28.4	200 ± 9.1
On Lemon Kola	Zbyszko	575^{def} ± 28.4	180 ± 9.1
Coca-Cola caffeine-free	The Coca-Cola Company	550^{ef} ± 22.0	176 ± 7.0
Coca-Cola Lime	The Coca-Cola Company	550^{ef} ± 22.0	176 ± 7.0
Pepsi Mango	Pepsi Co	475^{fg} ± 28.4	152 ± 9.1
Polo Cockta	Zbyszko	475^{fg} ± 28.4	152 ± 9.1
Dr Pepper	Keurig Dr Pepper	425^{gh} ± 28.4	136 ± 9.1
Freeway Cola Zero	Lidl	375^{gh} ± 29.6	120 ± 9.5
Pepsi Pineapple	Pepsi Co	375^{gh} ± 26.0	120 ± 8.3
Freeway Cola	Lidl	350^{h} ± 22.0	112 ± 7.0
Dr Pepper Cherry	Keurig Dr Pepper	125^{i} ± 28.4	40 ± 9.1

SD-standard deviation; $^{a-i}$ different letters indicate a statistically significant difference at $p \leq 0.05$.

Source: own elaboration.

The reported phosphate/phosphorus content of cola drinks in the literature is generally slightly lower than that determined in the presented study. Kalantar-Zadeh et al. (2010) reported lower phosphorus levels in Coca-Cola, Coca-Cola Light and Pepsi (after conversion, 182, 79 and 159 mg P/l, respectively), while higher levels were found in Dr Pepper (200 mg P/l). In the study by Lindley et al. (2014), Dr Pepper, similarly contained less phosphorus than Coca-Cola and Pepsi (after conversion 90 mg P/l vs 150 mg P/l), and the reported contents were also lower than those determined in this study. The lower phosphate content of Coca-Cola (530 mg PO_4^{-3}/l) and Pepsi (540 mg PO_4^{-3}/l) was also determined by Bello & Gustavo González (1996). Gutekunst (2010) revealed that Coca-Cola Classic and Caffeine Free

each contained 177 mg P/l, Cherry Coke 160 mg P/l, Coca-Cola Zero 154 mg P/l, while Pepsi and Pepsi Max 154 mg P/l each. Krekel et al. (2016) also found lower phosphorus contents in Coca-Cola (by approximately 56 mg/l), Coca-Cola Cherry (by 57 mg/l), Dr Pepper (by 27 mg/l) and Pepsi (by 68 mg/l). The differences between these research results and the literature data may be due to various methods of determination and/or variations of the same beverages produced at other production facilities.

3.2. Results of the Survey

A total of 124 people completed the survey questionnaire, and as the sample size was too small, the results cannot fully represent the entire population of young adults in Poland. However, they can provide valuable information about the surveyed group and, as a pilot study, indicate the direction of future research efforts.

Metrics on the respondents are shown in Table 2. The most significant group of people who participated in the survey were between 18 and 25, accounting for 79% of all the respondents. The second largest group comprised 25-35-year-olds, namely 26 (i.e. 21% of the participants).

Among the survey respondents, most had tertiary education (47%), followed by those with general secondary education (35%) and secondary technical education (16%), while the lowest were those with lower secondary (PL gimnazjum) and primary education, with 1% in each category (Table 2).

In the last question of the survey the participants provided information about their place of residence (Table 2). Most of the respondents came from cities with a population of more than 100,000 (66%). Rural residents were the next largest group, accounting for 16%, followed by residents of towns with up to 50,000 residents (13%) and towns with 50,000 to 100,000 residents (5%).

Table 2. The sociodemographic structure of the respondents (124 participants)

Characteristic	Description	Number of responses (n = 124)	Percentage of all answers [%]
Age	18-25 years of age	98	79
	26-35 years of age	26	21
Education	Tertiary	58	47
	Secondary	44	35
	Secondary technical	20	16
	Basic vocational	0	0
	'Gimnazjum'	1	1
	Primary	1	1
Place of residence	Village	20	16
	A town with up to 50,000 inhabitants	16	13
	A town of 50,000 to 100,000 inhabitants	6	5
	A city with more than 100,000 inhabitants	82	66

Source: own elaboration.

Two questions in the survey questionnaire were designed to test the knowledge of dietary sources of phosphorus and the effects of its excess in the body. The respondents had to identify products containing high amounts of phosphorus among those suggested (leaf vegetables, eggs, cola drinks, processed foods, processed meats, oil, apples, cheese, and nuts). Over half of them correctly identified cola drinks containing significant amounts of this mineral. Cured meats, such as ham and sirloin, were also correctly identified by 41% of the participants as products rich in phosphorus. Cheese, nuts and eggs, which are significant sources of phosphorus, were selected by 33%, 16% and 25%, respectively. Only 53% of the respondents considered processed foods rich in phosphorus, indicating a poor

awareness of the impact of food processing on its nutritional value. These results showed that consumers had some knowledge of dietary sources of phosphorus. When asked about the effects of phosphorus excess in the body, the respondents most often chose the incorrect answer (53%): poor skin, hair and nails (see Figure 1 – incorrect answers are marked in red). Nearly half of the participants (45%) were aware of the risk of reduced calcium absorption, but 40% of them unfortunately associate excess phosphorus with headaches. Increased risk of premature osteoporosis and abnormal bone development in children were identified by 37% and 39% of the respondents, respectively, whereas calcium efflux from bones as a consequence of excess phosphorus was identified by 36%. These results indicated that half of the respondents were unaware of the risks of excessive phosphorus intake.

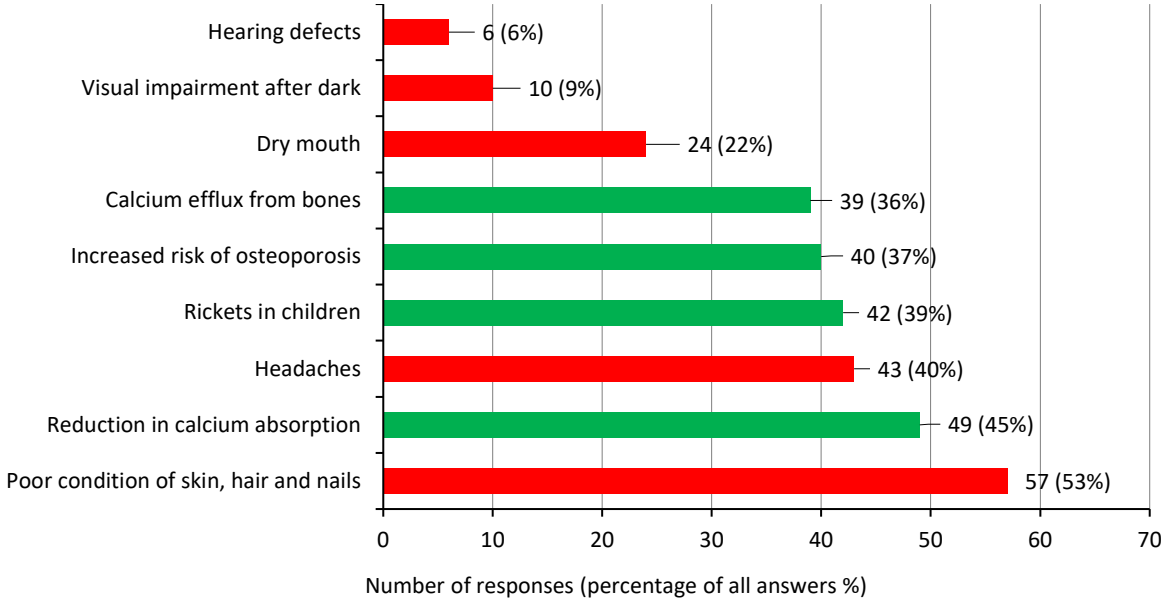

Fig. 1. Respondents' answers regarding the consequences of excess phosphorus in their diet

Source: own elaboration.

The survey revealed that most participants consumed sweet soft drinks (Table 3), with 127 responding affirmatively and 17 declaring they did not drink them. These results suggest the prevalence of soft drinks consumption among the studied group.

Table 3. Declarations of the respondents concerning consumption of sweet soft drinks

Do you consume sweet soft drinks?	Number of responses (n=124)	Percentage of all answers [%]
Yes	107	86
No	17	14

Source: own elaboration.

Among the participants who reported consuming sweet soft drinks (107), a significant number (17%) drank them daily (Figure 2), whilst around a third (31%) reached for such drinks several times a week. Roughly 19% consumed them once a week, and 12% several times a month, whilst the second largest group (21%) declared choosing soft drinks even less frequently. According to Kantar Poland, in the study Target Group Index 2024, 31.38% of Poles reported consuming sweet sodas in 2023. Of these, 21% drank them once a month or less often, and 20% consumed them 2-3 times a month, and 1 in 10 consumers of this category of beverages consumed them daily. Of those declaring to consume cola drinks, 6.8% drank them daily, and nearly 24% once a month or less often (Jurkitewicz, 2024).

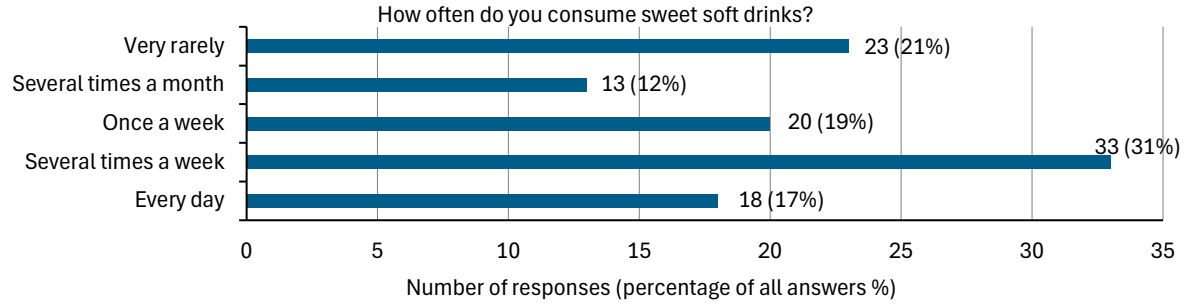

Fig. 2. Frequency of consumption of sweet soft drinks by the respondents (*n* = 107)

Source: own elaboration.

In the next open-ended question of the survey questionnaire, the respondents were asked to indicate the brand of soft drinks they most frequently purchased, and could type in their answers or choose from several suggested items. Coca-Cola Zero received the most votes (44%), followed closely by the classic Coca-Cola (Figure 3) which received 38%, confirming the strong position of this company in the market. Lipton Iced Tea was the third most popular choice (25%), which may indicate a preference for tea flavours. They were followed by other most consumed drinks (19%) which were Polish products from Tymbark. Next was Coca-Cola's rival product, Pepsi (18%). Energy drinks such as Redbull, Dzik, Monster and Black also demonstrated a significant percentage, indicating the popularity of this type of product. Other brands, such as Sprite and Fanta, enjoyed moderate popularity, while a smaller percentage of the respondents prefered other drinks, such as Mirinda and Mountain Dew. The most popular soft drink according to this survey was Coca Cola Zero (without sugar). This confirms the findings by Kumar & Ray (2018), who found that younger consumers (particularly those aged 18-30) preferred diet drinks and fruit juices. The large and growing popularity of sugar-free beverages has also been recognised in the international market by experts from Euromonitor International in the report "Product Innovation in Soft Drinks" (cf. Jurkitewicz, 2024). Sugar content also appears to influence the frequency of soft drink consumption – a study by Pacific and Hoefkins (2014) found that Belgian adults with higher consumption of soft drinks were more likely to consume sugar-free drinks (3-4 times a week). In contrast, those reporting lower consumption were more likely to choose beverages with sugar and most likely to consume them less than once a week.

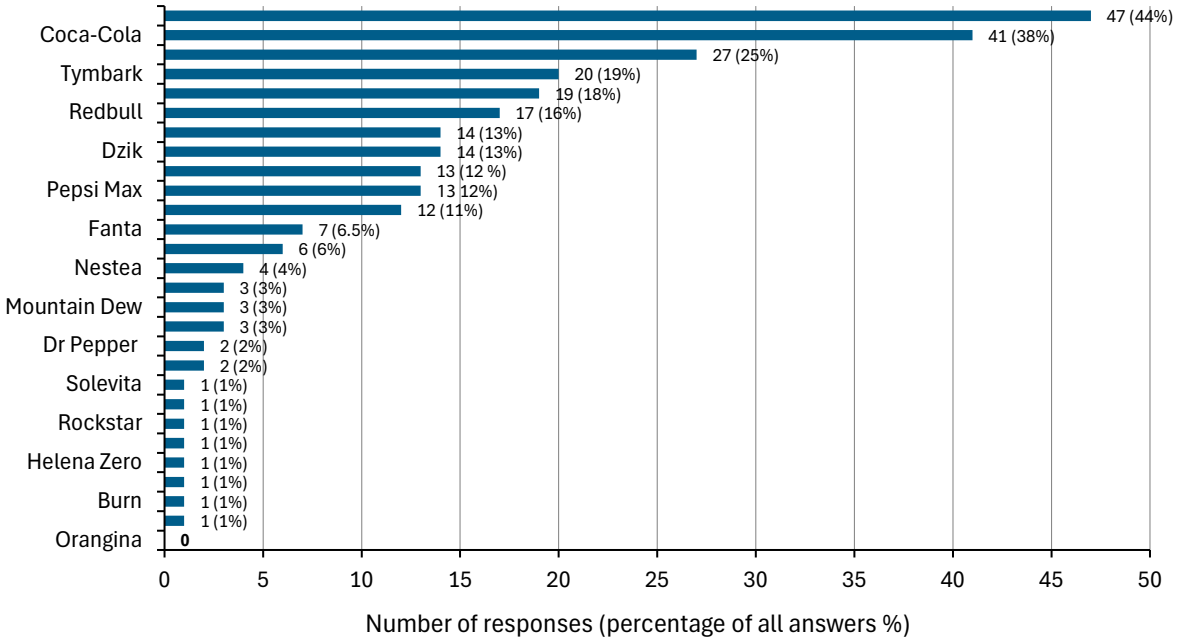

Fig. 3. Soft drink brands indicated by the survey respondents as most frequently purchased (number of responses and their percentage)

Source: own elaboration.

The survey's final question asked the respondents (*n* = 107) to specify the amount of cola drinks consumed. All the responses were converted to the total number of litres of cola drinks consumed per week (Figure 4). The vast majority of the respondents (73%) did not exceed the amount equivalent to a standard large bottle (1.5 l) during the week (Figure 4). The most frequently indicated amount of cola drinks consumed during the week was 1 litre. The average consumption of cola drinks among the respondents amounted to about 1.443 l per week (0.206 l per day). Three people reported consuming more than 9 litres of cola drinks per week (about 1.3 l/day).

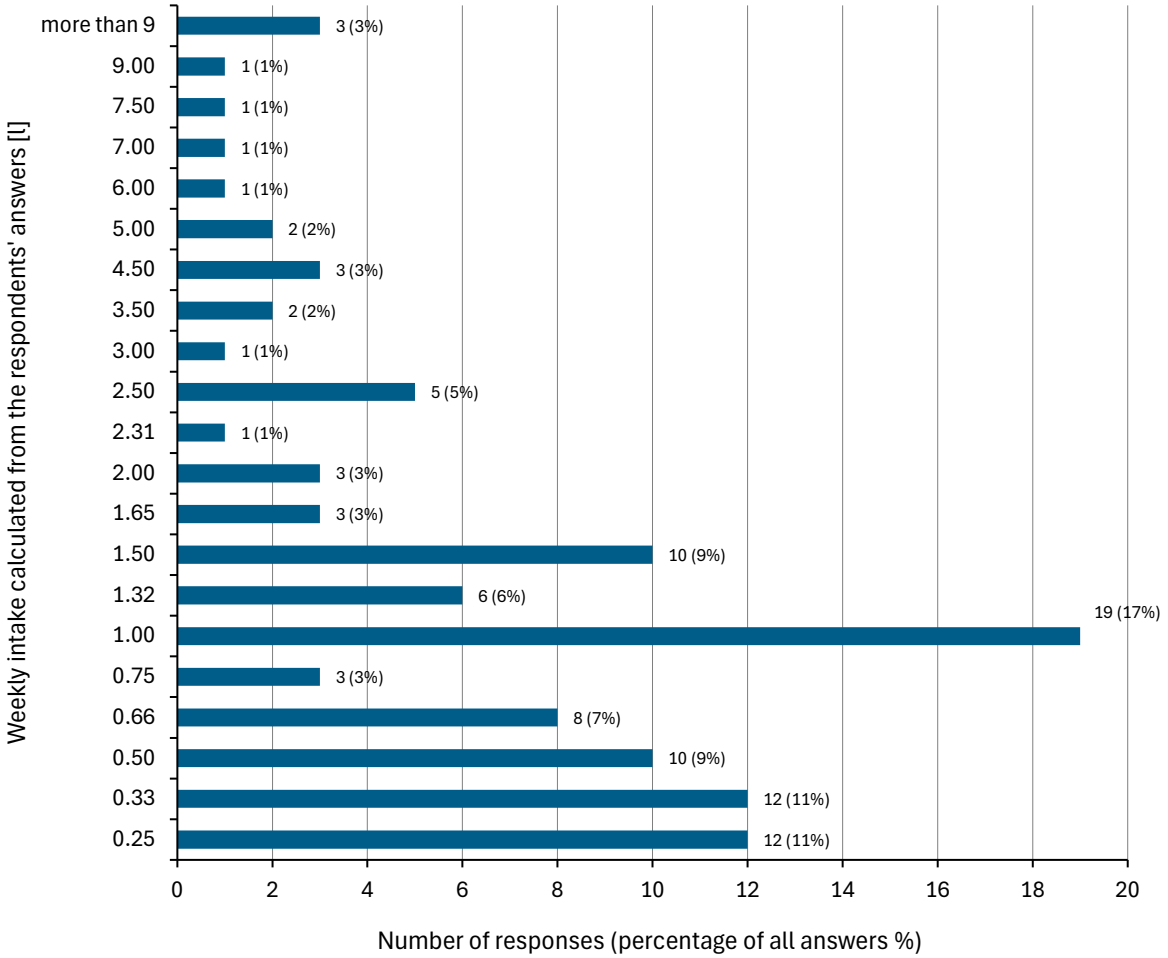

Fig. 4. Weekly consumption of cola drinks calculated from the respondents' answers (*n* = 107)

Source: own elaboration.

3.3. Estimation of Phosphate/Phosphorus Intake with Beverages

The most popular cola drinks among the respondents were Coca-Cola Zero and Coca-Cola (82%). The mean phosphate content determined in these beverages in this study was 650 mg PO_4^{-3}/l. The cola drinks consumption amounts declared in the survey questionnaire were used to estimate the amount of phosphate (PO_4^{-3}) and phosphorus (P) consumed with these particular beverages (Table 4). The average phosphorus content of Coca-Cola Zero and Coca-Cola was 208 mg P/l. According to the survey, the respondents' average consumption was about 200 ml per day, i.e. around 6% of the RDA standard for phosphorus. The highest consumption of cola drinks declared by the respondents was approximately 1,300 ml per day, 38% of the RDA standard for phosphorus.

Table 4. Estimation of the amount of phosphate and phosphorus delivered with beverages based on the declared amount of consumption and the results of the analysis of their content in the most frequently consumed beverage (Coca-Cola Zero and Coca-Cola classic; 650 mgPO_4^{-3}/l=0.65 mgPO_4^{-3}/ml on average)

Declared consumption of beverage	Per week [ml]	Per day [ml]	Phosphate amount (PO_4^{-3})* [mg]	Phosphorus amount (P)* [mg]	Percentage of daily recommended allowance (RDA) (700 mg/day)** [%]
Minimum	250	36	23.4	7.5	1
Maximum	9000	1286	835.9	267.5	38
Mean	1443	206	133.9	42.8	6

* In the amount of beverage consumed in one day.
** (Stoś et al., 2024).

Source: own elaboration.

Phosphorus homeostasis is intricately linked to that of calcium because of the actions of calcium-regulating hormones, such as parathyroid hormone (PTH) and 1,25-dihydroxy-vitamin D (1,25(OH)2D), at the level of the bone, the gut and the kidneys (EFSA, 2015). An elevation in serum phosphorus concentration due to a diet high in phosphorus leads to a decrease in serum calcium concentration and an increase in PTH release, resulting in increased renal phosphate excretion. According to EFSA (2005), although an increase in serum PTH concentration was found in acute or short-term loading studies, no significant bone changes could be demonstrated in longer-term studies with dosages of up to 3,000 mg/day (EFSA, 2015). The average phosphorus intake in European Union countries in adults is lower than 3,000 mg per day, ranging from 1,000 to 1,767 mg/day (EFSA, 2015; Stoś et al., 2024; Trautvetter et al., 2018).

The European Food Safety Authority EFSA recommendations for phosphorus intake for all population groups were set at adequate intake (AI – 550 mg/day), however the standards for the Polish population, specify the recommended dietary allowance (RDA) as 700 mg/day (Stoś et al., 2024). The ADI value for phosphate is 40 mg/kg body weight/day (Younes et al., 2019). According to the current state of knowledge, this value is the total amount of the substance that a person from all dietary sources can take in during the day without harming the organism. From the value mentioned above, the daily permissible phosphate intake for a man weighing 80 kg will be 3,200 mg PO_4^{-3} (1,024 mg P), while for a woman weighing 60 kg – 2,400 mg PO_4^{-3} (768 mg P).

In light of the analysis of PO_4^{-3} content carried out in the study, the smallest and average intake declared in the survey does not generate large amounts of P in the diet, yet the consumption of 9 liters of drinks, stated in the study by three people, provides a sum of P equivalent to 38% of RDA or 49% of AI, which is a significant amount, considering that the usual diet already provides phosphorus in excess (Kaczkan et al., 2018). Phosphate additives are estimated to increase total daily phosphorus intake by 300 to 1,000 mg, or about 10-50% of phosphorus intake in Western European countries (EFSA, 2015; National Institutes of Health (NIH), 2023; Stoś et al., 2024). In the context of this finding, the amount of phosphorus delivered with a cola beverage determined in this study is not large. However, when combined with phosphate-rich fast food, it will generate a significant excess of dietary phosphorus. This can cause problems not only for people with kidney disease but also with hypoparathyroidism. The literature describes the case of severe hypocalcemia (calcium deficiency) in a 28-year-old woman, a patient with postsurgical hypoparathyroidism, consuming 2 litres of Coca-Cola daily (Guarnotta et al., 2017). Dietary supplements containing various forms of calcium were not effective, and only discontinuation of the beverage's consumption resulted in a return to normal. In the context of this study, 2 litres of Coca-Cola contain 432 mg of P, which is more than the highest phosphorus intake with cola beverages (267,5 mg of P) established in the presented study (see Table 4).

4. Conclusion

The analysis of orthophosphate content showed significant differences between cola drinks from different manufacturers and different types of the same brand. It appears expedient to monitor the content of orthophosphates in beverages, especially those with new flavours and those produced locally. In the surveyed group of young adults, knowledge of the effects of excessive consumption of phosphates and their sources in the diet was limited, therefore educational activities should be undertaken to increase consumer awareness. In light of the literature data, the amount of dietary phosphorus found in cola drinks consumed by young adults is unlikely to pose a health risk. However, given the popularity of phosphate-rich processed foods, it would be advisable to conduct research on estimating phosphorus levels in the diets of young adults.

References

Bello, M. A., & Gustavo González, A. (1996). Determination of Phosphate in Cola Beverages Using Nonsuppressed Ion Chromatography: An Experiment Introducing Ion Chromatography for Quantitative Analysis. *Journal of Chemical Education*, *73*(12), 1174-1175. https://pubs.acs.org/doi/10.1021/ed073p1174

Benini, O., D'Alessandro, C., Gianfaldoni, D., & Cupisti, A. (2011). Extra-Phosphate Load from Food Additives in Commonly Eaten Foods: A Real and Insidious Danger for Renal Patients. *Journal of Renal Nutrition: The Official Journal of the Council on Renal Nutrition of the National Kidney Foundation*, *21*(4), 303-308. https://doi.org/10.1053/j.jrn.2010.06.021

Business Insider. (2023). *Polacy są wierni kilku markom leków i napojów. Inaczej jest z piwem*. https://businessinsider.com.pl/gospodarka/polacy-sa-wierni-kilku-markom-lekow-i-napojow-inaczej-jest-z-piwem/pyxkq4m

Calvo, M., Moshfegh, A., & Tucker, K. (2014). Assessing the Health Impact of Phosphorus in the Food Supply: Issues and Considerations. *Advances in Nutrition*, *5*(1), 104-113. https://doi.org/10.3945/an.113.004861

Calvo, M., & Uribarri, J. (2013). Public Health Impact of Dietary Phosphorus Excess on Bone and Cardiovascular Health in the General Population. *The American Journal of Clinical Nutrition*, *98*(1), 6-15. https://doi.org/10.3945/ajcn.112.053934

Calvo, M., & Uribarri, J. (2017). Phosphorus in the Modern Food Supply: Underestimation of Exposure. In O. Gutiérrez, K. Kalantar-Zadeh, & R. Mehrotra (Eds.), *Clinical Aspects of Natural and Added Phosphorus in Foods. Nutrition and Health* (pp. 47-76). Springer. https://doi.org/10.1007/978-1-4939-6566-3_4

Chang, A. R., & Anderson, C. (2017). Dietary Phosphorus Intake and the Kidney. *Annual Review of Nutrition*, *37*, 321-346. https://doi.org/10.1146/annurev-nutr-071816-064607

EFSA. (2005). Opinion of the Scientific Panel on Dietetic products, nutrition and allergies [NDA] related to the tolerable upper intake level of phosphorus. *EFSA Journal*, *3*(8), 1-19. https://doi.org/10.2903/j.efsa.2005.233

EFSA. (2015). Scientific Opinion on Dietary Reference Values for phosphorus. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). *EFSA Journal*, *13*(7), 1-54. https://doi.org/10.2903/j.efsa.2015.4185

Guarnotta, V., Riela, S., Massaro, M., Bonventre, S., Inviati, A., Ciresi, A., Pizzolanti, G., Benvenga, S., & Giordano, C. (2017). The Daily Consumption of Cola Can Determine Hypocalcemia: A Case Report of Postsurgical Hypoparathyroidism-Related Hypocalcemia Refractory to Supplemental Therapy with High Doses of Oral Calcium. *Frontiers in Endocrinology*, *8*(1), 1-5. https://doi.org/10.3389/fendo.2017.00007

Gutekunst, L. (2010). Water, Water Everywhere, But What to Drink? An Update on Hidden Phosphorus in Popular Beverages. *Journal of Renal Nutrition*, *20*, e1-e5.https://doi.org/10.1053/J.JRN.2009.11.001

Jurkitewicz, K. (2024). Rynek napojów bezalkoholowych w Polsce 2024. Sprzedaż i trendy. *Wiadomości Spożywcze.* https://wiadomoscispozywcze.pl/artykuly/13824/rynek-napojow-bezalkoholowych-w-polsce-sprzedaz-i-trendy/

Kaczkan, M., Bienias, A., & Małgorzewicz, S. (2018). Realization of Low Phosphate Diet and Hidden Sources of Phosphorus. *Forum Nefrologiczne*, *11*(1), 15-23.

Kalantar-Zadeh, K., Gutekunst, L., Mehrotra, R., Kovesdy, C. P., Bross, R., Shinaberger, C. S., Noori, N., Hirschberg, R., Benner, D., Nissenson, A. R., & Kopple, J. D. (2010). Understanding Sources of Dietary Phosphorus in the Treatment of Patients with Chronic Kidney Disease. *Clinical Journal of the American Society of Nephrology*, *5*(3), 519-530. https://doi.org/10.2215/CJN.06080809

Krekel, C., McClure, S. T., & Chang, A. R. (2016). Improving Estimates of Phosphorus Additive Content: Manufacturers Needed. *Journal of Renal Nutrition*, *26*(5), e27–e30. https://doi.org/10.1053/j.jrn.2016.07.002

Kumar, N., & Ray, S. (2018). Attitude towards Soft Drinks and Its Consumption Pattern: A Study of Gen Y Consumers of India. *British Food Journal*, *120*(2), 355-366. https://doi.org/10.1108/BFJ-05-2017-0320

Lampila, L. (2013). Applications and Functions of Food-Grade Phosphates. *Annals of the New York Academy of Sciences*, *1301*, 37-44. https://doi.org/10.1111/nyas.12230

León, J. B., Sullivan, C. M., & Sehgal, A. R. (2013). The Prevalence of Phosphorus-Containing Food Additives in Top-Selling Foods in Grocery Stores. *Journal of Renal Nutrition*, *23*(4), 265-270.e2. https://doi.org/10.1053/j.jrn.2012.12.003

Lindley, E., Costelloe, S., Bosomworth, M., Fouque, D., Freeman, J., Keane, D., & Thompson, D. (2014). Use of a Standard Urine Assay for Measuring the Phosphate Content of Beverages. *Journal of Renal Nutrition: The Official Journal of the Council on Renal Nutrition of the National Kidney Foundation*, *24*(6), 353-356. https://doi.org/10.1053/j.jrn.2014.07.002

Mancini, F., Affret, A., Dow, C., Balkau, B., Clavel-Chapelon, F., Bonnet, F., Boutron-Ruault, M., & Fagherazzi, G. (2017). High Dietary Phosphorus Intake is Associated with an Increased Risk of Type 2 Diabetes in the Large Prospective E3N Cohort Study. *Clinical Nutrition*, *37*(5), 1625-1630. https://doi.org/10.1016/j.clnu.2017.07.025

McCarty, M., & DiNicolantonio, J. (2014). Bioavailable Dietary Phosphate, a Mediator of Cardiovascular Disease, May Be Decreased with Plant-Based Diets, Phosphate Binders, Niacin, and Avoidance of Phosphate Additives. *Nutrition*, *30*(7-8), 739-747. https://doi.org/10.1016/j.nut.2013.12.010

Moser, M., White, K., Henry, B., Oh, S., Miller, E. R., Anderson, C. A., Benjamin, J., Charleston, J., Appel, L. J., & Chang, A. R. (2015). Phosphorus Content of Popular Beverages. *American Journal of Kidney Diseases*, 65(6), 969-971. https://doi.org/10.1053/j.ajkd.2015.02.330

National Institutes of Health (NIH). (2023). *Office of Dietary Supplements. Phosphorus – Health Professional Fact Sheet*. https://ods.od.nih.gov/factsheets/Phosphorus-HealthProfessional/#h15

Pacific, R., & Hoefkins, C. (2014). Consumption Pattern, Attitudes and Nutrition Knowledge on Soft Drinks among Belgian Adults. *Tanzania Journal of Agricultural Sciences*, *13*(1), 55-66.

Picard, K., Griffiths, M., Senior, P. A., Mager, D., & Richard, C. (2023). Phosphorus Additives and Their Impact on Phosphorus Content in Foods – An Analysis of the USDAs Branded Foods Product Database. *Journal of Renal Nutrition: The Official Journal of the Council on Renal Nutrition of the National Kidney Foundation*, *33*(3), 443-449. https://doi.org/10.1053/j.jrn.2022.12.007

Regulation (EU) No 1169/2011. (2011). Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers. *Official Journal of the European Union*, 18-63. https://eur-lex.europa.eu

Ritz, E., Hahn, K., Ketteler, M., Kuhlmann, M., & Mann, J. F. E. (2012). Phosphate Additives in Food – A Health Risk. *Deutsches Arzteblatt International*, *109*(4), 49-55. https://doi.org/10.3238/arztebl.2012.0049

Sherman, R. A., & Mehta, O. (2009). Dietary Phosphorus Restriction in Dialysis Patients: Potential Impact of Processed Meat, Poultry, and Fish Products as Protein Sources. *American Journal of Kidney Diseases*, *54*(1), 18-23. https://doi.org/10.1053/j.ajkd.2009.01.269

Stoś, K., Woźniak, A., Wojtasik, A., Rychlik, E., Ziółkowska, I., & Głowala, A. (2024). Składniki mineralne. In E. Rychlik, K. Stoś, A. Woźniak, & H. Mojska (Eds.), *Normy żywienia dla populacji Polski* (pp. 255-342). Narodowy Instytut Zdrowia Publicznego PZH – Państwowy Instytut Badawczy.

The Coca-Cola Company. (2024a). *Coca-Cola Reports Fourth Quarter and Full Year 2023 Results*. https://www.coca-colacompany.com/media-center/fourth-quarter-full-year-2023-results

The Coca-Cola Company. (2024b). *How Many Drinks Does The Coca-Cola Company Sell Worldwide Each Day?* https://www.coca-cola.com/ng/en/about-us/faq/how-many-drinks-does-the-coca-cola-company-sell-worldwide-each-d

The Economic Times. (2024). *Mexico: A State in Mexico That Consumes More Coke Than Any Other Place in the World – The Economic Times*. https://economictimes.indiatimes.com/news/international/us/a-state-in-mexico-that-consumes-more-coke-than-any-other-place-in-the-world/articleshow/112635370.cms?from=mdr

Trautvetter, U., Ditscheid, B., Jahreis, G., & Glei, M. (2018). Habitual Intakes, Food Sources and Excretions of Phosphorus and Calcium in Three German Study Collectives. *Nutrients*, *10*(2), 171 https://doi.org/10.3390/nu10020171

Uribarri, J., & Calvo, M. (2013a). Dietary Phosphorus Excess: A Risk Factor in Chronic Bone, Kidney, and Cardiovascular Disease? *Advances in Nutrition*, *4*(5), 542-544. https://doi.org/10.3945/an.113.004234

Uribarri, J., & Calvo, M. (2013b). Introduction to Dietary Phosphorus Excess and Health. *Annals of the New York Academy of Sciences*, *1301*. https://doi.org/10.1111/nyas.12302

Vorland, C. J., Stremke, E. R., Moorthi, R., & Gallant, K. H. H. (2017). Effects of Excessive Dietary Phosphorus Intake on Bone Health. *Current Osteoporosis Reports*, *15*, 473482. https://doi.org/10.1007/s11914-017-0398-4

Watanabe, M. T., Barretti, P., & Caramori, J. (2018). Dietary Intervention in Phosphatemia Control-Nutritional Traffic Light Labeling. *Journal of Renal Nutrition: The Official Journal of the Council on Renal Nutrition of the National Kidney Foundation*, *28*(6), e45-e47. https://doi.org/10.1053/j.jrn.2018.04.005

Younes, M., Aquilina, G., Castle, L., Engel, K. H., Fowler, P., Frutos Fernandez, M. J., Fürst, P., Gürtler, R., Husøy, T., Mennes, W., Moldeus, P., Oskarsson, A., Shah, R., Waalkens-Berendsen, I., Wölfle, D., Aggett, P., Cupisti, A., Fortes, C., Kuhnle, G., & Gundert-Remy, U. (2019). Re-Evaluation of Phosphoric Acid–Phosphates – Di-, Tri- and Polyphosphates (E 338–341, E 343, E 450–452) as Food Additives and the Safety of Proposed Extension of Use. *EFSA Journal*, *17*(6). https://doi.org/10.2903/j.efsa.2019.5674

Analiza zawartości fosforanów w napojach typu cola i próba oszacowania spożycia fosforanów z tymi napojami przez młodych dorosłych – badanie pilotażowe

Streszczenie

Cel: Celem badań było określenie zawartości ortofosforanów (PO_4^{3-}) w napojach typu cola dostępnych w Polsce na rynku wrocławskim, próba oszacowania ilości fosforu (P) spożywanego wraz z napojami przez młodych dorosłych (18-35 lat) oraz zbadanie poziomu wiedzy respondentów na temat źródeł fosforanów w diecie i potencjalnej szkodliwości ich nadmiaru.

Metodyka: Analizę napojów typu cola wykonano za pomocą szybkiego testu reflektometrycznego firmy Merck. Przeprowadzono również badanie ankietowe za pośrednictwem platformy Google Forms.

Wyniki: Badania wykazały, że zawartość PO_4^{3-} wahała się od 125 do 875 mg/l. Badanie ankietowe wykazało, że respondenci mają ograniczoną wiedzę na temat szkodliwości nadmiaru P i jego źródeł w diecie. Deklarowane spożycie napojów typu cola wyniosło od 250 do 9000 ml/tydzień. Najczęściej wybieranymi napojami były Coca-Cola Zero i klasyczna. Średnie spożycie P przez młodych dorosłych z tymi napojami wynosiło od 23 do 267 mg/dzień.

Implikacje i rekomendacje: Według doniesień naukowych, oznaczone dzienne spożycie P nie powinno powodować problemów zdrowotnych. Niemniej jednak należy kontrolować dzienne spożycie tego pierwiastka z różnych źródeł, zwłaszcza w przypadku osób z problemami zdrowotnymi, takimi jak choroby nerek lub niedoczynność przytarczyc.

Oryginalność/wartość: Monitoring zawartości PO_4^{3-} w żywności przetworzonej jest ważny ze względu na wzrastającą popularność tego typu żywności i ocenę ryzyka zdrowotnego związanego z nadmiarem P w diecie.

Słowa kluczowe: ortofosforany, fosfor, napoje, dodatki do żywności, składniki mineralne