Biotechnology in Animal Husbandry 40 (2), 169-176, 2024
Publisher: Institute for Animal Husbandry, Belgrade-Zemun
ISSN 1450-9156
UDC 637.04'637.5
https://doi.org/10.2298/BAH2402169P

TOTAL PHOSPHORUS CONTENT IN MEAT PRODUCTS ON THE MARKET OF THE REPUBLIC OF SERBIA AND REGULATORY COMPLIANCE

Maja Petričević[1], Nikola Stanišić[1], Tanja Keškić[1], Veselin Petričević[1], Dragan Nikšić[1], Boris Pisinov[2], Tamara Stamenić[1]

[1] Institute for Animal Husbandry, Autoput Beograd-Zagreb 16, 11080 Belgrade, Serbia
[2] Institute for Plant Protection and Environment, Teodora Drajzera 9, 11040 Belgrade, Serbia
Corresponding author: Maja Petričević, majanovakovic@live.com
Original scientific paper

Abstract: This study focused on monitoring the phosphate levels in meat products on the Serbian market over a two-year period and evaluating the producers' compliance with regulations on additive usage. During the mentioned period, 74 different meat products (222 samples in total) were analyzed, including finely and coarsely minced cooked sausages. The analysis was conducted using the standard method (SRPS ISO 13730:1999) at the Institute of Animal Husbandry, Belgrade – Zemun laboratory. Content of total phosphorus expressed as P_2O_5 varied between 2.01 g/kg and 6.98 g/kg for finely minced sausages, while for coarsely minced sausages, it ranged from 4.13 g/kg to 7.97 g/kg. The results show that producers incorporate phosphates in line with the specified limits.

Key words: additives, total phosphorus, phosphates, meat products, Serbia

Introduction

Different foods contain a wide range of nutrients, some of which are naturally present, while others are added for specific functional properties. In the food industry, where it is essential to produce goods that meet consumer expectations regarding appearance, texture, aroma, and taste while ensuring a high level of food safety (Prica et al., 2012; Abedi-Firoozjah et al., 2024), the inclusion of substances used to modify certain technological, sensorial, or other characteristics in products must be justified (Abedi-Firoozjah et al., 2024). To achieve these goals, manufacturers have turned to a wide range of different substances—natural spices, herbs, and extracts, as well as synthetic additives. Animal- and plant-based powder proteins are also emerging options that improve the functionality of meat products while contributing to a boost in protein intake (Goemaere et al., 2021). The diversity of additives added to foods to target specific

desirable effects highlights the growing importance of the additive industry, where more attention is given to additives than to the product itself (Prica et al., 2012).

When appropriately used, food additives help preserve quality and safety, extend shelf life, and improve the sensory properties of the products. However, excessive and inappropriate use of additives can negatively affect not only the quality of the product but also the health of consumers (Willett, 2024). Regular market monitoring and periodic safety re-evaluation of additives used in meat products industry is crucial to ensure compliance with established limits and standards. This approach helps build trust in the food chain and aligns with consumer preferences, while industry innovations increasingly favor natural alternatives. Furthermore, regular monitoring and re-evaluation of quantity and safety assessments of additives used in meat products are used to ensure that they meet certain standards and requirements and, finally, to establish trust in the food chain and align with consumer preferences (Abedi-Firoozjah et al., 2024). According to the Rulebook on food additives (2018), all ingredients, including additives, must be clearly listed on the product label, and their labeling is by specific regulations on declaration, labelling and advertising on food, Rulebook (2024).

The addition of various additives, such as phosphates, is aligned with modern technological standards from developed European countries. Phosphates stand out as one of the fundamental additives in meat products industry due to their functional properties as emulsifiers, stabilizers, and acid regulators influencing the pH value of the products. Regardless of the primary mechanism of action, their basic function is to increase the ability of meat to retain its own and added water, thereby improving the texture, juiciness, and tenderness of the product (Saičić et al., 2008; Đerić et al., 2015; Cao et al., 2022). Phosphates are commonly used in products such as cooked sausages and smoked meat products. The most commonly used are disodium and potassium diphosphates, pyrophosphates, and polyphosphates, usually in quantities of 0.3-0.5% per kilogram of meat, which increases water retention capacity by 5-10% and increases the meat yield by about 2-3% (Đerić et al., 2015).

Although phosphates hold an important technological role, phosphorus as an element also has vital biological functions for both human and animal organisms, with 85% of the total phosphorus found in bones and teeth (Prica et al., 2015). However, excessive phosphorus intake can lead to health problems, as the imbalance between calcium and phosphorus can disrupt hormonal processes. For example, excess phosphorus can interfere with calcium absorption in the intestines, causing calcium release from bones and increasing the risk of bone diseases (Đerić et al., 2015; Cao et al., 2022).

It is important to note that meat, as a raw material, naturally contains phosphorus in concentrations that may vary depending on the animal species, the specific part of the carcass, the diet, and the processing methodology used.

However, the excessive addition of synthetic phosphates can increase water retention, diminishing the product's nutritional value (Perši et al., 2010). The balanced use of phosphates should ensure the desired product quality while minimizing potential health risks due to excessive phosphorus intake.

Changes in consumer awareness and their preference for natural and health-friendly food products have led to the widespread adoption of the “clean label” initiative among many food industry participants (Asioli et al., 2017). Although a legal definition or specific regulations for “clean label” products have not yet been established, consumer demand for meat products with natural ingredients has steadily increased in recent years (Câmara et al., 2020). According to the research performed by Maruyama et al. (2021), consumers view stabilizers and thickeners as unnatural and less acceptable in food formulations, suggesting that companies wishing to produce products should cease using or replace these ingredients. Thus, the meat industry faces a significant challenge in replacing phosphates with natural ingredients without compromising product quality.

This study aimed to determine the total phosphorus content in meat products available on the market of the Republic of Serbia and assess producers' compliance with the applicable legal regulations regarding the allowable amounts of additives.

Materials and Methods

During a two-year period (2022–2024), 74 meat products collected from the territory of Belgrade were analyzed with the aim of determining the total phosphorus content, expressed as P_2O_5. Of the total number, 41 samples consisted of finely minced cooked sausages (36 samples of small diameter and 5 samples of large diameter), while the remaining 33 samples were coarsely minced cooked sausages. Each product was analyzed in three replicates based on three different lot numbers, totaling 222 samples. The analysis was conducted using the standard ISO method (SRPS ISO 13730:1999) at the Institute of Animal Husbandry, Belgrade – Zemun laboratory. Absorbance was measured using a UV/VIS spectrophotometer (Analytik Jena, SPEKOL 1300). The results are expressed in g/kg as P_2O_5. Upon receiving them in the laboratory, samples were stored in their original packaging at a temperature of 4°C until analysis, or, in cases where they were not vacuum-sealed, homogenized and analyzed within 24 hours after homogenization.

Data processing was carried out using MS Excel. The results are presented as the mean content of total phosphorus, expressed as P_2O_5 (g/kg) ± standard deviation.

Results and Discussion

The total phosphorus content, expressed as P_2O_5 (g/kg) in meat products is presented in tables 1 and 2. Table 1 provides data for finely minced cooked sausages, with a range of total phosphorus content from 2.01 g/kg to 6.98 g/kg, as P_2O_5, while Table 2 shows the total phosphorus content in coarsely minced cooked sausages, ranging from 4.13 g/kg to 7.97 g/kg, as P_2O_5. The results demonstrated that all samples had total phosphorus content within the permissible limits according to the Rulebook on quality of chopped meat, semi-products and products of meat (2023), i.e., below 8 g/kg. The average content of total phosphorus in all analyzed finely minced cooked sausages and coarsely minced cooked sausages was 4.63 g/kg and 6.04 g/kg, respectively.

Table 1. Content of total phosphorus, expressed as P_2O_5 (g/kg) in finely minced cooked sausages

Product type (sausage type)	Average content of total phosphorus Mean±SD (g/kg)	CV (%)	Min (g/kg)	Max (g/kg)
	Small-diameter finely minced cooked sausages, n=36			
Hot dog sausage, n=6	4.17±1.04	0.25	2.82	5.79
Hot dog-style sausage, n=27	4.88±1.13	0.23	2.01	6.98
Debreciner sausage, n=3	3.76±0.56	0.15	3.05	4.72
	Large-diameter finely minced cooked sausages, n=5			
Extra sausage, n=5	4.34±0.67	0.16	3.39	5.49
Total	4.63±1.12	0.24	2.01	6.98

n − total number of analysed samples; SD - standard deviation; CV - coefficient of variation; Min – minimum; Max - maximum

In the study by Milicević et al. (2021), the average phosphate content in finely minced cooked sausages was 4.68 g/kg (total phosphorus as P_2O_5). Other authors report similar results: Petrović (2022) found an average value of 4.83 g/kg, Korićanac et al. (2015) reported 4.89 g/kg, while Saičić (2008) noted a somewhat lower value (2.13 g/kg). These findings align with the results of our study. Milešević et al. (2022) also investigated the phosphate content in various meat products. According to their results, the average total phosphorus content in finely minced cooked sausages was 4.70 g/kg, while coarsely minced cooked sausages had a slightly higher average value of 5.21 g/kg. The highest values for total phosphorus were recorded in smoked meat products, while the lowest were found in liver sausage and pâté. In addition to phosphate content, these authors assessed

phosphorus intake through processed meat products, particularly in children. Their research showed that the daily phosphorus intake from processed meat products in children was significantly below the recommended permissible values, with the primary sources of phosphorus being cooked sausages, canned meat, and bacon. Considering all dietary sources of phosphorus, including bakery products, cheeses, and sugars, there is a possibility of exceeding the recommended daily intake (EFSA, 2019).

Table 2. Content of total phosphorus, expressed as P_2O_5 (g/kg) in coarsely minced cooked sausages

Product type (sausage type)	Average content of total phosphorus Mean±SD (g/kg)	CV	Min (g/kg)	Max (g/kg)
	Minced cooked sausages n=33			
Beef sausage, n=4	6.06±0.61	0.10	5.23	7.38
Novosadska sausage, n=4	6.20±0.43	0.07	5.43	6.81
Grill sausage, n=6	6.71±0.60	0.09	5.31	7.60
Srpska sausage, n=4	5.97±0.44	0.07	5.39	6.85
Domaća sausage, n=4	6.07±1.23	0.20	4.13	7.97
Tirolska sausage, n=7	5.19±0.51	0.10	4.50	6.41
Toast sausage, n=4	6.34±0.75	0.12	5.30	7.87
Total	6.04±0.83	0.14	4.13	7.97

n − total number of analysed samples; SD - standard deviation; CV - coefficient of variation; Min – minimum; Max - maximum

In contrast to our study, where all analized samples had total phosphorus content below allowable value (8g/kg, as P_2O_5), Milešević et al. (2022) found that 1.7% of the analyzed meat products had phosphate levels exceeding 8 g/kg. Similarly, Milicević et al. (2021) reported that 0.5% of the samples exceeded the permissible limit, while Korićanac et al. (2015) found that 0.43% of the products did not meet the defined limits. These results imply the rare misuse of phosphates in meat processing, resulting in excess allowable levels in some samples. Such irregularities underline the importance of continued monitoring, joint measures, and actions to enforce phosphate regulations, assuring compliance and protecting consumer safety.

Conclusions

All analyzed samples were within the permissible total phosphorus. The average total phosphorus content expressed as P_2O_5 (g/kg) was 4.63 g/kg for finely minced sausages and 6.04 g/kg for coarsely minced sausages. However, analytical methods cannot distinguish between naturally occurring phosphates and food additives. Interpreting these results requires an understanding of natural phosphorus levels in raw materials. Nevertheless, monitoring phosphate additives in meat products to ensure compliance with acceptable limits is essential, as this is critical for consumer health and product quality and safety. Based on the comprehensive market survey, it can be concluded that producers are using phosphates appropriately, in accordance with the guidelines outlined in the Rulebook (2023), despite variations in meat product preparation technologies.

Sadržaj ukupnog fosfora u proizvodima od mesa na tržištu Republike Srbije i usklađenost sa propisima

Maja Petričević, Nikola Stanišić, Tanja Keškić,Veselin Petričević, Dragan Nikšić, Boris Pisinov, Tamara Stamenić

Rezime

Ovo istraživanje se fokusiralo na praćenje nivoa fosfata u proizvodima od mesa na tržištu Srbije u periodu od dve godine i procenu usklađenosti proizvođača sa propisima o upotrebi aditiva. Tokom pomenutog perioda analizirana su 74 različita proizvoda od mesa (ukupno 222 uzorka), uključujući fino i grubo usitnjene barene kobasice. Analiza je sprovedena standardnom metodom (SRPS ISO 13730:1999) u Laboratoriji Instituta za stočarstvo, Beograd – Zemun. Sadržaj ukupnog fosfora, izražen kao P_2O_5 se kretao od 2,01 g/kg do 6,98 g/kg kod fino usitnjenih kobasica, dok je kod grubo usitnjenih bio između 4,13 g/kg i 7,97 g/kg. Rezultati pokazuju da proizvođači koriste fosfate u skladu sa propisanim granicama.

Ključne reči: aditivi, ukupan fosfor, fosfati, proizvodi od mesa, Srbija

Acknowledgement
The results of this research were financed by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia - SRO No. 451-03-66/2024-03/200022.

Conflict of interest
The authors declare that they have no conflict of interest.

References

Abedi-Firoozjah R., Tavassoli, M. 2024. Functionality of Food Additives. *IntechOpen*. doi: 10.5772/intechopen.114959.

Asioli D., Aschemann-Witzel J., Caputo V., Vecchio R., Annunziata A., Næs T., Varela P. 2017. Making sense of the "clean label" trends: A review of consumer food choice behavior and discussion of industry implications. *Food Research International*, 99, 58-71.

Câmara A. K. F. I., Vidal V. A. S., Santos M., Bernardinelli O. D., Sabadini E., Pollonio M. A. R. 2020. Reducing phosphate in emulsified meat products by adding chia (Salvia hispanica L.) mucilage in powder or gel format: A clean label technological strategy. *Meat Science*, 163, 108085.

Cao C., Yuan D., Li X., Kong B., Chen Q., Sun F., Liu Q. 2022. Reduction of phosphate content in frankfurters by up to 50% using micronized cold-pressed sesame seed cake. *Meat Science*, 185, 108708.

Đerić Z., Brenjo D. 2015. Fosfati u proizvodima od mesa–zakonski osnov i praksa. *Scientific journal" Meat Technology"*, 56(2), 120-130.

EFSA Panel on Food Additives and Flavourings (FAF), Younes M., Aquilina G., Castle L., Engel K. H., Fowler P., ... & 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), e05674.

Goemaere O., Glorieux S., Govaert M., Steen L., Fraeye I. 2021) Phosphate elimination in emulsified meat products: Impact of protein-based ingredients on quality characteristics. *Foods*, 10(4), 882.

Koricanac V., Vranic D., Lilic S., Milicevic D., Sobajic S., Zrnic M. 2015. Total phosphorus content in various types of cooked sausages from the Serbian market. *Procedia Food Science*, 5, 152-155.

Maruyama S., Streletskaya N. A., Lim J. 2021. Clean label: Why this ingredient but not that one? *Food Quality and Preference*, 87, 104062.

Milešević J., Vranić D., Gurinović M., Korićanac V., Borović B., Zeković M., Šarac I., Milićević D., Glibetić M. 2022. The intake of phosphorus and nitrites through meat products: a health risk assessment of children aged 1 to 9 years old in Serbia. *Nutrients*, 14(2), 242.

Milicevic D., Vranic D., Koricanac V., Petrovic Z., Bajcic A., Betic N., Zagorac S. 2021. The intake of phosphorus through meat products: A health risk assessment. In *IOP Conference Series: Earth and Environmental Science* (Vol. 854, No. 1, p. 012057). IOP Publishing.

Rulebook. 2023. The Rulebook on Quality of Chopped Meat, Semi-Products and Products of Meat. *Official Gazette of RS*, No. 50/2019 and 34/2023.

Rulebook. 2018. Rulebook on food additives. *Official Gazette of RS*, No. 53/2018.

Rulebook. 2024. Rulebook on declaration, labeling and advertising of food. *Official Gazette of RS*, No. 61/2024.

Perši N., Pleadin J., Vulić A. 2010. Aditivi u mesu i proizvodima od mesa. *Veterinarska stanica*, 41(5), 409-420.

Petrović J. B. 2022. *Procena izloženosti hemijskim opasnostima u hrani animalnog porekla.* Univerzitet u Beogradu, Poljoprivredni fakultet.

Prica N., Baloš M. Ž., Mihaljev Ž., Jakšić S., Kapetanov M. 2012. Total nitrite and phosporus content in meat products on novi sad market. *Archives of Veterinary Medicine*, 5(1), 69-75.

Prica N., Zivkov-Balos M., Jaksic S., Mihaljev Z., Kartalovic B., Ljubojevic D., Savic S. 2015. Total phosphorus content in technologically unprocessed meat. *Procedia Food Science*, 5, 243-246.

Saičić S., Vranić D., Trbović D., Pavlov N. 2008. Total phosphorus content in meat products. *Tehnologija mesa*, 49(3-4), 147-152.

SRPS ISO 13730:1999. Meat and meat products — Determination of total phosphorous content

Willett W. 2024. The role of food additives and ingredients in enhancing food quality and safety: a comprehensive review. *Journal of Food Science and Nutrition*, 7(4):247.

Received 3 December 2024; accepted for publication 12 December 2024