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# Phosphates as food additives in meat and meat products in North Macedonia

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**Abstract.** Phosphates are used as food additives by meat processing industries to improve the technological properties of the products. However, phosphates can have adverse effects on human health so their use is regulated by law setting the maximum allowable level of phosphates in a meat product. This study evaluates the total phosphorus contents in meat and meat products placed on the Macedonian market in the previous five years. The results showed that a significant number of analysed meat products contained more than 5000 mg/kg total phosphorus as P<sub>2</sub>O<sub>5</sub>. However, it must be stressed that for the time being there is no analytical methodology available capable of distinguishing the naturally present phosphates from the added ones.

## 1. Introduction

Phosphorus is essential for all living organisms. Inorganic phosphate used as food additive is assumed to dissociate in the gastrointestinal tract. Approximately 80-90% of the inorganic phosphorus deriving from food additives is absorbed as free orthophosphate. Excretion is *via* the kidney through glomerular filtration and tubular mechanisms. The EFSA panel on food additives and flavourings considered phosphates to be of low acute oral toxicity, and to be of no concern with respect to genotoxicity and carcinogenicity [1]. In standard short-term, subchronic and chronic toxicity studies, the only significant adverse effects of phosphates are calcification of the kidney and tubular nephropathy. The epidemiological studies recently reviewed did not find consistent associations between dietary phosphorous intake and cardiovascular-related outcomes and do not provide sufficient and reliable data to assess the role of phosphate in bone health. Clinical interventional trials in which phosphorous doses were administered on top of normal diets were performed over several months. No impairment of renal function was reported with daily doses of up to 2000 mg phosphorus (28.6 mg/kg per day), whereas doses of 4800 mg (68.6 mg/kg per day) elicited renal impairment [1].

The EFSA panel concluded a group acceptable daily intake (ADI) of 40 mg/kg body weight per day, expressed as phosphorus, is protective for healthy adults because it is below the doses at which clinically relevant adverse effects were reported in short-term and long-term studies in humans. However, this ADI does not apply to people with moderate to severe reduction in renal function [1].



Phosphates used in meat processing industries are salts of phosphoric acid, sodium or potassium. Phosphates are polyvalent ions which can form structures containing from one to hundreds or even thousands of phosphate tetrahedra. Depending on the number of P atoms in the molecule, the usual name will change as follows: (i) one phosphorus atom ( $\text{PO}_4$ )<sup>3-</sup> monophosphates (formerly orthophosphates); (ii) two phosphorus atoms ( $\text{P}_2\text{O}_7$ )<sup>4-</sup> diphosphates (formerly pyrophosphates); (iii) three phosphorus atoms ( $\text{P}_3\text{O}_{10}$ )<sup>5-</sup> tripolyphosphates; and more than three phosphorus atoms ( $\text{P}_n\text{O}_{3n+1}$ )<sup>(n+2)-</sup> polyphosphates [3,4].

Phosphates are authorised food additives in the EU in accordance with Annex II and III to Regulation (EC) No 1333/2008. According to the European legislation, food phosphates are not permitted in fresh meat, but can be added at a maximum amount of 0.5 % (expressed as  $\text{P}_2\text{O}_5$ ) to meat products [5].

Food phosphates used in meat and meat products must be manufactured according to good manufacturing practices (GMP). Phosphates are not permitted in fresh meat but can be added to meat preparations, minced meat and meat products (Regulation EC No 853/2004, 2004). The maximum permitted level of phosphates in meat and meat products according to European legislation is 5 g/kg expressed as phosphorus pentoxide ( $\text{P}_2\text{O}_5$ ) individually or in combination in the finished product (Directive No 95/2/EC, Rev. 2006). Accordingly, the national legislation in North Macedonia for food additives, which is harmonised with EU legislation, stipulates the same maximum permitted level for phosphates in meat products, 5 g/kg [6].

Meat processing operators in North Macedonia are obligated according to the food safety law to confirm the safety of their products by appropriate testing conducted by an external laboratory. The Institute of Public Health has developed laboratory capacities for testing phosphates in meat products at the request of food business operators.

The aim of the study was to evaluate the findings from phosphate determinations in raw meat and meat products for the period from 2014 to 2019.

## 2. Materials and methods

Over a period of 5 years (2014-2019), 323 samples of raw meat and meat products were analysed for total phosphorus content. The samples were delivered to the laboratory by the Food and Veterinary Agency of the Republic of North Macedonia under regular surveillance programs or by the manufacturers interested in the quality of raw materials or of their own manufactured meat products. Of the total number of samples, 190 were pork/beef meat products, 109 were poultry meat products, 12 samples of raw beef/pork meat and 12 samples of raw poultry meat.

After receiving the samples in the laboratory, they were homogenised with appropriate equipment, kept in a seal-tight container at 4°C and analysed within 24 h of homogenisation.

The total phosphorus content in the samples was determined by the standard ISO method[7].

## 3. Results and Discussion

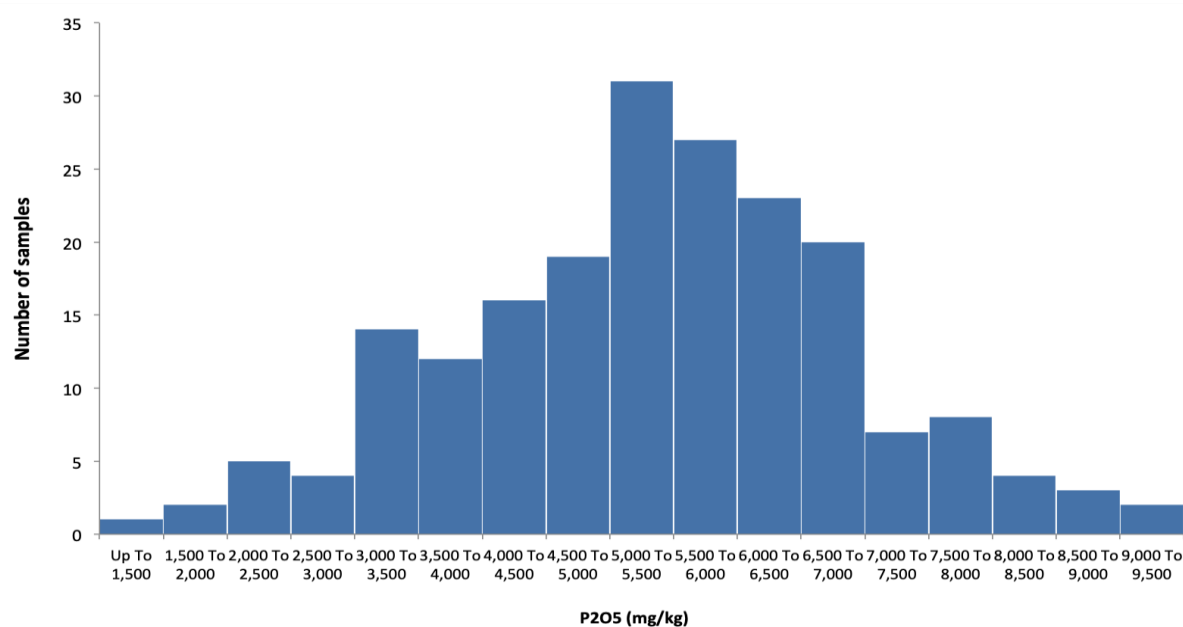
The total phosphorus contents in meat and meat products placed on the North Macedonian market are presented in Table 1.

**Table 1.** Total phosphorus (mean  $\pm$  standard deviation), minimum and maximum contents measured in meat and meat products in North Macedonia, 2014-2019

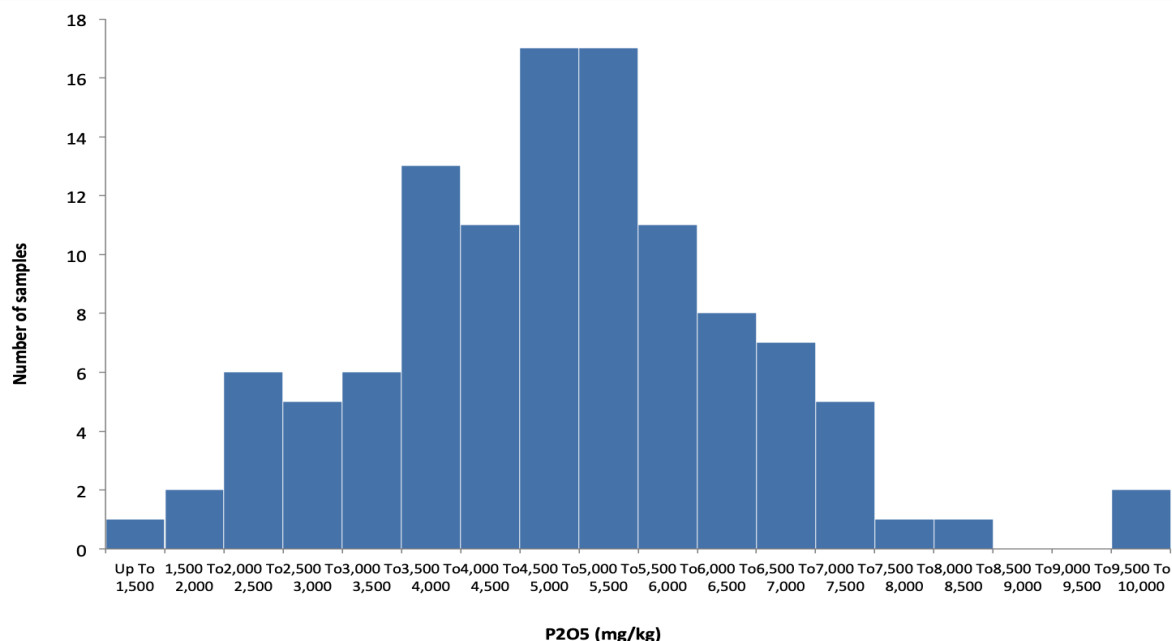
Type of sample	No. of samples	Average $\text{P}_2\text{O}_5$ (mg/kg) content	Minimum content $\text{P}_2\text{O}_5$ (mg/kg)	Maximum content $\text{P}_2\text{O}_5$ (mg/kg)	No. of samples $>5000$ mg/kg $\text{P}_2\text{O}_5$
Beef/pork meat products	190	$5396 \pm 1492$	1783	9408	122
Beef/pork raw meat	12	$4234 \pm 1312$	2298	6038	4

Poultry meat products	109	4872 ± 1462	1878	9737	50
Poultry raw meat	12	4898 ± 769	3474	6268	5

Over 60% of the beef/pork meat products (Figure 1) and around 45% of the poultry meat products (Figure 2) exceeded the legal limit of 5000 mg/kg added phosphates expressed as  $P_2O_5$ , which is a much greater percentage of unsatisfactory products than was published by Prica *et al.* [8]. The mean content of total phosphorus in beef/pork meat products was 5396 mg/kg. The maximum contents of  $P_2O_5$  in meat products were measured in smoked turkey drumstick (9737 mg/kg) and smoked pork tenderloin (9408 mg/kg). Considering raw meat, one sample of frozen pork loin contained 6038 mg/kg  $P_2O_5$ , and the maximum content of  $P_2O_5$  among the raw poultry meats was measured in a sample of chicken steak (6268 mg/kg). The results obtained for poultry meat were similar to those reported by Serdar *et al.* [9].



**Figure 1.** Distribution of the beef/pork meat products according to their  $P_2O_5$  content in mg/kg



**Figure 2.** Distribution of the poultry meat products according to their P<sub>2</sub>O<sub>5</sub> content in mg/kg

Elevated values of total phosphorus in raw meat indicate the raw materials used by the meat industry were treated with additives, which is against the law. Moreover, addition of phosphates during the technological process of manufacturing meat products additionally enhances their phosphate contents over the content of phosphate in the initial raw meat used.

Another point of discussion is the limitation of the method used for measurement of the total phosphorus content. This method is incapable of differentiating the naturally present phosphates in the meat and the ones added as food additives in the meat products. As a result, increased values of phosphates were especially encountered in smoked products with high protein content, even though they were produced without addition of phosphates as food additives. An alternative solution of this analytical problem could be determination of the added phosphates by calculation. The protein content of the meat product is used in the formula, based on the approximation that the ratio between the phosphorus content and the meat protein content is constant, as was proposed by Deric *et al.* [10].

The EFSA panel on food additives and flavourings, in their re-evaluation of phosphates, concluded the development of analytical methods for the determination of phosphate additives in the range of foods and beverages permitted to contain them should be considered.

#### 4. Conclusion

A significant number of meat products analysed in this study contained total phosphorus in levels higher than 5000 mg/kg P<sub>2</sub>O<sub>5</sub>. The maximum limit for phosphorus set by legislation refers to the added phosphates during technological processing of the meat. On the other hand, no analytical method is able to distinguish between the naturally present phosphates in a meat product and those added as food additives. As a result, the interpretation of the analytical results still remains under debate and requires knowledge of the natural levels of phosphorus in the raw materials used to manufacture the meat products. In any case, it is important to monitor phosphates as additives in meat products and ensure levels are maintained below the maximum limit, in terms of consumer health, but also in terms of quality and safety of the products.

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