International Journal of Community Medicine and Public Health
Anukam CC et al. Int J Community Med Public Health. 2017 May;4(5):1445-1449
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20171496

Original Research Article

Health implications of inorganic phosphate additives in food products: a systematic review

Chinedu C. Anukam*, Benedicta N. Agu

Department of Public Health, Madonna University Faculty of Health Science, Rivers State, Nigeria

Received: 28 March 2017
Revised: 30 March 2017
Accepted: 31 March 2017

***Correspondence:**
Chinedu C. Anukam,
E-mail: collgeraclemt01@gmail.com

ABSTRACT

Background: Evidence based data identifies phosphate additives in food products as a public health concern, especially in the progression of chronic kidney disease (CKD). However, there is limited public awareness of the risks associated with phosphate additives. This study focuses on a systematic review of findings on health implications of phosphate additives, with the aim of strengthening public health knowledge, insight, understanding and prevention of exposure to phosphate toxicity and chronic diseases.
Methods: Studies with primary data on phosphate additives were identified using keyword electronic database search in PubMed and BMC. To meet the review criteria, articles needed to (1) be published in English (2) focus on phosphate additives (3) address the potential health risks associated with phosphate additives (4) identify existing health problems caused by phosphate additives (5) published between 2005 to 2017 to provide a more dynamic review and (6) hold a strong research evidence that confirms the associated risks of phosphate additives.
Results: Findings from reviewed literature suggest a link between high phosphate content in food products and chronic renal failure, cardiovascular complications, accelerated aging process, allergic reactions and increased morality rate. The need to regulate the use of phosphates additives in food products and strengthen public health education is essential to minimise high exposure to phosphate additives.
Conclusions: Further research, proper food labelling, strict regulation of unhealthy food additives, nutrition education and sensitisation of consumers are required to minimise exposure to phosphate additives and susceptibility to chronic diseases.

Keywords: Systematic review, Phosphate additives, Health implications

INTRODUCTION

There is a need to strengthen global awareness of the rapidly growing use of inorganic phosphate additives in food products to minimise their potential untoward effects. Phosphate additives increase the total phosphorous content of food products, but the extent is unclear.[1] Thus, consumers of phosphate additives-based food products may be unaware of the associated health consequences of high phosphate consumption and require evidence-based information to make informed decision about their phosphate intake. Therefore, this systematic review was necessitated by the urgent need to constantly review and analyse findings from published studies on the health effects of phosphate additives, enhance public health awareness, sensitization, and chronic disease prevention. This study aims to strengthen public health knowledge, understanding, prevention of phosphate toxicity, and advise the necessity to regulate the use of phosphate additives. Public health may continue to be in

jeopardy with less focus and underestimation of the potential impact of phosphate additives on diet safety and health.[2]

Empirical data reveals the potential risk of phosphate additives in food products and the essence of a normal phosphate balance.[3] Nevertheless, even a normal serum phosphate concentration was found to aggravate chronic kidney disease.[4] This supports the findings in which phosphate additives were identified as potential health risk and a strong predictor of mortality among advanced chronic kidney disease patients due to hyperphosphatemia.[5] Similar negative outcome was recorded in a study conducted on patients undergoing haemodialysis, with increased death rate consequently.[6] Complications of phosphate additives have also been identified in glucose and lipid metabolism by the liver, as found in recent epidemiological and animal studies, revealing accelerated phosphate concentrations in chronic diseases.[7] Although an essential nutrient to the body, serum phosphate concentration is influenced by inorganic phosphate additives in food products, with the potential to accelerate tissue damage, aging process and stimulation of lung tumors.[8] Susceptibility to serious health consequences may be heightened in the presence of abnormal phosphate levels exceeding the body's nutrient needs, leading to potential disruption of phosphate homeostasis.[9]

Socioeconomic impact

Adherence to a phosphate restricted diet may be difficult for individuals, especially children who may be addicted to phosphate additives-based processed foods provided by caregivers or purchased at social gatherings. Hence, a recent study identified elevated phosphate levels in adolescents undergoing kidney dialysis.[10] Moreover, more than a quarter of food products were found to contain phosphorous additives in a study to determine the prevalence of phosphorous-containing food additives in top selling foods in grocery stores, uncovering the risk of high exposure to phosphate additives in low cost food products, and a socioeconomic association with the development of phosphate induced chronic diseases.[11] As reported, abject poverty has also been linked to high serum phosphate concentration and increased likelihood of phosphate toxicity due to limited food choices.[12]

In examining the added phosphate contents of some food products, enhanced meat and poultry products were found to contain a high percentage of phosphate additives, 28.4% higher than the amount in other regular products, thus increasing the risk of excessive consumption and chronic diseases.[13] Dairy products and cereals containing phosphate additives have also been found to increase serum phosphate concentration, even when consumed less regularly than other foods with no phosphate additives.[14] This evidence suggests the need to consider viable alternatives to phosphate additives. Although some foods such as milk and vegetables contain organic phosphorus considered essential for cellular function and homeostatic balance, regular consumption of inorganic phosphate additives was found to affect serum parathyroid hormone concentration in a cross-sectional study on healthy premenopausal women, and further predicted possible bone defects.[15] Therefore, understanding the amount of phosphorous intake required by the body is essential to help consumers to restrict their consumption. As pointed out in a recent study, several challenges (such as poor coding of food products, absence of nutrient databases, and inaccurate report of dietary consumption) affect accurate assessment of dietary phosphorous intake and increase the risk of toxicity and chronic diseases.[16] Excessive dietary phosphorous intake is a public health challenge that requires adequate primary interventions and diet modification.[17] Strategies to minimise excessive intake of dietary phosphate additives have been suggested, including restriction of food products containing high phosphate additives, preference for organic foods, proper boiling, and nutritional education.[18] Furthermore, complete replacement of phosphate additives-containing foods with natural foods was found to reduce serum phosphate concentration with no negative effect on nutritional status.[19] Given the increasing incidence of chronic diseases associated with phosphate additives, a study concludes that lack of adequate intervention and strict regulation may increase the burden of associated chronic diseases.[20] Evidence suggests that serum phosphate levels may not represent accurate amount of phosphate uptake by individuals, hence the difficulty in assessing actual amount of phosphate intake and increased susceptibility to hyperphosphatemia.[21] This report gives credence to the importance of advancing strategies to minimise the use of phosphate additives. Besides, its effects reportedly contributed to accelerated aging process in mammals as found in mice studies, revealing premature aging features such as body weight loss, infertility, tissue degeneration and life span reduction.[22] In this report, the effects of elevated serum phosphate concentrations on the lungs, intestine and skin was conducted. The outcome showed the development of emphysema at 6 weeks of age in mice (as recorded in human populations) following exposure to high phosphate levels. There were also negative pathological changes in the intestine and skin. Conversely, these effects were suppressed by lowering phosphate levels. Moreover, phosphate composition of foods has been found to be misleading and inaccurate when compared to the levels recorded in chemical analysis, a situation that requires scrutiny and health policy implementation to regulate indiscriminate use of phosphate additives, and to prevent phosphate-induced tissue damage.[23,24] In the assessment of its nutritional value, high inorganic phosphorous has been described as a possible marker for an unhealthy diet, associated with high mortality in persons with chronic diseases.[25]

METHODS

Publishes Studies with primary data on phosphate additives were identified with a keyword electronic database search, including PubMed and BMC. Specific keywords comprised: (1) phosphate additives in foods (2) health effects of phosphate additives (3) implications of phosphate additives in food products and (3) awareness of health effects of phosphate additives in food products. All retrieved articles were further scrutinised to identify those that met the review inclusion criteria.

To meet the review inclusion criteria, articles needed to (1) be published in English (2) focus on phosphate additives (3) address the potential health risks associated with phosphate additives and (4) identify existing health problems caused by phosphate additives (5) published between 2005 to 2017 and (6) hold strong research evidence that confirms the associated risks of phosphate additives. Thirty selected studies met the review criteria. Studies published pre-2005 and those lacking the above inclusion criteria were excluded.

Data extraction was facilitated by two independent reviewers. The process comprised the following: (1) identification of author's name (2) year of publication/ citation (3) study location (4) population of the study (5) sample size and (6) study design (example, qualitative; in-depth interviews, or quantitative; randomised controlled trial, cross-sectional study), and results. The results were considered relevant based on strong evidence of an association between phosphate additives and adverse health effects.

The quality of the reviewed studies was assessed based on the following: (1) identification of the research question, description, and focus (2) identification of the research problem and adherence to literature and (3) adoption of a systematic approach in the comprehensive review.

The data was analysed by comparing the consistency and dissimilarities in the study results. The impact of the study quality on results was evaluated with the aim of exploring potential bias. In this process, the summary of data was recorded and compared with respect to the authors, year of publication, and effects of phosphate additives on health. Similar findings from each publication were noted with respect to the complications of exposure to phosphate additive.

RESULTS

Findings indicate high incidence and prevalence of chronic diseases associated with high exposure to phosphate additives. Chronic renal diseases, cardiovascular and liver complications, accelerated aging, and allergic reactions were among the various health implications reported due to exposure to high phosphate additives. Animal studies involving mice exposure to high phosphate levels revealed similar risks and complications in the lungs and liver as found in humans. These finding were attributed to increased serum phosphate concentration, caused by excessive intake of inorganic phosphate additives in food products. Although, some studies held the opinion that organic phosphate is essential for cellular function, they however maintained that phosphate additives in food products remained a matter of concern which may have been underestimated. Recommendations from available data suggest the need for intensified effort to regulate the use of phosphate additives in food products and educate the public about its potential health implications.

DISCUSSION

The reviewed studies suggest an association between phosphate additives in foods products and negative health outcomes. Hyperphosphatemia, an increase in serum phosphate level was identified as a potential risk factor and predictor of advanced chronic kidney and cardiovascular diseases.[26] However, other findings recognised the essential role of phosphate additives in food preservation but argued that their public health implications may have been underestimated because consumers may be unable to determine the quantity of added phosphate in food products. Furthermore, there is limited evidence to assess the role of phosphate additives in metabolic diseases like type 2 diabetes and obesity, but a negative effect on the liver has been demonstrated.[27] These negative health consequences may be explained by the disruption of phosphate balance through excessive consumption of inorganic phosphate additives in food products. As reported, normal phosphorous balance may be essential for bone health and mineralization, but without proper education, and healthier food options, consumers may be unable to regulate their phosphate intake to normal.[28] This situation brings to light a possible socioeconomic perspective to high exposure to phosphate additives, which may be linked to limited choices for safe organic foods and increased availability of low cost food items with added phosphate additives. In addition to the affordability of phosphate additives-rich foods, further examination of their impact on health revealed their high concentration in bioavailability than organic phosphates and their contribution to the development of tumors.[29] However, the safety of phosphate additives for public consumption may not be completely disregarded, but requires more evidence and caution to prevent potential health hazards.[30]

Given the importance of nutrition in health, public education and accurate food labelling may serve as first step approach to inform consumers of the inherent risks associated with phosphate additives.

CONCLUSION

Increase in the amount of phosphate additives in food products has attracted limited public health attention in

recent years, resulting in poor regulation and susceptibility of consumers to phosphate toxicity due to high exposure. Phosphate additives in food products may continue to pose greater public health risks and therefore require adequate interventions through education, proper food labelling, and functional regulatory officers for food content analysis before approval and distribution, and sensitization of consumers through the mainstream media and further research to provide best prevention strategies.

ACKNOWLEDGEMENTS

Our gratitude goes to all public health academic staff who contributed to the success of this research, and to all public health students for their efforts and hard work.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Carrigan A, Klinger A, Choquette SS, Luzuriaga-McPherson A, Bell EK, Darnell B, et al. Contribution of Food Additives to Sodium and Phosphorus Content of Diets Rich in Processed Foods. J Ren Nutr. 2014;24(1):13-9.
2. Lederer E. Why would serum phosphorus correlate with cardiovascular risk, and how is the clinician supposed to use this information? Clin Nephrol. 2017;87:1-10.
3. McCarron DA. Protecting Calcium and Phosphate Balance in Chronic Renal Disease. J Am Soc Nephrol. 2005;16:93-4.
4. Chang AR, Lazo M, Appel LJ, Gutiérrez OM, Grams ME. High dietary phosphorus intake is associated with all-cause mortality: results from NHANES III. Am J Clin. Nutr. 2014;99(2):320-7.
5. Ritz E, Hahn K, Ketteler M, Kuhlmann MK, Mann J. Phosphate Additives in Food—a Health Risk. Dtsch Arztebl Int. 2012;109:49-55.
6. Noori N, Sims JJ, Kopple JD, Shah A, Colman S, Shinaberger S, et al. Organic and inorganic dietary phosphorus and its management in chronic kidney disease. Iran J Kidney Dis. 2010;4:89-100.
7. Abuduli M, Ohminami H, Otani T, Kubo H, Ueda H, Kawai Y, et al. Endocrinology and Metabolism. Am J Physiol. 2016;310(7):526-38.
8. Razzaque MS. Phosphate toxicity: new insights into an old problem. Clin Sci (Lond). 2011;120:91-7.
9. Calvo MS, Moshfegh AJ, Tucker KL. Assessing the Health Impact of Phosphorus in the Food Supply: Issues and Considerations. Adv Nutr. 2014;5:104-13.
10. Taylor JM, Oladitan L, Degnan A, Henderson S, Dai H. Psychosocial Factors That Create Barriers to Managing Serum Phosphorus Levels in Pediatric Dialysis Patients: A Retrospective Analysis. J Ren Nutr. 2016;26:270-5.
11. León JB, Sullivan CM, Sehgal AR. The Prevalence of Phosphorus Containing Food Additives in Top Selling Foods in Grocery Stores. J Ren Nutr. 2013;23:265-70.
12. Gutiérrez OM, Isakova T, Enfield G, Wolf M. Impact of poverty on serum phosphate concentrations in the Third National Health and Nutrition Examination Survey. J Ren Nutr. 2011;21:140-8.
13. Sherman RA, Mehta O. Phosphorus and Potassium Content of Enhanced Meat and Poultry Products: Implications for Patients Who Receive Dialysis. Clin J Am Soc Nephrol. 2009;4:1370-3.
14. Moore LW, Nolte JV, Gaber AO, Suki WN. Association of dietary phosphate and serum phosphorus concentration by levels of kidney function. Am J Clin Nutr. 2015;102:444-53.
15. Kemi VE, Rita HJ, Kärkkäinen MU, Viljakainen HT, Laaksonen MM, Lamberg-Allardt CJ. Habitual high phosphorus intakes and foods with phosphate additives negatively affect serum parathyroid hormone concentration: a cross-sectional study on healthy premenopausal women. Public Health Nutr. 2009;12:1885-92.
16. Gallant KM. Studying dietary phosphorus intake: the challenge of when a gram is not a gram. Am J Clin Nutr. 2015;102: 237-8.
17. Girish N, Nadkarni, Uribarri J. Phosphorus and the Kidney: What Is Known and What Is Needed. Adv Nutr. 2014;5:98–103.
18. D'Alessandro C, Piccoli GB, Cupisti A. The "phosphorus pyramid": a visual tool for dietary phosphate management in dialysis and CKD patients. BMC Nephrology. 2015;16:9.
19. De Fornasari ML, Sens Y. Replacing Phosphorus-Containing Food Additives with Foods Without Additives Reduces Phosphatemia in End-Stage Renal Disease Patients: A Randomized Clinical Trial. Journal of Renal Nutrition. 2016;27:97-105.
20. Komaba H, Fukagawa M. Phosphate-a poison for humans? Kidney Int. 2016;90:753-63.
21. Osuka S, Razzaque MS. Can features of phosphate toxicity appear in normophosphatemia? Journal of bone and mineral metabolism. 2012;30:10-8.
22. Ohnishi M, Razzaque MS. Dietary and genetic evidence for phosphate toxicity accelerating mammalian aging. The FASEB Journal. 2010;24:3562- 70.
23. Uribarri J. Phosphorus Additives in Food and their Effect in Dialysis Patients. Clin J Am Soc Nephrol. 2009;4:1290-2.
24. Brown RB, Razzaque MS. Dysregulation of phosphate metabolism and conditions associated with phosphate toxicity. BoneKEy Reports. 2015;4:705.
25. Chang WX, Xu N, Kumagai T, Shiraishi T, Kikuyama T, Omizo H, et al. The Impact of Normal Range of Serum Phosphorus on the Incidence of End-Stage Renal Disease by A Propensity Score Analysis. PLoS ONE. 2016;11: e0154469.

26. Heine GH, Nangaku, M, Fliser, D. Calcium and phosphate impact cardiovascular risk. Eur Heart J. 2013;34:1112-21.
27. Chun S, Bamba T, Suyama T, Ishijima T, Fukusaki E, Abe K, et al. A High Phosphorus Diet Affects Lipid Metabolism in Rat Liver: A DNA Microarray Analysis. PLoS ONE. 2016;11:e0155386.
28. Penido MGMG, Alon US. Phosphate homeostasis and its role in bone health. Pediatric Nephrol (Berlin, Germany). 2012; 27:2039-48.
29. Jain N, Elsayed EF. Dietary phosphate: what do we know about its toxicity? J Nephrol. 2013;26:856-64.
30. Gutiérrez OM. Sodium and phosphorus-based food additives: persistent but surmountable hurdles in the management of nutrition in chronic kidney disease. Adv Chronic Kidney Dis. 2013;20:150-6.

Cite this article as: Anukam CC, Agu BN. Health implications of inorganic phosphate additives in food products: a systematic review. Int J Community Med Public Health 2017;4:1445-9.