

*The Phosphate Forum of the Americas &  
The International Food Additives Council Presents*

# Phosphates in Our World: Food and Non-Food Uses of Phosphates

**Tony Gichuhi, PhD;** Global R&D Director, ICL Phosphate Specialty

**Paola Campo;** Applications Development Manager, Prayon Inc.

**Taylor Wallace, PhD, CFS, FACN;** Think Healthy Group, Inc. and George Mason University

**Tuesday, March 3, 2020**



**Phosphate  
Forum of the  
Americas**



# Introduction

## **Moderator:**

Berit Dockter MPP, RD, LD  
Scientific and Regulatory Affairs Manager  
International Food Additives Council  
Phosphate Forum of the Americas



## **Technical Difficulties:**

Call Holly at 1-847-686-2347

## **Q&A:**

Input questions into the “ask a question box”

# About the Phosphate Forum of the Americas

- The Phosphate Forum of the Americas (PFA) was established in 1996 to facilitate the exchange of information on matters relating to inorganic phosphates.
- The mission of the Phosphate Forum of the Americas is to provide educational information on scientific and technical matters relating to inorganic phosphate products, and assess the role of activities progressing toward a sustainable environment.
- Visit [phosphatesfacts.org](http://phosphatesfacts.org)

# About the International Food Additives Council



- The International Food Additives Council (IFAC) is a global association representing manufacturers and end-users of food ingredients, including food additives.
- IFAC strives to promote science-based regulations, standards and specifications for food ingredients worldwide.
- The IFAC mission is to be the recognized global leader for food ingredient information, education and science, advocating for sound food ingredient policies.
- Visit: [foodingredientfacts.org](http://foodingredientfacts.org)



# Objectives of the Webinar

- Be able to identify at least one indication for the use of phosphates in food and use in non-food products.
- Be able to identify at least one innovative use of phosphates used to substitute other components or ingredients in food and non-food products.
- Be able to identify the different regulations between food and non-food uses of phosphates.
- Be able to identify myths that are associated with phosphates.

# Speakers



**Tony Gichuhi, PhD**

Global R&D Director, ICL Phosphate Specialty



**Paola Campo**

Applications Development Manager, Prayon Inc.

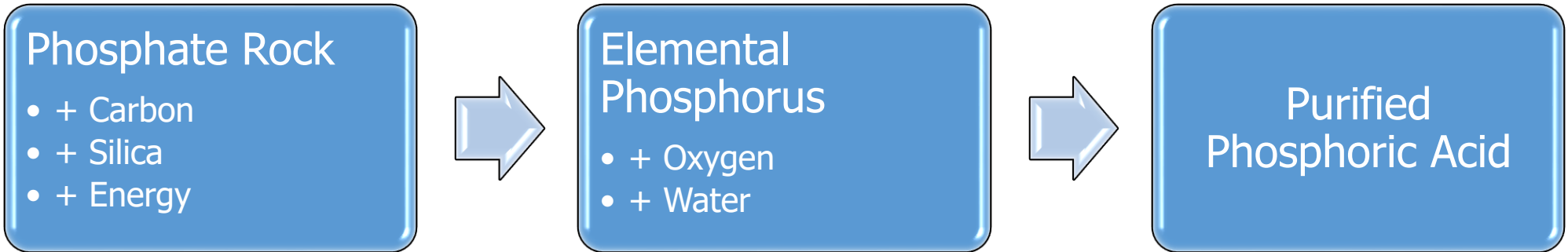


**Taylor Wallace, PhD, CFS, FACN**

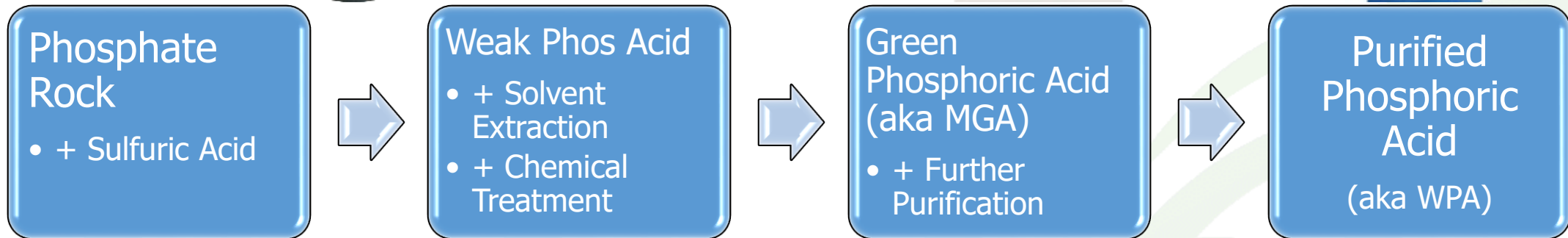
Think Healthy Group, Inc. and George Mason  
University

# Phosphoric Acid Manufacturing

**Thermal**



**Wet**



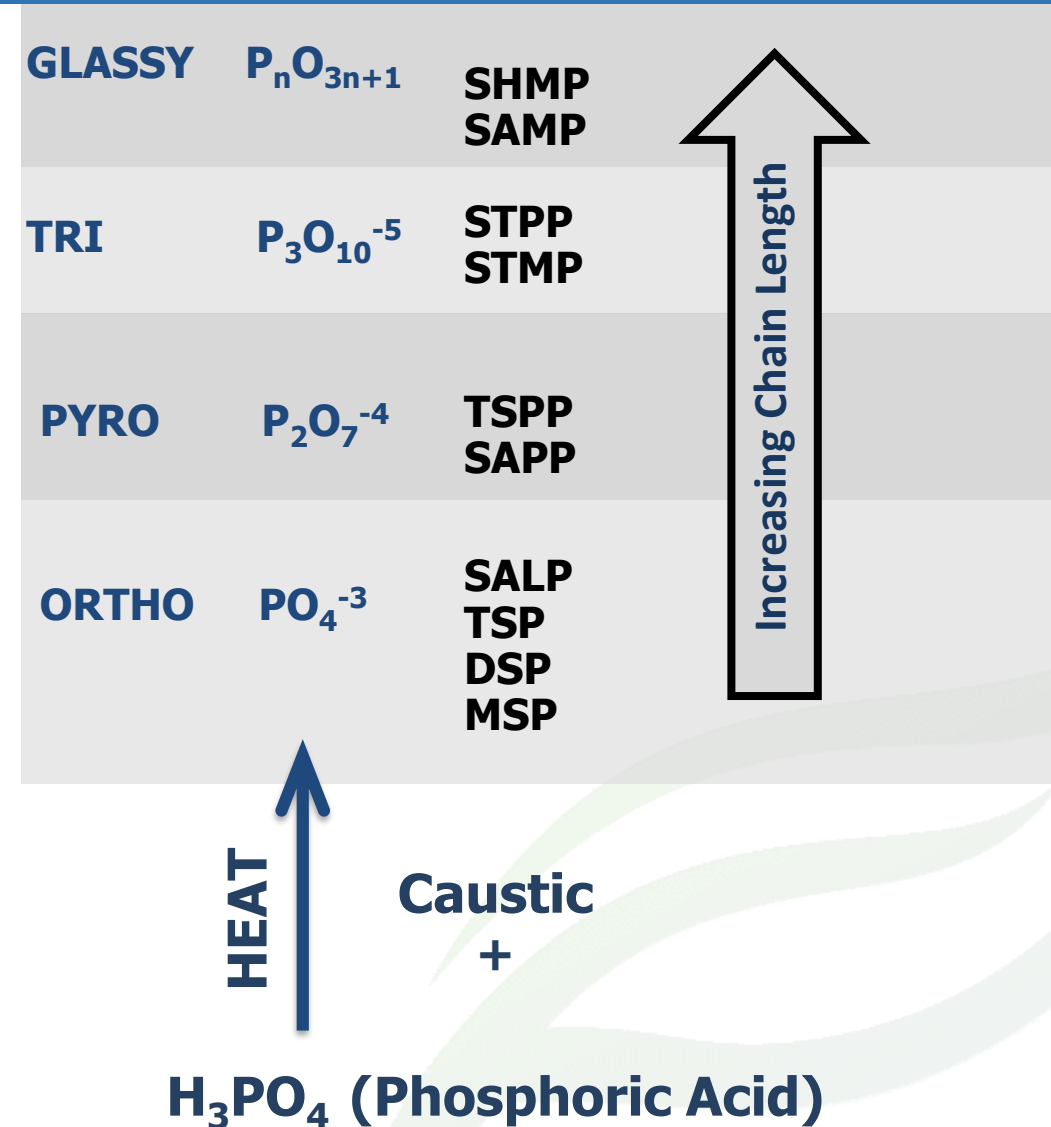
# What Do We Use Phosphates For?

## Non-food applications

- Tartar control in oral products
- Fight forest fires
- Coat the surface of pipes to prevent leaching of lead
- Electronic semiconductor cleaning
- Construction (asphalt, cement)

## Food applications

- Leaven baked goods
- Maintain structure of meat
- Improve fluidity of dairy products
- Mineral supplements





## Function

- Fluoridation
- Corrosion control
- Sequestration
- Deflocculation



**Products:** Phosphoric acid, Disodium phosphate, Trisodium phosphate, Sodium hexametaphosphate, Tetrapotassium pyrophosphate, Sodium tripolyphosphate, Fluorosilic acid

# Important Uses of Phosphates in Water Treatment

## What went wrong?

- Flint switched water sources from Detroit to the Flint River as a money saving initiative.
- Flint River water was more corrosive, had 8x the amount of dissolved chloride.
- Water was improperly treated leading to high levels of lead in the tap water.
- Orthophosphates should have been added to the water to combat the corrosion of lead pipes.

## THE FLINT WATER CRISIS

The American city of Flint, Michigan, has been in the news recently due to the discovery of very high levels of lead in its water supply. But how did this lead get there? Here's a brief explainer.



### TRIHALOMETHANES

Disinfectant byproducts; formed by the reaction of chlorine (added to disinfect the water) with organic matter.

X = halogen (commonly Cl or Br)

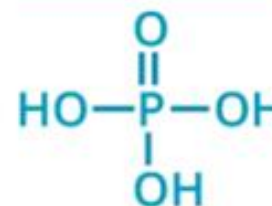
### CORROSION: DETROIT VS. FLINT RIVER

0.45 vs 1.60  
DETROIT vs FLINT

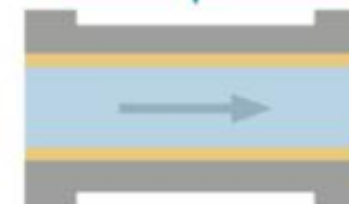
Chloride to sulfate mass ratio (CSMR); 0.45 = low corrosion; 1.60 = very high corrosion.

When high levels of trihalomethanes were detected in Flint's water, ferric chloride ( $\text{FeCl}_3$ ) was added to improve removal of organic matter. However, this increased the water's already high concentration of chloride ions, and as a result made the water more corrosive.

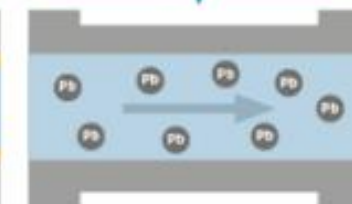
### CORROSION CONTROL



### WITH PHOSPHATES



### WITHOUT PHOSPHATES



Orthophosphates are added to water to reduce the amount of lead leaching into it from pipes. They do this by forming a layer of low-solubility lead-phosphate complexes inside the pipe. This method of corrosion control was not used for the Flint River water supply.



# Oral & Dental Care

## Function

- Abrasive
- Fluoride Carrier
- Anti-Calculus (Tartar Control)
- Mouthwashes
- Whitening gels (pastes)



**Products:** Sodium monofluorophosphate, Dicalcium phosphate dihydrate, Calcium pyrophosphate, Dicalcium phosphate anhydrous, Tetrasodium pyrophosphate, Sodium hexametaphosphate, Insoluble sodium metaphosphate, Tricalcium phosphate

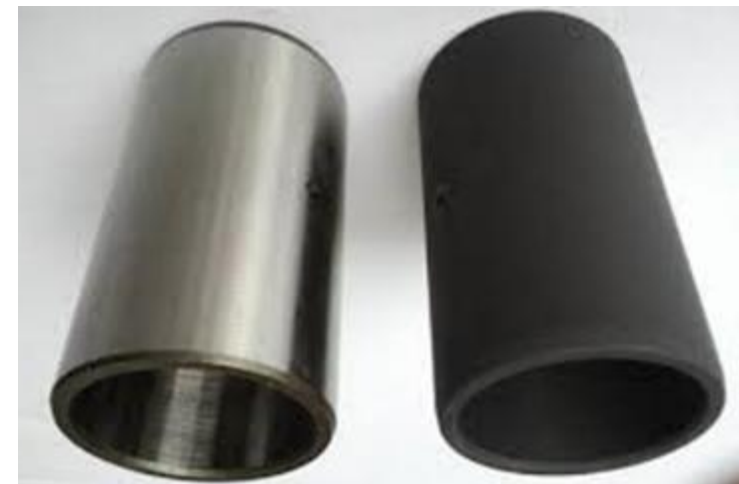
# Metal Cleaning, Treatment & Finishing

## Function

- Cleaning: soften the water
- Descaling: remove oxide scale
- Pickling
- Phosphatizing
- Passivation



Before & After



**Products:** Phosphoric Acid, Monosodium phosphate, Trisodium phosphate, Monopotassium phosphate, Dipotassium phosphate

## Function:

- Anticorrosion
- Pigment dispersant
- Defoamer
- Stain blocker
- Paint stabilizer

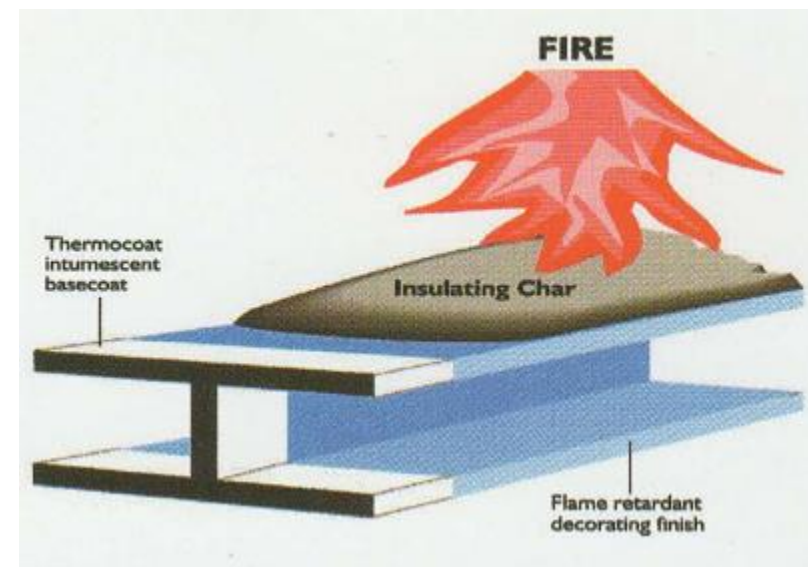
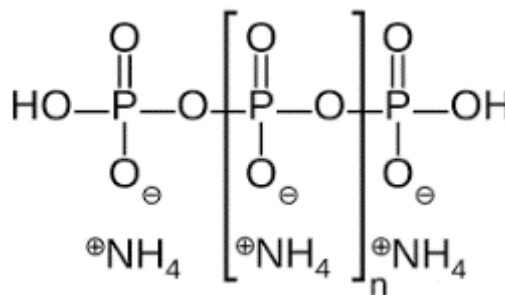


**Products:** Zinc phosphate, Zinc aluminum phosphate, Dicalcium phosphate, Potassium tripolyphosphate (KTPP), Tetrapotassium pyrophosphate (TKPP)

# Important Uses of Phosphates in Fighting Fires

## How do phosphates work?

- The active fire-retarding components are Monoammonium Phosphate (MAP), Diammonium Phosphates (DAP), or Liquid Ammonium Polyphosphate (APP).
- The fire retardant solution reacts with the cellulose present in the woody material, grass, needles, and other vegetative matter which would normally provide fuel for the fire.
- APP is also used in intumescent coatings applied to steel structures.



# Phosphates Used in Food vs. Non-Food Products

**Phosphates for food and non-food applications are made using phosphoric acid and a base (such as caustic and potash)**

- Mined materials.
- May differ in degrees of purification – presence of other mineral such as copper, iron, aluminum, fluoride, etc.

## **What is the difference?**

- Regulations – FCC, EC, JECFA.
- Food Grade products must meet all regulatory requirements and ensure food safety.
  - GMP, HACCP, FSMA, GFSI

# Food Uses of Phosphates

Very versatile – unique functionality

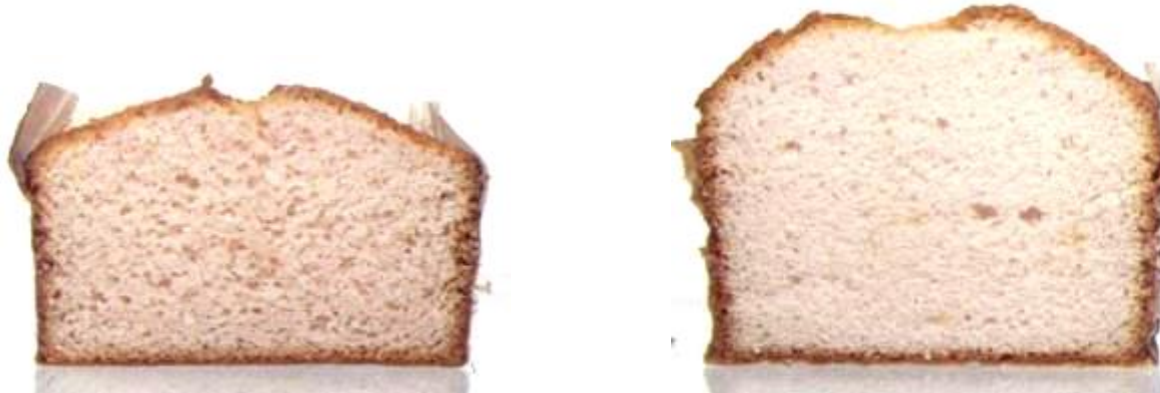




## Leaven baked goods

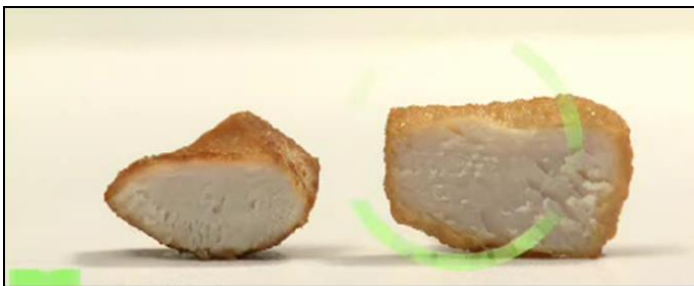
- Sodium acid pyrophosphate (SAPP)
- Monocalcium Phosphate (MCP)
- Sodium Aluminum Phosphate (SALP)
- Others

Chemical leavening is an acid-base reaction:

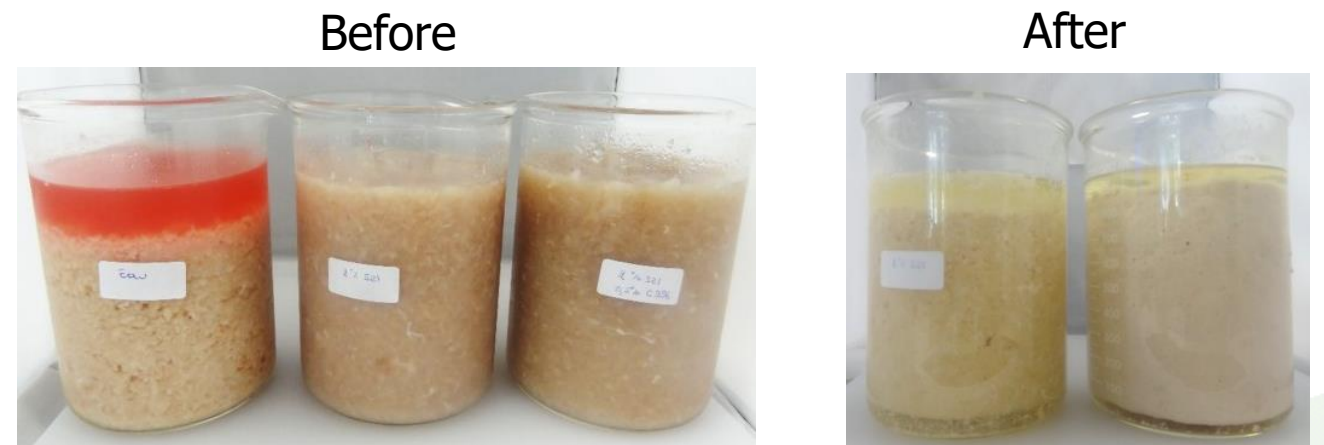


# Food Uses of Phosphates

- Improves water retention in meat, poultry, and seafood.
- Enhances tenderness and juiciness.
- Protein extraction.
- Sodium Tripolyphosphate.



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Salt only vs. Salt + Phosphate



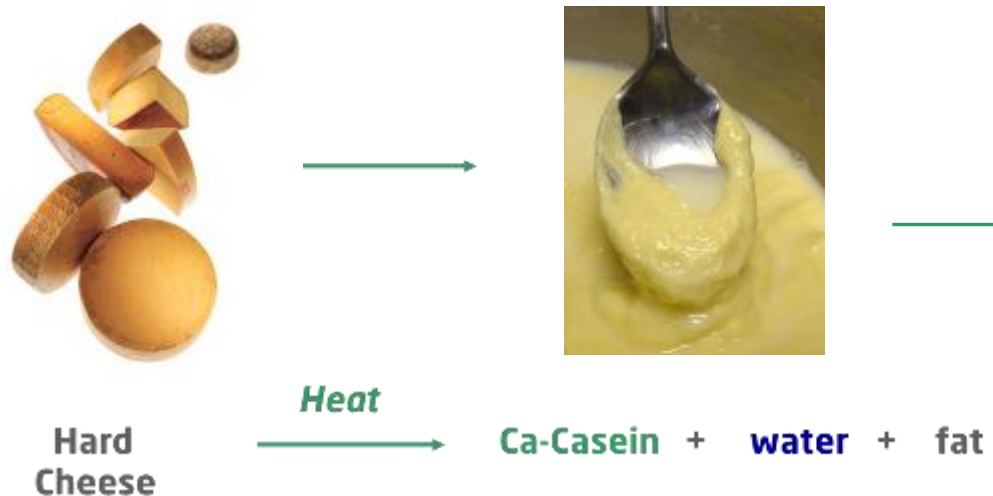
Salt only vs. Salt + Phosphate



# Food Uses of Phosphates

## Emulsifier and Stabilizers

- Phosphates provide protection from heat and acidic conditions.
- Disodium Phosphate, Sodium Hexametaphosphate, Dipotassium Phosphate.



**Homogeneous mix**

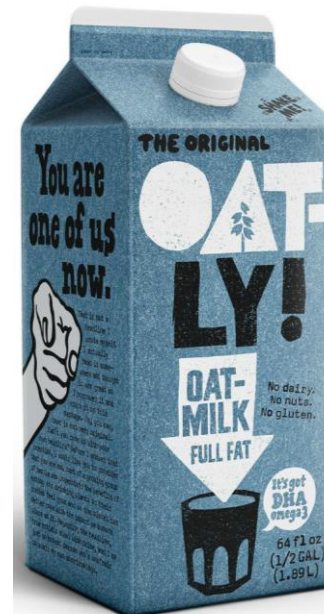
# Food Uses of Phosphates

## Mineral Enrichment and Anticaking

- Very good source of calcium, magnesium, and potassium.
- Prevent clumping.
- Tricalcium Phosphate, Monopotassium Phosphate, Magnesium Phosphate.



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# Using Phosphates to Lower Sodium

- U.S. Food and Drug Administration: Initiative to reducing sodium intake. Final guidance on voluntary, short-term targets for sodium is being developed.
- Meat: Potassium phosphate blends – reduce salt (sodium chloride) while maintaining desirable taste, texture, and tenderness.
- Baking: Calcium phosphates to substitute sodium leavening agents.
- Health Canada: Approved the use of potassium phosphate, dibasic (DKP) to be used in foods with sodium phosphate, dibasic (DSP).



Health  
Canada

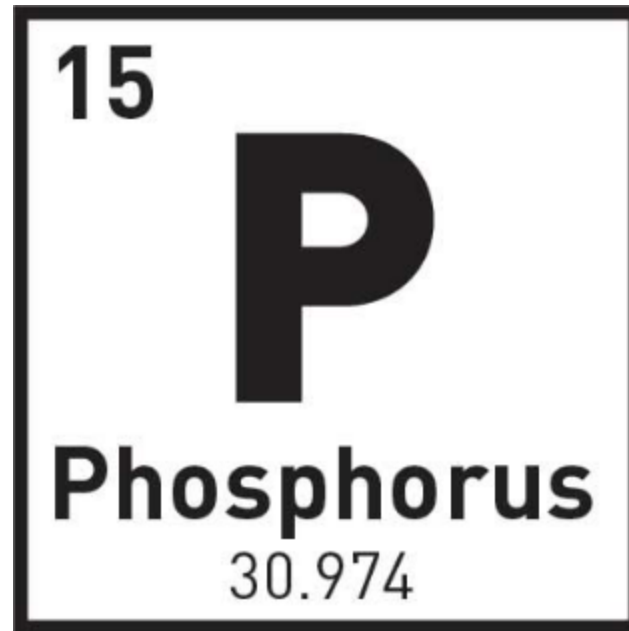


**U.S. FOOD & DRUG**  
ADMINISTRATION

# Dietary Phosphorus in Nutrition and Health

Taylor C. Wallace, PhD, CFS

Think Healthy Group and George Mason University



# Disclosures

- Think Healthy Group, Inc.
- George Mason University
- The Dr. Oz Show
- Atkins and Biocell Collagen Spokesperson
- Scientific Advisory Board – The Vitamin Shoppe
- Journal of American College of Nutrition
- Journal of Dietary Supplements
- Honoraria for this presentation provided by the International Food Additives Council.
- All conflicts listed at [www.drtylorwallace.com](http://www.drtylorwallace.com)



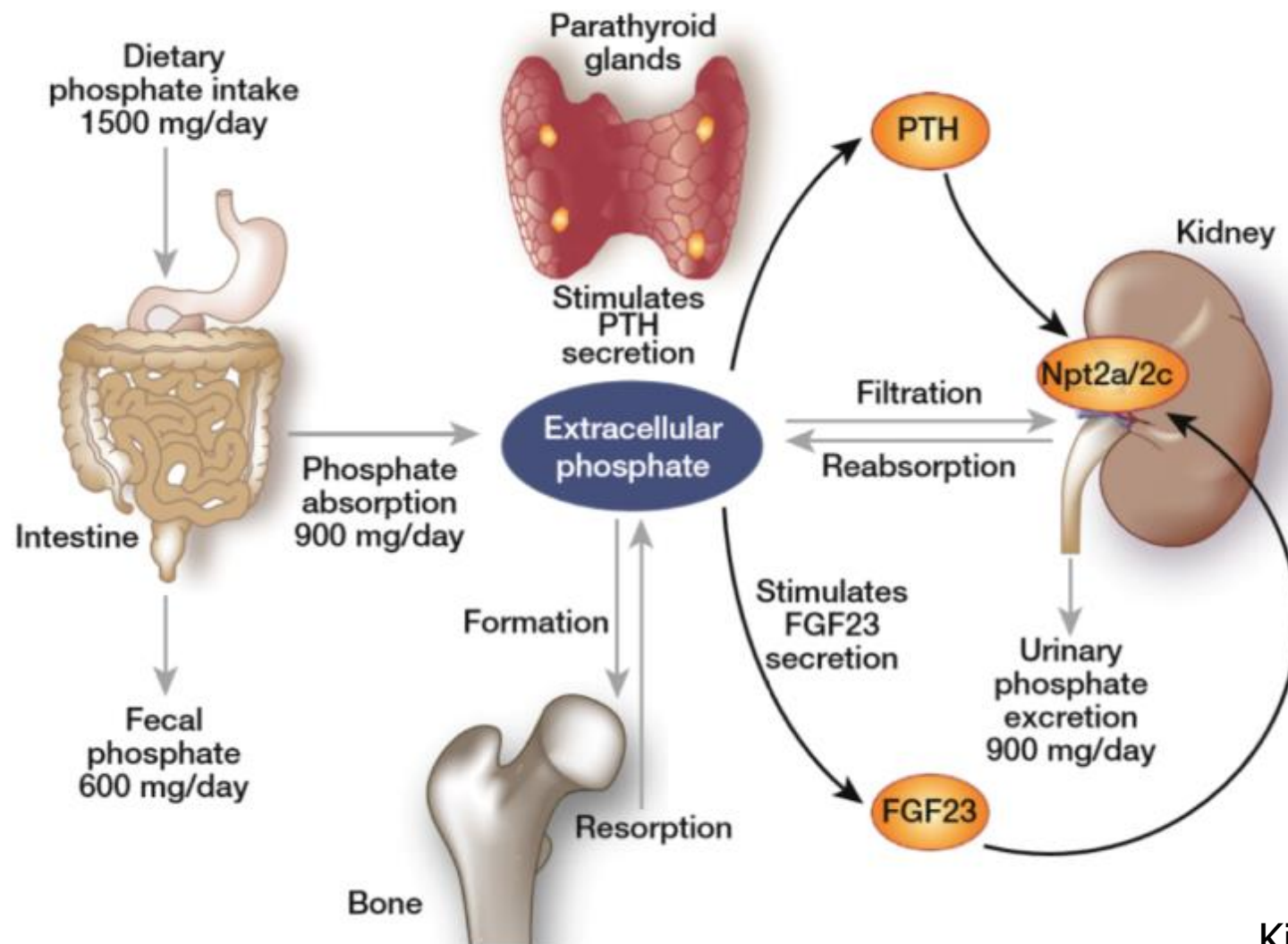
# Dietary Phosphorus

- An **essential mineral** that is a component of bones, teeth, DNA, and RNA.
- In the form of phospholipids, phosphorus is a component of cell membrane structure and of the body's key energy source, ATP.
- Plays a key role in regulation of gene transcription, activation of enzymes, maintenance of normal pH in the extracellular fluid, and intracellular energy storage.
- **85% is located in the bones and teeth**, and the other 15% is distributed throughout the blood and soft tissues.
- Phosphorus and calcium are interrelated because hormones, such as parathyroid hormone regulate metabolism of both minerals.





# Phosphorus Homeostasis



# Dietary Reference Intakes for Phosphorus

Life Stage	RDA (mg/d)	UL (mg/d)
Birth to 6 months	100*	<i>Not established</i>
7–12 months	275	<i>Not established</i>
1–3 years	460	3,000
4–8 years	500	3,000
9–13 years	1,250	4,000
14–18 years	1,250	4,000
19–70 years	700	4,000
71+ years	700	3,000

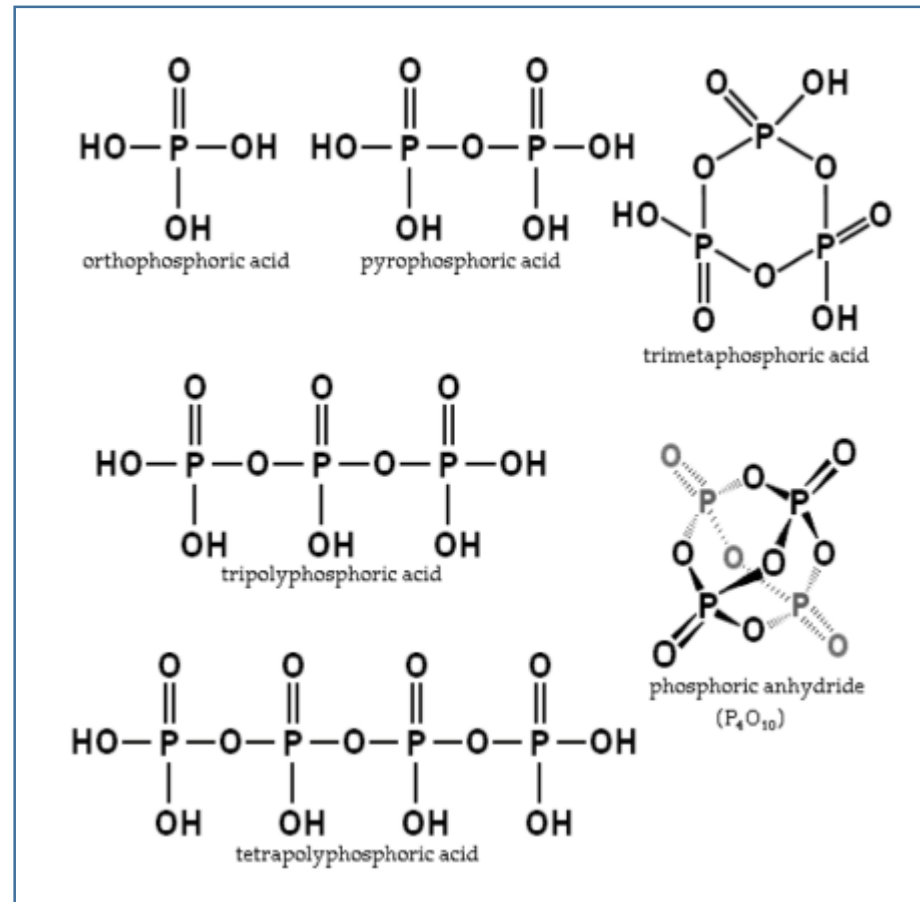
# Phosphorus – Absorption Efficiency in Humans

## Plant-Derived



**20 – 50% Absorbed**

## Inorganic Phosphate Salts



**70 – 100% Absorbed**

## Animal-Derived



**40 – 60% Absorbed**

# Key Food Sources of Phosphorus



245 mg



214 mg



178 mg



123 mg



90 mg



86 mg



60 mg



49 mg



22 mg



18 mg

# Phosphorus Intake in the United States

- **5–6% of Americans consume below the Estimated Average Requirement (EAR) for phosphorus (i.e., <580 mg/d).**
- Phosphorus intakes exceeding the tolerable upper intake level (UL) are not prevalent.
- Calcium from foods and dietary supplements can bind to some phosphorus in foods and prevent its absorption.

Phosphorus	Usual intake (mg/d)
Naturally Occurring	1295 ± 9
+ Enriched/Fortified	1326 ± 9
+ Dietary Supplements	1343 ± 9

# Phosphate Additives

- Foods with phosphate additives have an average of **67 mg more phosphorus per serving** than similar foods not containing these additives.
- The European Food Safety Authority (EFSA) re-evaluation of phosphate additives in 2019 found the contribution of added phosphates in the diet is only **about 20% of phosphorus intakes**.
- Published research over the past decade suggests that phosphate additives do not present health issues in the healthy population but may be of clinical concern among those with chronic kidney disease (CKD).

J Ren Nutr. 2013;23:265  
Semin Dial. 2013;26:54.  
J Nutr. 1996;126:1168S.

<http://www.efsa.europa.eu/en/press/news/190612>

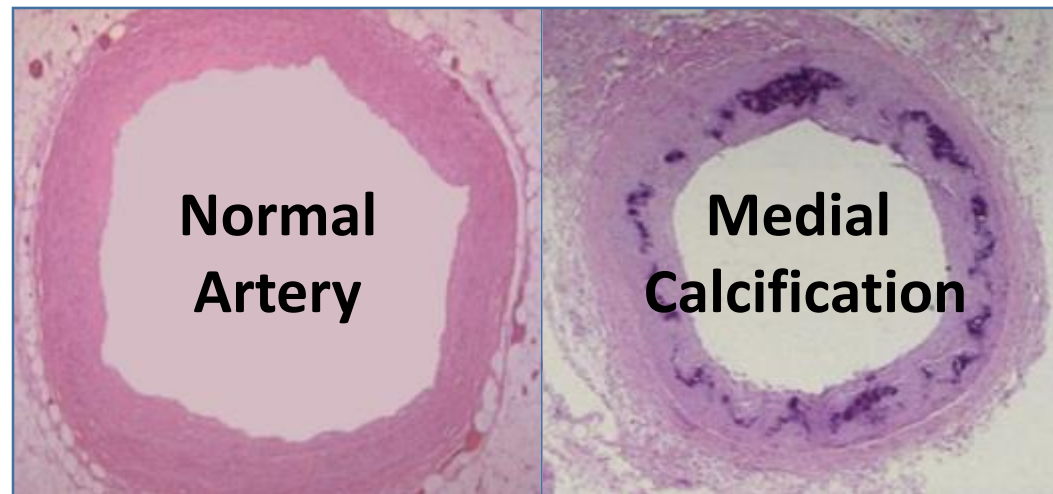
# CKD – A Deeper Dive

- **Reflects abnormal metabolism of calcium and phosphorus.**
- Nephron/glomerular loss is associated with increased glomerular capillary pressure that in turn leads to eventual sclerosis of remaining nephrons.
- Pathophysiology includes hypertension, proteinuria, diabetes, hyperlipidemia, and hyperphosphatemia (or inadequate excretion of phosphorus) with calcium phosphate deposition in the endothelium occurring as a result.



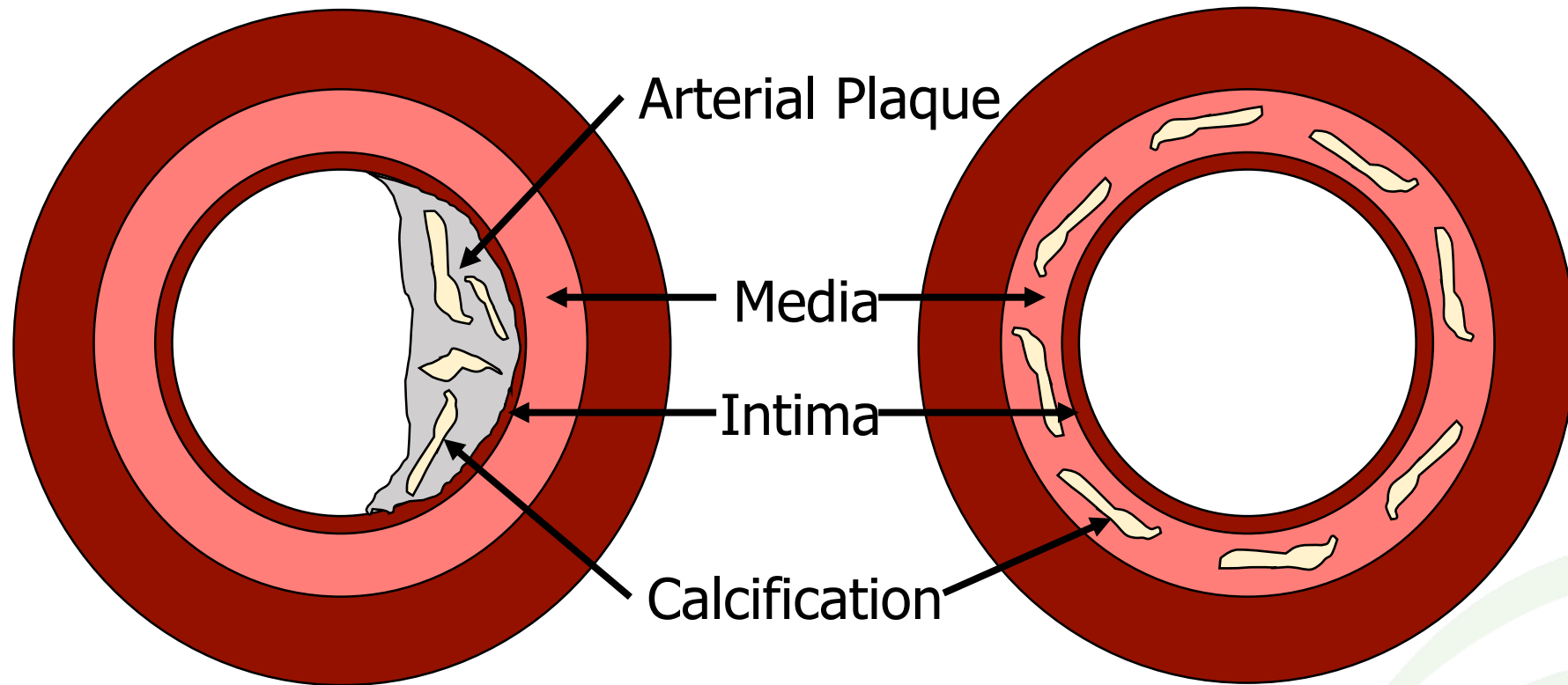
# Soft Tissue Calcification

- Vascular calcification in patients with **CKD (as well as diabetes)** occurs in the **medial layers** that causes arterial stiffness.
- **Healthy individuals with normal renal function tend to develop plaque calcification in the intima** that causes reduced vascular compliance.
- In healthy individuals, calcification occurs as a result of **local tissue factors and not circulating calcium or phosphorus concentrations**, which are under tight homeostatic control.





# Soft Tissue Calcification



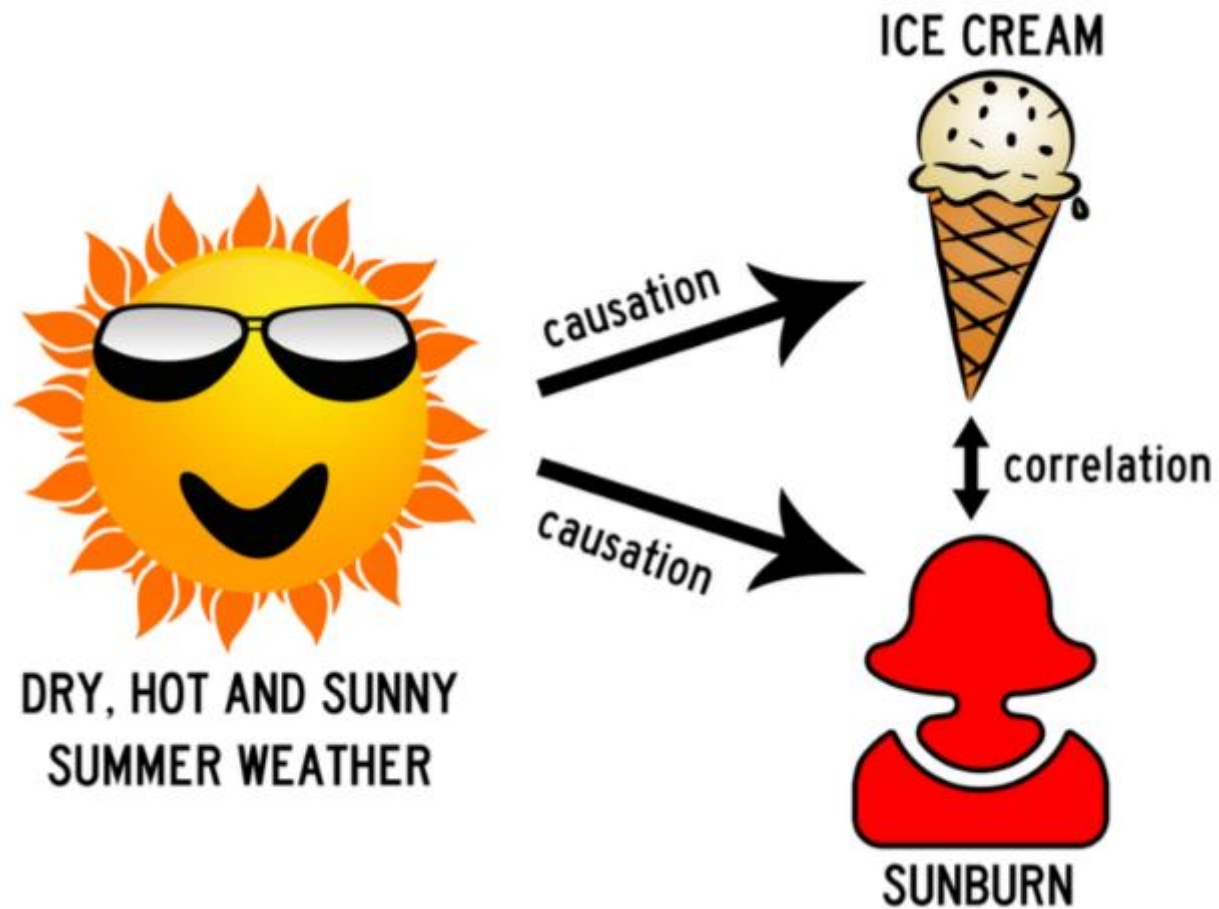
**Calcification of the Intima**  
"Healthy Adults"

**Calcification of the Media**  
"CKD"

# Patients with CKD

- Unhealthy kidneys are unable to remove phosphorus (and calcium) from the blood and excrete in the urine.
- Higher serum levels of phosphorus and other minerals (calcium, sodium, potassium) can be problematic.
- Phosphorus and other mineral intake levels should remain lower.
- A recent Cochrane Review found limited **low-quality evidence** to indicate that dietary interventions (e.g., low phosphorus/protein intake) positively effects CKD.

# Correlation vs. Causation in Nutrition Research



## Conclusion and Future Research

- More exhaustive, accurate, and quantitative reporting of phosphate additives is essential.
- Available scientific and **clinical data do not support a direct causal linkage between phosphorus or phosphate additives and disease-producing mechanisms** in humans.
- Additional research is needed to fully elucidate the pathology of CKD and the role of phosphorus.
- Large RCTs are greatly needed...

- Phosphorous is an essential mineral present in our bodies, especially for bones and teeth.
- Phosphates are salts which are very versatile and can be used in many applications with different benefits.
- Levels of phosphates used in food are small, and their use is regulated differently than in non-food applications.

## phosphatesfacts.org

## foodingredientfacts.org



# Questions – Submit in the Ask a Question Box



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Food Additives  
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Forum of the  
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