Sodium, Potassium & Phosphorus Additives: Implications in the Renal Diet

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Body function

- **Na**
  - Nerve activity
  - Muscle contraction
  - Fluid balance

- **K**
  - Nerve activity
  - Muscle contraction

- **Phos**
  - Bone mineral
  - Muscle contraction (heart)
  - Nerve signaling
Dietary Na Intake

- Western-style diet characterized by:
  - High Na
  - High sugar
  - High fat & protein from red meat
  - Refined and processed foods: 75% of Na comes from processed foods or foods eaten away from home

- Western-style diet associated with CKD
  - Fat: hyperlipidemia induced inflammation; hyperglycemia, obesity
  - Sugar: adverse metabolic effects (hypertriglyceridemia, hyperuricemia, obesity, insulin resistance) even in adolescents, HTN
  - Combination of high fat, sugar, salt promotes disease including kidney disease
    - Physiologic mechanism still being studied in animals

Na Intake from INTERMAP Study

- **US and UK**
  - Breads, cereals, grains, meats, sauces, canned items
- **Japan**
  - Soy sauce
- **China**
  - Salt added in cooking/at the table

Dietary Na Intake

- High Na intake associated with ↑disease including CKD
  - Elevated urinary Ca excretion
  - Kidney stone formation
  - Elevated BP
  - Increases oxidative stress
  - Increases urinary Alb excretion in microalbuminuric pts
  - HTN and CVD

- Lower Na intake associated with improved health (DASH diet)
  - Improved BP
  - Decreased kidney stones
  - Calcium homeostasis
Na = GRAS?

- Na is GRAS according to the FDA, but they have had second thoughts.
  - Latest effort: 2010 IOM report of strategies to reduce the Na content of processed foods.
Food Science Review

- Na/K/Phos additives used for:
  - Enhance quality, preservative (lowers water activity)
  - Enhance flavor
  - Enhance texture
  - Preference to consumer

- Na
  - Increases saltiness
  - Decreases bitterness
  - Increases sweetness

- Mg, Ca, Phos: may be added in very small amounts to table salt to prevent absorption of water and caking.

Preferences

- Removing or reducing 1 component of flavor can change the entire flavor profile
  - Ca, Mg, K: bitter, metallic after taste reported
- Salt taste sensitivity is not likely heritable, but environmental ("learned" rather than "innate")
Hidden Sodium

- Breads
- Cereals
- Muffins
- Frozen meals/products
- “healthy” foods: cottage cheese, tomato sauce, low calorie meals/products
  - Trade sugar & calories for sodium
Usual Suspects

Inconspicuous
**Sea Salt vs Table Salt?**

- By weight, there is no difference in Na content! (both ~40% Na)
- Main differences are in taste, texture and processing.
  - Sea salt: obtained through the evaporation of seawater; not processed so retains trace levels of minerals like magnesium, potassium, calcium and other nutrients; “stronger flavor” in cooking
  - Table salt: mined from salt deposits; processed
Reading Food Labels for Na

- “Low Sodium”: 140 mg Na or less
- “Reduced or Less Sodium”: 25% less Na than original
- “No Salt Added” or “Unsalted”: no Na added during processing, but does not mean Na-free
- “Lightly Salted” or “Light in Salt”: 50% less Na than original
Potassium Salts

- Add K⁺!
- May have bitter, metallic, or astringent after tastes
- Added health benefits to general public, but not CKD.
  - Salt substitutes market the benefits of K⁺ in controlling BP, preventing CVD
  - Not appropriate with kidney, heart (on heart meds), or liver disease
  - The amount of K⁺ allowed will depend on kidney function
Mineral Salt to Replace NaCl

- **Mineral salt**
  - 50% NaCl, 25% KCl, 25% Mg₄K(NH₄)₃Cl 24H₂O

- **Study in Finland** replaced mineral salt for table salt to see if dietary intake of Na could be decreased by 3–5 g and BP could be improved in the intervention group.
  - **Intervention group**: mineral salt (Smart Salt®, California)
  - **Control group**: table salt
  - 45 subjects total
  - 8 weeks long
  - Study foods included salted with table salt (control) or Smart Salt (study). Goal: reduce NaCl to 3.1–5. g (1.2–2.2 g Na); replace 60% of reg salt with Smart Salt. Both groups allowed to freely eat fruit, veggies, & dairy. Both educated on avoiding other salty foods.
  - Gathered Urine Na, K, Mg; plasma Na, K, Mg; BP; wt, ht; daily NaCl intake (diaries) at the beginning and the end

Mineral Salt to Replace NaCl

- Results: (p < 0.05)
  - Intervention group had:
    - lower NaCl intake
    - Drop in urine-Na by 2 g
    - SBP decreased by 7.5 mmHg; DBP decreased by 2.7 mmHg (vs a slight increase in SBP & DBP in control group)
    - Higher Urine-K
    - Urine-Mg trended up, but not significantly

Able to reduce SBP significantly with a reduction of NaCl by 2–3.2 g (0.8–1.2 g Na).

Improved BP may be related to lower Na + higher K & Mg

Conclusion: Replacing table salt with mineral salt may be a feasible way to help lower BP in those with mild HTN.

Salt Substitutes

- **Potassium Chloride** most commonly used
  - Nu-Salt: KCl
    - Contains no Na
    - 1/6 tsp = 530 mg K

- **Saltrite**: KCl (made in UK)
  - ¼ tsp = 780 mg K+
Salt Substitutes

- Morton’s Lite Salt: \( \frac{1}{2} \) Na than regular 
  potassium chloride
  - \( \frac{1}{4} \) tsp = 290 mg Na, 350 mg K+

- Morton’s Salt Balance: NaCl+ KCl
  - \( \frac{1}{4} \) tsp = 440 mg Na, 200 mg K+
Salt Substitutes

- **Also Salt: KCl + L-lysine**
  - $\frac{1}{4}$ tsp = 356 mg K+
  - Heinz No Salt

- **LoSalt: NaCl + KCl (made in UK)**
  - $\frac{1}{4}$ tsp = 170 mg Na, 450 mg K+
KCl as Salt Substitute
Salted vs Unsalted

Potassium content does not change! Sodium does.

Potassium: 440 mg
Sodium: 5 mg

Potassium: 170 mg
Sodium: 170 mg

Potassium: 410 mg
Sodium: 410 mg

Potassium: 170 mg
Sodium: 20 mg
No Preservatives = BEST

5 mg Na

80 mg Na

25 mg Na

0 Na, 5–10 mg K
Bone Health

- 85% P found in bones & teeth as the calcium PO4 salt hydroxyapatite.
Hyperphosphatemia & CKD

- >95% of absorbed Phos is excreted in urine
- Link between Bone Health & CVD
  - ↑Phos, ↓sCa, ↑PTH, and ↑CaxPhos are associated with CVD
  - Calcifications settle into soft tissue including the heart and blood vessels
  - Recent data show ↑Phos associated with ↑risk of CVD in those without CKD
    - Inorganic phosphate additives more detrimental vs organic phos
- Difficult to avoid processed foods
  - Expense, convenience

Organic vs Inorganic Phosphorus

- **Organic P:** found in foods rich in protein.
  - Bound to protein
  - Dairy, meat, fish, poultry
  - Legumes, nuts, seeds (in the form of phytate)
  - 40–60% absorbed in the intestine; digestibility from animal products is higher than plant proteins

- **Inorganic P:** found as a food additive in many foods.
  - Not bound to protein, are salts
  - ~100% absorbed
  - Early 1990s, contributed ~500 mg/day; today ~1000 mg/day ave American diet.

Phosphorus Additives

- Many phosphorus additives are used in today’s food supply
- Phos content can vary depending on the packaging.
  - Different manufacturers make different forms of the same brand of food/beverage
    - Bottled ice tea ingredients different than canned or plastic container of ice tea
- Nutrition labels not always accurate on websites
- Nutrition Labeling and Education Act does not require phosphorus to be included on the nutrition facts label.
- Generally recognized as safe for consumption by the general population
Phos = GRAS?

- Like Na, FDA has had second thoughts, but have not done studies recently.
- Most of the previous studies done in 1960–70s & on animals, not humans.
  - Issues associated with CVD and biological pathways unknown back then.
  - Now we know FGF23 hormone is stimulated by high phos intake and associated with CVD.
Common Phos Additives

- Dicalcium phosphate
- Disodium phosphate
- Monocalcium phosphate
- Phosphoric acid
- Potassium phosphate
- Hexametaphosphosphate
- Tricalcium phosphate
- Tripotassium phosphate
- Sodium aluminum phosphate
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<table>
<thead>
<tr>
<th>Common Uses</th>
<th>Common Foods</th>
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<tbody>
<tr>
<td>Emulsifier</td>
<td>Meats</td>
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<tr>
<td>Leavening</td>
<td>Frozen meals</td>
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<tr>
<td>Acid</td>
<td>Cereals</td>
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<tr>
<td>Stabilizer</td>
<td>Snack bars</td>
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<tr>
<td>Improve texture, color, flavor</td>
<td>Processed or spreadable cheese</td>
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<tr>
<td>Decrease cooking time</td>
<td>Instant products</td>
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<tr>
<td>Anti-caking</td>
<td>Refrigerated bakery products</td>
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<td>beverages</td>
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Phosphates added as a preservative in processed foods
  ◦ Leavening agent
  ◦ Enhance quality
  ◦ More convenient to prepare

Beverages–increased amounts of phos content
  ◦ Juice concentrate, glass bottles & cartons best vs plastic

Manufacturers not required to list phos quantities; no database that lists amounts of phos additives in foods
Hidden Phosphorus

- Leon et al. reviewed >2000 top selling grocery items for phos additives
- Matched foods containing phos additives with those not containing phos additives
- Analyzed sample meals with foods containing and not containing phos additives

Results:

- Nearly **half** of top selling products contains phos additives.
- Ave 67 mg Phos/100 g food in phos additive food vs without
- Sample meal: +736 mg/day (41% increase)

Hidden Phosphorus

- Variation of 0% canned vegetables to 72% prepared frozen foods
- Dry foods 70%; packaged meat 65%; bread/baked goods 57%; soups 54%; yogurt 51%
- Minimal difference in those with & w/out additives in breads, canned vegetables, soups
- Cost analysis: $2.00 more/day to prepare meals with additive–free foods

Hidden Phosphorus
Hidden Phosphorus

- Hawaiian Punch: 173 mg
- Coca-Cola Classic: 62 mg
- Fanta Orange: 11 mg
- Mug Root Beer: 0 mg
Hidden Phosphorus
Hidden Phosphorus

- Nestea Cool: 140 mg
- Nestea: 35 mg
- Lipton PureLeaf Green Tea: 0 mg
Same product, different formula

- No preservatives
- Na, K, Phos additives
- Na, K, Phos additives

Same brand manufactured by different companies with different formulas
Phos additives

No Phos additives
Hidden Phos in Beverages

NOT ALLOWED!
No Phos Additives Listed

ALLOWED!
Patient Perspective

- Difficult to maintain lower Na & Phos diet long-term
- Reading food labels is challenging to some
  - Low literacy handouts
  - Phos not always listed on nutrition label
General Consumer

- Difficult to lower Na & Phos additives voluntarily due to consumer preference
  - Fear of losing customers
- UK strategy: sodium reduction by stealth
  - Gradually decrease sodium in processed foods that is unnoticeable by consumers
  - Has been successful!
  - Benefit: does not rely on behavior change of consumers

Adequate energy and protein without excessive amounts of Na, K, and Phos
- Na: fresh foods
- K+: avoiding K+ salts
- Phos: more organic P vs inorganic P, less processed foods

FDA mandate for more accurate reporting of K+ and Phos

Food manufacturing & GRAS status changes
Overall Health Implications

- WHO: strong evidence for cost effectiveness of lowering Na in our diets
  - Expense of treating CVD would cost 0.3% of current cost worldwide
  - Upper daily limit 2000 mg Na (87 mmol Na)
- Hyperkalemia can be fatal.
- Phosphorus: strong implications on those with renal disease; emerging data for those without renal disease but the verdict is still out
- Best strategy: life–style change with healthy diet and exercise