Sodium, Potassium & Phosphorus Additives: Implications in the Renal Diet Marisa Juarez, MPH, RD, LD Texas Children's Hosptial

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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

Odermatt A. Am J Physiol Renal Physiol, 2011.

Gutierrez OM. Adv CKD, 2013.

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

Anderson CA etal. JAMA, 2010.

Dietary Na Intake

- High Na intake associated with 1 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.
 - Lastest 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 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.

Liem DG, et al. Nutrients, 2011.

Preferences

- Removing or reducing 1 component of flavor can change the entire flavor profile
 Ca, Mg, K: bitter, metalic 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 Nafree
- "Lightly Salted" or "Light in Salt": 50% less Na than original

Potassium Salts

- Add K⁺!
- May have bitter, metalic, 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, vegs, & 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

Sarkkinen, et al. Nutrition J. 2011.

Mineral Salt to Replace NaCl

- Results: (p< 0.05)</p>
 - 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

Sarkkinen, et al. Nutrition J. 2011.

Mineral Salt to Replace NaCl

- 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.

Sarkkinen, et al. Nutrition J. 2011.

Salt Substitutes

- Potassium Chloride most commonly used
- Nu-Salt : KCl
 - Contains no Na
 - 1/6 tsp= 530 mg K
- Saltrite: KCl (made in UK)
 ¹/₄ tsp= 780 mg K+





Salt Substitutes

- Morton's Lite Salt: ½ Na than regular potassium chloride
 - ¼ tsp=290 mg Na, 350 mg K+

- Morton's Salt Balance: NaCl+ KCl
 - ¼ tsp=440 mg Na, 200 mg K+





Salt Substitutes

- Also Salt: KCl + L-lysine
 - ¼ tsp= 356 mg K+
 - Heinz No Salt
- LoSalt: NaCl + KCl (made in UK)
 - ¼ tsp=170 mg Na, 450 mg K+





KCl as Salt Substitute







Salted vs Unsalted



440 mg K+



Potassium content does not change! Sodium does.

5 mg Na



170 mg K+

410 mg Na



20 mg Na

No Preservatives=BEST



5 mg Na



80 mg Na





0 Na, 5-10 mg K





25 mg Na



Phosphorus

- 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
 - \uparrow Phos , \downarrow sCa, \uparrow PTH, and \uparrow CaxPhos are associated with CVD
 - Calcifications settle into soft tissue including the heart and blood vessels
 - Recent data show 个Phos associated with 个risk of CVD in those without CKD
 - Inorganic phosphate additives more detrimental vs organic phos
- Difficult to avoid processed foods
 - Expense, convenience

Kemi VE etal, Public Health Nutr, 2009. Gutierrez OM. Adv in CKD, 2013.

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.

Benini etal. J Renal Nutr, 2011. Kalantar-Zadeh etal. Clin J Am Soc Nephrol, 2010.

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
- Hexametaphosphate
- Tricalcium phosphate
- Tripotassium phospate
- Sodium aluminum phosphate

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Common Uses

- Emulsifier
- Leavening
- Acid
- Stabilizer
- Improve texture, color, flavor
- Decrease cooking time
- Anti-caking

Common Foods

- Meats
- Frozen meals
- Cereals
- Snack bars
- Processed or spreadable cheese
- Instant products
- Refrigerated bakery products
- beverages

- 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

- 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

Leon J et al. J of Renal Nutrition, 2013

- 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)

Leon J et al. J of Renal Nutrition, 2013

- 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



















140 mg



35

mg

Honey Lipton

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

Girgis S, etal. Eur J Clin Nutr, 2003.

Balance

- 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 stategy: life-style change with healthy diet and exercise