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"No Need to Get Salty" Or Is There? Sodium Functionality as a Consideration in Nutrition Public Health Policy

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Abstract

Aim: Public health professionals focus on both downstream (individual) and upstream (population-level) interventions to reduce sodium consumption and prevent sodium-related chronic diseases. Effective upstream interventions specifically aimed at reducing dietary sodium intake include the implementation of comprehensive nutrition standards that restrict the amount of sodium contained in foods available for purchase. The aim of this work was to identify sought-after foods that did not meet the Philadelphia Nutrition Standards' sodium limits and reformulate those foods to be standards-compliant and consumer-acceptable. **Subject and Methods:** Two foods were reformulated for compliancy with the Philadelphia Nutrition Standards' sodium limits and consumer acceptability: the hoagie roll and soft pretzel. Reformulation included sensory testing and engaging potential manufacturing partners to investigate products' commercial potential. **Results:** While hoagie roll reformulation led to a local company manufacturing and selling the reformulated product, soft pretzel reformulation stalled due to lack of consumer acceptability of the reformulated product. Salt contributes desirable characteristics in the texture, taste, and appearance of the soft pretzel, the absence of which consumers found unacceptable. **Conclusion:** Product reformulation holds great potential to create lower-sodium foods that otherwise have all of the characteristics of the higher-sodium "original" products but requires an understanding of the role of salt in product recipes. Reducing salt without considering its multiple functions in food may result in a product that is unacceptable or even unsafe. A simple four-step tool can help public health practitioners evaluate the extent to which products are suitable for reformulation.

Keywords

Sodium Chloride, Dietary/Administration & Dosage, Health Promotion/Methods, Nutrition Policy, Food/Standards, Food Technology

1. Background

Public health professionals recognize that diets that include a large proportion of highly-processed foods are a major cause of chronic disease, and that overconsumption of high-sodium foods increases a person's risk for heart disease and hypertension [1] [2] [3] [4]. National dietary and lifestyle guidelines encourage individuals to limit their sodium intake to less than 2300 mg each day [5] [6]. Despite these recommendations, nearly 90% of the US population consumes sodium at or above the recommended level [5]. The primary sources of sodium in the US diet are ultra-processed foods and foods consumed at/from restaurants, with over 60% of calories coming from packaged food and beverages [1] [7] [8] [9] [10].

To prevent sodium-related chronic diseases, public health professionals focus on both downstream (individual) and upstream (population-level) interventions to reduce sodium consumption [11] [12]. Effective upstream interventions specifically aimed at reducing dietary sodium intake include the implementation of comprehensive nutrition standards that restrict the amount of sodium contained in foods available for purchase [11].

Comprehensive nutrition standards face two major barriers to implementation: low market-availability of compliant products, and high implementation costs in food service operations [13]. In light of these barriers, a recent systematic review of national government initiatives to reduce sodium intake reported that policies, such as comprehensive nutrition standards, are more effective when paired with one or more other strategies, such as *product reformulation* [14]. Food product reformulation presents a promising opportunity for public health professionals, research chefs, food scientists, and dieticians to collaboratively reformulate food products to meet sodium standards and affordability needs, and increase the market availability of lower-sodium foods.

This article is intended to provide background to public health practitioners on the functional properties of salt in foods, and illustrate the extent to which reformulation is possible through two cases where Drexel Food Lab attempted to reformulate culturally-appropriate and highly-desired foods that did not have nutrition standards-compliant versions on the market. It concludes with a simple four-question tool, piloted informally in these cases, that the authors propose can be used to evaluate the extent to which products are suitable for reformulation.

While it may seem simple to reduce the sodium in a recipe by merely removing a portion of the salt and sodium-containing ingredients, successful product reformulation requires an understanding of the functional role salt plays in a food product, and finding ways to get acceptable flavor, texture, stability, and appearance despite less sodium in the formula. Understanding the functional properties of salt in foods is a critical first step to successful food reformulation. **Table 1** details the many and varied functions of salt in food [15].

2. Using Sodium Knowledge in Two Food Reformulations: Materials and Methods

Since 2017, the Philadelphia Department of Public Health Division of Chronic Disease and Injury Prevention (Philadelphia Division of Chronic Disease and Injury Prevention) and Drexel Food Lab at Drexel University have worked together on food product reformulation. Drexel Food Lab convenes faculty and students in culinary arts, food science, nutrition sciences, product design, and other fields of study to conduct culinary innovation projects that promote a sustainable, healthy and equitable food system. Philadelphia Division of Chronic Disease and Injury Prevention and Drexel Food Lab work collaboratively to identify sought-after foods that do not meet the Philadelphia Nutrition Standards' sodium limits and reformulate those foods to be standards-compliant and consumer-acceptable [16].

Given the complex functionalities of salt detailed in **Table 1**, these cases from the Philadelphia Division of Chronic Disease and Injury Prevention/Drexel Food

Table 1. Functional properties of salt in food.

Function	Explanation	Example
Increases taste perceptions [16] [17]	Increases perception of desirable tastes and flavors. Suppresses bitter tastes. Can be helpful in reducing sugar.	Salted caramel
Regulates yeast [17]	Controls growth of yeast to prevent overproofing Enhances texture of baked goods.	Bread
Aids in preservation [16] [17]	Slows or stops microbial growth Contributes to formation of desirable flavors in fermentation.	Marinades and Brines
Protein Coagulation [18]	Helps adjust egg coagulation. Helps meat products retain moisture.	Lunch meat
Extends Shelf Life [18]	Inhibits microbial growth Lowers water activity Minimizes oxygen exposure to promote fermentation Inhibits growth of clostridium botulinum	Cured Ingredients like olives or anchovies

Lab collaboration illustrates why public health nutrition advocates need to be cognizant not only of the nutritional value of nutrients, but also their functional performance in food products [15] [17] [18].

2.1. Case Study 1: The Hoagie Roll

Though chefs and foodservice managers reported little trouble sourcing some Philadelphia Nutrition Standards-compliant foods, such as sliced whole grain-rich bread, it was impossible to find a compliant hoagie roll, which needed to have ≤ 290 mg sodium per serving. Hoagies, called subs or grinders in other regions, are a popular Philadelphia food, and hoagie rolls are also used in other locally-popular items like Philadelphia cheesesteaks.

Finding that no local, regional, or national bakery carried a compliant ready-to-eat, appropriately sized hoagie roll, Drexel Food Lab approached manufacturers to offer assistance in reformulating their rolls. Manufacturers claimed that existing salt ratios were critical for yeast regulation, texture, and flavor. To test this claim, Drexel Food Lab developed its own formula to demonstrate that these functional limitations could be overcome by adjusting for other factors in the baking process. For example, while salt retards yeast growth, the proofing time of the bread can be shortened to accommodate a salt reduction, providing an additional efficiency benefit to a baker. The initial recipe reduced the sodium to 250 mg per 6-inch roll, well under the nutrition standards' threshold to allow room for error and formula changes when the recipe was optimized for commercial baking machinery and standards.

Beyond the chemical function of salt in the hoagie roll, manufacturers warned that consumers would notice and reject a less salty roll. Drexel Food Lab conducted sensory tests and found that, while tasters preferred the original higher-sodium rolls to the reformulated rolls when tasted plain (not as a sandwich) side-by-side, most consumers found the roll acceptable and some did not detect a difference when they tasted the roll without the original present and when eaten in application (*i.e.* with sandwich fillings) [19]. Since hoagie rolls are nearly always consumed in application as a carrier, or a means of consuming other foods as in a sandwich, with savory fillings containing additional salt, the reduced sodium hoagie roll was acceptable. Convinced by Drexel Food Lab's initial formula and findings, a bakery in the Philadelphia region agreed to produce the reduced sodium hoagie roll at scale and is now producing over one million units annually.

In this case, reformulating hoagie rolls to contain less sodium was relatively straightforward with a few modifications to the formula and manufacturing process. This relatively minor adjustment brought the final hoagie roll formulation from 440 mg to 290 mg of sodium, a 34% reduction. Additionally, the seamless substitution of a lower-sodium roll for the "original" demonstrated the potential for broad sodium reduction to institutional buyers including public school districts.

2.2. Case Study 2: The Soft Pretzel

Pennsylvania is credited with the commercialization of the soft pretzel in the US, which are a popular Philadelphia snack [20]. Soft pretzels vary in size and shape, but are a consistently higher sodium snack that includes large crystals of coarse salt ("pretzel salt") sprinkled on top. Inspired by hoagie roll reformulation success, Drexel Food Lab reformulated this popular, but more challenging, product to meet the Philadelphia Nutrition Standards (≤290 mg sodium per serving).

The reduced-sodium soft pretzel formula met several challenges. First, as with the hoagie roll, less salt resulted in increased yeast activity, which causes an overproduction of carbon dioxide bubbles in the dough, tripling the size compared to the control during the proofing stage. Reducing the amount of yeast in the recipe controlled the size issue. However, reducing the yeast resulted in a sweeter-tasting dough, since less yeast results in more unfermented sugars. Drexel Food Lab tested salt replacement products and acids such as vinegar to balance the sweetness, but found marginal differences in the outcome and determined they were unnecessary. The final compliant dough formula resulted in a sweeter, softer, airier, and noticeably different pretzel.

Beyond the dough, the majority of sodium in soft pretzels comes from the "pretzel salt" on top. Reductions or exclusion of that salt was very noticeable to consumers: the absence of pretzel salt was a visual cue that this product was different. Unlike the hoagie roll, the soft pretzel is not eaten "in application," as a sandwich; rather it is eaten plain or with mustard. As such, the lower-sodium reformulation's diminished sensory appeal was more apparent, and ultimately contributed to low consumer acceptability. Drexel Food Lab subsequently identified a regional bakery selling a reduced sodium soft pretzel that has some of the same consumer acceptance challenges. Meanwhile, Drexel Food Lab searches for a breakthrough in its own reformulation.

3. A Four Question Tool for Evaluating Product Reformulation Opportunities

Product reformulation has great potential to reduce sodium in popular foods. Public health practitioners are encouraged to consider not only the science of the nutritional recommendation but also the science of salt's functions and opportunity for sales when identifying promising products for reformulation. While the current manuscript cannot provide an empirical conclusion or detailed analysis to the research status and development tendency of related studies, there are clear learnings that may be helpful to public health nutrition regulators and food product developers. As noted above, comprehensive nutrition standards face two major barriers to implementation: low market-availability of compliant products and high implementation costs in food service operations. By increasing supply of compliant products through reformulation, prices can be made more affordable resulting in an eased path for adoption of these products.

Based on the authors' work through these cases, we propose a simple four-step tool that can help public health practitioners evaluate the extent to which products are suitable for reformulation. This is not an empirical conclusion but rather a suggested tool for improving policy and practice. It will be applied and validated in a future study.

1) ***Are there products on the market that meet proposed sodium standards?*** While lower-sodium products are generally more available than ever before, conducting a market study of most-used food products as well as their pricing and availability for foodservice will help public health practitioners identify whether their proposed sodium standards are able to be met without reformulation.

2) ***What are salt's functions in this product? Are there reasons a sodium reduction would not be feasible?*** Referring to Table 1 as an example, it is a useful exercise to consider the implications of reducing salt in a recipe. Even prior to partnership with food scientists, public health professionals may be able to identify products that are more challenging or more amenable to reformulation based on their properties. It is also incumbent upon public health practitioners and policy-makers to bear in mind the multiplicity of functions that salt plays in food, and to understand the potential trade-offs for restricting sodium in some food products. For example, a number of commercial salt substitutes exist that can provide a salty flavor with less salt. While the use of such substitutes may be effective in reducing sodium, they may increase the price of the product, reducing its accessibility, and may result in some consumers avoiding the product if it contains an unappealing or avoidable additive.

3) ***What would the process be to reformulate this product? Beyond taste, what concerns need to be accounted for?*** Philadelphia Division of Chronic Disease and Injury Prevention was fortunate to be in the same city as Drexel Food Lab, which already specialized in product reformulation and could translate needs and values between the public health practitioners and manufacturers. While the actual reformulation of the product may take weeks or months, depending upon equipment needs and ability to conduct taste tests, getting a product manufactured could take years of relationship-building. In the example of the hoagie roll, it took nearly three years to move from idea to product on the market. Given the long-time horizon, product reformulation should be considered when the impact of reduced sodium can be maximized across many venues.

4) ***How is this product consumed in context?*** In the case of the hoagie roll, initial product evaluations and taste tests led the research group to believe that the reformulated roll would not be acceptable. But once tested in the appropriate context, as a sandwich with fillings, it was acceptable and even undetectable. The soft pretzel did not have such context, and was found not to be acceptable without the multiple attributes salt provided: texture and mouthfeel of the baked dough, and the appearance, crunch, and hit of salinity of the "pretzel salt" on top of the pretzel.

In developing this four-part reformulation evaluation tool, Philadelphia Division of Chronic Disease and Injury Prevention is more prepared to approach reformulation requests than it was at the start of its relationship with Drexel Food Lab. Clear communication and mutual understanding helps calibrate expectations regarding how much sodium can be reduced in some products, and helps public health practitioners identify areas of focus when implementing sodium-reduction standards and practices. Awareness of the complex role of salt in foods can assist public health practitioners set realistic targets in comprehensive nutrition standards, and can provide insights into identifying reformulation opportunities where collaboration with food scientists and research chefs is likely to yield successfully reformulated lower-sodium food products.

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Availability of Data and Materials

Data is available upon request.

Authors Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by JD, RS, and LM. The first draft of the manuscript was written by MR, BJM, JD, RS, and JA, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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