

An overview of sodium reduction policy in the United States and its impact on the food industry

by

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Abstract

Salt is not only essential for sustaining human life, but it is also a functional ingredient. The sodium and chloride ions are used in food products to control microbial growth that can lead to food spoilage and cause illness. Salt is also used to enhance flavor, texture, leavening, and fermentation. The human body needs only a small amount of salt to properly function. Consuming excessive amounts of sodium has been correlated to adverse health effects including cardiovascular disease, cancer and high blood pressure. Most sodium in the American diet is derived from manufactured or processed foods. Only a small portion of the salt in the American diet is from adding salt as a seasoning to prepared foods. Americans are overconsuming salt in their daily diet. Over the past fifty years, the U.S. government has established policies to help Americans reduce sodium in their diets. Federal governmental policy has been influenced by the actions of non-governmental organizations and local governments. Reducing sodium in the American diet will prevent hundreds of thousands of premature deaths and illnesses. Food manufacturers are tasked with reducing sodium in their product, without compromising the quality attributes consumers expect. There are several strategies used to remove sodium from manufactured food products and maintain functionality. These strategies include stealth reduction, adjusted processing techniques, modified salt crystal structures, and salt substitutes. Large food manufacturers have made commitments to achieve these goals. Some manufacturers have been able to achieve their commitments, while others are still in progress. Sodium reduction strategies are not a one-size-fits-all solution. Depending on the application, some strategies work better than others. Although removing sodium from the diet will benefit Americans from both an economic and public health standpoint, it will be challenging for food manufacturers.

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Chapter 1 - Salt, Society, and the Food System

Introduction to Salt

The author, a professional food scientist, has spent her first few years in the food industry working with salt. Over the past fifty years, the U.S. government has adopted sodium reduction policies to prevent the increasing number of diseases related to overconsumption of salt. In this report, the author describes consumer perceptions, the response from the food industry, and strategies to remove sodium from the American diet. Overconsumption of salt is a relevant public health concern that can be mitigated by sodium reduction strategies such as stealth reduction, modifying the salt crystal shape, and salt substitutes.

Salt is composed of sodium (Na⁺) and chloride (Cl⁻) ions joined by an ionic bond. Since the dawn of time salt has been used by the human population. Salt was used thousands of years ago to preserve food and enhance flavor (Christopher & Wallace, 2014). The composition of salt is approximately 40% sodium and 60% chloride. Today salt is still used for many applications including road deicing, water softening, chemical manufacturing, and agriculture and food processing. Though most individuals associate salt with food and agricultural uses, food and agriculture account for only three percent of the total salt used in the United States (USGS, 2019).

Salt is typically derived from one of three production methods: excavation, solution mining, or solar evaporation (Cargill, 2019a). Excavation is the process of extracting sodium chloride from underground salt deposits using mechanical methods (Cargill, 2019a). This method is most commonly used for water softening and deicing salts, but it can also be used for manufacturing food salt. Solution mining is the practice of evaporating moisture from a manufactured brine to form salt crystals (Cargill, 2019a). In the solution mining process,

freshwater is injected into an underground salt deposit (Cargill, 2019a). The freshwater dissolves in the deposit and becomes a brine (Cargill, 2019a). The brine is pumped back up to the surface, heated, and evaporated to create salt crystals (Cargill, 2019a). Solution mining is the most common practice for producing food-grade salt products, because it consistently produces high-quality salt crystals with purities ranging from 99.6% to 100% (Cargill, 2019a). Solar evaporation is the process of evaporating naturally occurring saltwater by the elements of sun, wind, and time (Cargill, 2019a). Salt produced by solar evaporation is channeled into a series of interlocking ponds (Cargill, 2019a). As the brine moves through the sequence of ponds, it continues to evaporate, forming salt crystals (Cargill, 2019a).

Salt is the main source of sodium in the human diet and is essential for sustaining human life. The sodium and chloride ions play a role in maintaining membrane potential and extracellular fluids (Silow, Axel, Zanni, & Arendt, 2016). The sodium ion is absorbed in the small intestine and is used in the absorption of amino acids, chloride ions, and glucose (Silow et al, 2016). Sodium is required to conduct nerve impulses, contract and relax muscles, and maintain the proper balance of water and minerals in the body (Harvard School of Public Health, 2019).

Sodium deficiency is uncommon in most of the United States population but can occur if an individual does not consume the suggested 500 mg of sodium per day (Harvard School of Public Health, 2019). Hyponatremia is the term used to describe abnormally insufficient amounts of sodium in the body; its symptoms include vomiting and diarrhea (Harvard School of Public Health, 2019). Hyponatremia typically occurs in older adult populations and is especially common for individuals who take medications or have health conditions that deplete the body of sodium (Harvard School of Public Health, 2019). Excessive perspiration can cause hyponatremia,

if salt is lost in fluids that are expelled from the body due to heat, stress, or other sweat-inducing circumstances (Harvard School of Public Health, 2019).

Although salt is essential for sustaining life, in excessive quantities salt has been associated with harmful diseases (Kim, Lopetcharat, Gerard, & Drake, 2012). For most people, consuming too much salt limits the efficacy of the kidneys causing excess sodium in the blood stream (Harvard School of Public Health, 2019). When sodium accumulates, the body retains water to dilute the sodium (Harvard School of Public Health, 2019). The retained water increases the amount of fluid surrounding cells and the volume of blood in the blood stream (Harvard School of Public Health, 2019). The increased blood volume requires the heart to work harder and places more pressure on the blood vessels (Harvard School of Public Health, 2019).

An excess of sodium chloride is considered a major risk factor for cardiovascular disease, stroke, heart failure, kidney failure, coronary heart disease, and premature death (Kim et al., 2012). Over time, the extra strain on the heart caused by excessive sodium intake causes the blood vessels to stiffen. The stiff blood vessels restrict blood flow, which can lead to high blood pressure, heart attack, and stroke. Positive correlations exist between increased salt intake and increased blood pressure, and the latter can be a precursor to cardiovascular disease (Kim et al., 2012).

Other health concerns caused by excessive sodium consumption include osteoporosis and stomach cancer. There is a direct positive correlation between the amount of sodium an individual consumes and the amount of calcium that leaves the body during urination (Harvard School of Public Health, 2019). Human bones will leach calcium if there is not enough present in the blood supply (Harvard School of Public Health, 2019). High-sodium diets decrease the amount of calcium in the blood stream, which can lead to the bone-thinning disease osteoporosis

(Harvard School of Public Health, 2019). Overconsumption of sodium damages the stomach lining resulting in lesions, which if left untreated can result in stomach cancer (Kim et al., 2012).

It is a common misconception that most salt in our diet is from table salt added after cooking. Dietary salt intake is derived from one of three sources: commercially prepared or manufactured foods, salt that naturally occurs in foods, and discretionary salt, which is added by the consumer after preparation (Zandastra, Lion, & Newson, 2016). Only 11% of sodium in the diets of people in the United States is attributed to table saltshakers (Kim et al., 2012).

Understanding individuals' salt consumption is imperative to reducing total sodium intake. The majority of salt intake lies in commercially prepared and manufactured foods (Zandstra et al., 2016). The data from the 2003-2006 National Health and Nutrition Examination Surveys (NHANES) suggest that 63% of sodium intake comes from foods eaten at home, and 37% from foods eaten away from home (IOM, 2010). It is a common misconception that foods prepared in the home contain less sodium than foods prepared outside the home. Both channels make a significant contribution to total sodium intake. In 2012, the Centers for Disease Control and Prevention (CDC) named the top sources of sodium in the diet: bread and rolls, cold cuts/cured meat, pizza, poultry, soups, sandwiches, cheese, pasta dishes, meat dishes, and snacks (CDC, 2012). Many of these top sources of sodium can be prepared in the home and be eaten multiple times a day. By acknowledging that 63% of sodium intake comes from foods eaten at home, policy makers can target manufacturers of packaged foods. An individual may mistakenly reason that he or she is consuming a healthy at-home meal that is supposedly low in sodium, when it is not.

Functionality of Salt

Salt is a food additive that enhances food safety by either destroying or limiting the growth of food-borne pathogens or spoilage organisms (IOM, 2010). Few foods today are solely preserved by the addition of salt. Reducing the sodium content is not a food safety or spoilage concern for these foods with additional preservatives because they have additional antimicrobial properties that protect the product from harmful bacteria. These foods include frozen products, products that are sufficiently thermally processed to destroy pathogenic organisms, acidic foods (pH < 3.8), and foods in which water activity remains low when sodium is removed (IOM, 2010).

It is difficult to remove salt from some commercially prepared and manufactured foods, because salt plays a crucial role in microbial stability (Kim et al., 2012). Certain pathogens have the potential to grow more rapidly in foods with reduced salt and sodium-containing ingredients, such as baking soda (IOM, 2010). These pathogens include *Listeria monocytogenes*, *Clostridium botulinum*, *Bacillus cereus*, *Staphylococcus aureus*, *Yersinia enterocolitica*, *Aeromonas hydrophila*, *Clostridium perfringens*, and *Arcobacter* (IOM, 2010). It is important to note which pathogens may thrive when salt is removed. For example, when the United Kingdom began its sodium reduction efforts in chilled, ready-to-eat foods, a cited increase in the number of *L. monocytogenes* outbreaks occurred (IOM, 2010).

The sodium ions in salt are positively charged, and the chloride ions are negatively charged. When sodium chloride encounters water, disassociation occurs until no available hydrogen atoms remain available in the water (Christopher & Wallace, 2014). One way to determine the impact of removing salt from a food product is to determine the water activity (Christopher & Wallace, 2014). Water activity is the amount of available water present in a food

product. Most food pathogens will flourish in conditions where the water activity level is above 0.90 (Christopher & Wallace, 2014). If salt is removed from a product that has an initial water activity above 0.90, additional microbial hurdles will need to be considered (Christopher & Wallace 2014).

Salt plays a vital role in the fermentation of products such as pickles, sauerkraut, cheese and fermented sausage (IOM, 2010). During the fermentation process, salt favors the growth of salt-tolerant bacteria while inhibiting the growth of undesirable spoilage bacteria (IOM, 2010). In the process of fermenting vegetables, salt draws water and sugar out of the plant (IOM, 2010). Salt also aids in fermentation by filling any air pockets present in the fermentation vats (IOM, 2010). The salt reduces the oxygen in the fermentation vat which supports the growth of the required lactic acid bacteria (IOM, 2010). A method known as dry salting is used in cheddar cheese production to control the production of lactic acid by the activity of the starter culture (Hystead, Diez-Gonzalez, & Schoenfuss, 2013).

Today the food industry is examining cost-effective strategies for removing sodium from processed foods. However, salt is an inexpensive ingredient; to maintain a quality product and prevent microbial growth without salt, the product will likely need to be reformulated with more expensive hurdles such as temperature control or additional additives (IOM, 2010). Additionally, salt will also affect the product quality. Salt has a functional role that can be seen by the naked eye, such as foaming and leavening (Busch, Yong, & Goh, 2013). It also has functional roles that can be seen only at the microscopic level, such as gel and crystal networks (Busch et al., 2013).

Chapter 2 - A Synopsis of Sodium Reduction Milestones in the U.S.

Federal Governmental Milestones in Sodium Reduction Policy

The direct correlation between harmful diseases and sodium intake is alarming. The U.S. government recognizes these correlation and has established sodium reduction policies. This section outlines milestones in sodium reduction policy from the federal government, as well as the influence the non-federal government had in establishing federal sodium reduction policies.

Although salt has featured in American diets for centuries, the U.S. government began developing policies around salt in 1958 (FDA, 2019a). On December 9, 1958 the U.S. government published in the *Federal Register* the first list of substances that are generally recognized as safe (GRAS), which is now referred to as the GRAS List (FDA, 2019b). This list can be found in Parts 182, 184, and 186 of the *Code of Federal Regulations* (FDA, 2019b). The first GRAS list included about 200 substances and now includes hundreds of substances ranging from food additives to substances added to food packing (FDA, 2019b). Some food ingredients may forgo the GRAS approval process, because these ingredients are considered common food ingredients. The Food and Drug Administration Commissioner regards common food ingredients such as salt, pepper, vinegar, and baking powder are generally recognized as safe when used for their intended purpose, and recognizes their use in accordance with good manufacturing practices (21 CFR 170.35).

On October 30, 1969 President Richard Nixon requested the FDA complete an exhaustive evaluation of the safety of GRAS food substances (FDA, 2019c). As a result, on March 28, 1972, the Life Sciences Research Office (LSRO) of the Federation of American Societies for Experimental Biology (FASEB) summarized the available scientific literature and

determined appropriate restrictions should be established to ensure the GRAS substances are safe food ingredients (FDA, 2019c). The LSRO appointed qualified scientists to the Select Committee on GRAS Substances (SCOGS). Members of SCOGS independently reviewed and evaluated the available information on GRAS substances (FDA, 2019c). In 1972, the FDA established the concise rulemaking procedure (21 CFR 170.35), titled affirmation of generally recognized as safe (GRAS) status (FDA, 2019c). The GRAS Affirmation procedure allows individuals to petition the FDA to review the GRAS status of a substance not being considered as part of the agency's GRAS review (FDA, 2019c).

In 1978, the Center for Science in the Public Interest (CSPI) filed a citizen's petition to the FDA to revoke the GRAS status of salt (HHS & FDA, 2007). A safety review of sodium and potassium chloride was completed by SCOGS in 1979 (HHS & FDA, 2007). The FDA received a report from SCOGS, entitled "Evaluation of the Health Aspects of Sodium Chloride and Potassium Chloride as Food Ingredients." In summary, this report stated that sodium chloride is an essential constituent of the body, is present in many foods, and is therefore difficult to recommend an optimal level of intake for, because required levels can fluctuate based on a person's individual needs (FDA, 1982). This report also concluded, there was insufficient evidence to determine if current levels of sodium chloride cause harmful health effects (HHS & FDA, 2007). However, the report recommended the development of guidelines for restricting the amount of salt in processed foods and adequate labeling of salt content in foods (HHS & FDA, 2007).

The FDA denied the CSPI citizen petition to revoke GRAS status of salt in a letter from Joseph P. Hile, Associate Commissioner for Regulatory Affairs, dated August 18, 1982 (HHS & FDA, 2007). The denial letter stated salt would remain in section 182 of the ON CFR (HHS &

FDA, 2007). This letter also stated that mandatory labeling for all processed foods was not justified (HHS & FDA, 2007). The letter also suggested a new proposed rule FDA declaration of Sodium Content of Foods and Label Claims for Foods on the Basis of Sodium Content would affect approximately one-third of all processed foods at that time (HHS & FDA, 2007).

The proposed rule “Declaration of Sodium Content of Foods and Label Claims for Foods on the Basis of Sodium Content” was published in the *Federal Register* on June 18, 1982 (FDA, 1982). This proposed rule suggested amending the food labeling regulations to include the terms “sodium free,” “low sodium,” “moderately low sodium,” and “reduced sodium” (FDA, 1982). This rule was proposed to allow for the proper use of these terms in food labeling, and to provide the inclusion of potassium content information in the nutrition labeling format on a voluntary basis (FDA, 1982). Additionally, this rule provided guidelines for appropriate use of terms such as “without added salt,” and “no salt added,” and specified sodium content of foods must be included in necessary nutrition labeling information (FDA, 1982).

In 1981, the CSPI filed a second citizen petition requesting the U.S. government take additional measures to reduce sodium consumption by requiring warning labels on packages of salt weighing half an ounce or more (HHS & FDA, 2007). The FDA denied this petition in a letter dated October 7, 1982 from Joseph P. Hile (HHS & FDA, 2007). In the denial letter, the FDA stated that an isolated warning appearing on one class of food products would be inappropriate because many foods contribute to an individual’s sodium intake (HHS & FDA, 2007). During this time the FDA encouraged food manufacturers to voluntarily reduce the amount of added salt and other sodium-containing ingredients in processed foods (HHS & FDA, 2007).

The CSPI was disappointed by the FDA's failure to take action on their first citizen's petition that sought to reclassify the GRAS status of salt and sued the agency in 1983-1984 (HHS & FDA, 2007). On June 11, 1984 the case "Center for Science in the Public Interest v. Novitch, Food, Drug, and Cosm. L. Rep." took place in the United States District Court of the District of Columbia (HHS & FDA, 2007). On June 11, 1984 CSPI argued that the FDA's denial of its petition was subjective and unreasonable because it violated the FDA's procedures for reviewing substances on the initial GRAS list (HHS & FDA, 2007). The CSPI also argued that the FDA's decision to defer any changes of salt regulations resulted in delays which violated the Administrative Procedures Act (5 U.S.C. 706(1)) (HHS & FDA, 2007). The district court concluded that the FDA's decision to defer revision in the GRAS status was rational and that the FDA did not unreasonably delay reconsideration (HHS & FDA, 2007). The CSPI did not appeal this ruling (HHS & FDA, 2007).

The FDA continued to make progress on sodium labeling. On April 18, 1984, the FDA established the definitions in 21 CFR 101.13 for terms related to sodium content such as "sodium free," "low sodium," and "no added salt" (HHS & FDA, 2007). The FDA later revised and re-designated 21 CFR 101.13 as nutrient content regulations and added a clause in 21 CFR 101.56 to include "light" and "lite" on January 6, 1993 (HHS & FDA, 2007). President George H.W. Bush signed the Nutrition Labeling and Education Act (NLEA) on November 8, 1990 (Porter, 1992). The NLEA changed the list of nutrients that must appear on the nutrition label to focus on those of primary public health concern and required nutrition information to appear on packaged and bulk foods with few exceptions (Porter, 1992).

In response to the NLEA, the FDA published sodium labeling regulations in the Federal Register on January 6, 1993 (HHS & FDA, 2007). Before NLEA, the law required sodium to be

labeled on a product's nutrition label in milligrams (Porter, 1992). Some proposed regulations included requiring nutrition labeling of sodium content on nearly all processed food products and the establishment of a reference value or "Daily Value" (DV) for sodium (HHS & FDA, 2007). Another proposed regulation would establish a health claim regarding low sodium diets and reduced risk of hypertension (HHS & FDA, 2007). On May 10, 1994, the FDA published regulations requiring that foods labeled as "healthy" contain less than the specified amounts of certain food components, including sodium (HHS & FDA, 2007).

CSPI filed a citizen's petition for the third time on November 8, 2005 (HHS & FDA, 2007). This petition requested the agency take regulatory action by initiating a policy to revoke the GRAS status of salt, amend prior sanctions regarding salt, and require food manufacturers to reduce sodium in all manufactured foods (HHS & FDA, 2007). The petition also requested the FDA require a health message on retail packages of salt that were one-half ounce or larger, reduce the DV for sodium from its current level of 2,400 mg/day to 1,500 mg/day, and take action to reduce the amount of sodium in processed foods sold directly to restaurants (HHS & FDA, 2007). The FDA issued a tentative response to the CSPI petition in 2006, stating that they needed more information before providing a final response (HHS & FDA, 2007).

In the 2005 petition, CSPI cited the Dietary Guidelines for Americans. The United States Department of Health and Human Services (HHS) and the United States Department of Agriculture (USDA) have published the Dietary Guidelines for Americans every five years since 1980. Salt was first mentioned in these guidelines in 1995 with language stating "Choose a diet moderate in salt and sodium" (ODPHP, 2019a). When the guidance was updated in 2000 it stated "Choose and prepare foods with less salt" (ODPHP, 2019b). The 2005 Dietary Guidelines for Americans publication was more specific than previous years, and stated that consumers

should not only choose and prepare foods with little salt, but also consume potassium-rich foods, such as fruits and vegetables (ODPHP, 2019c). The 2005 Guidelines also stated that Americans should consume less than 2,300 mg (approximately 1 tsp of salt) of sodium per day and Americans with hypertension should aim to consume no more than 1,500 mg of sodium per day, and consume the potassium recommendation of 4,700 mg/day (ODPH, 2019c).

On October 23, 2007, the FDA published its announcement of a public hearing concerning the FDA's policies regarding salt and sodium in food (HHS & FDA, 2007). At this time, the FDA also announced the agency would be accepting comments regarding the 2005 citizen petition submitted by CSPI requesting that the FDA (1) make changes to the regulatory status of salt, (2) require limits on salt in processed foods, and (3) require health messages related to salt and sodium (FDA, 2007). The CSPI stated approximately 200 comments were submitted, many of which supported CSPI's requested action or similar regulatory actions (CSPI, 2019).

In response to the FDA hearing in 2007, the Institute of Medicine (IOM) published a report "Strategies to Reduce Sodium" in 2010. A 14-member committee was formed to compose the report and provide the IOM with candid and critical comments (IOM, 2010). The committee was asked to make recommendations for additions to the 2005 Dietary Guidelines for America about various means that could be used to reduce sodium intake which was a recommendation of 2,300 mg/day at the time (IOM, 2010). The committee examined efficacy of the outcomes of past and current efforts to reduce sodium intake and recommended the FDA set mandatory national standards for sodium content in foods (IOM, 2010). The strategies recommended by the committee were to include actions by food manufacturers, government approaches such as regulations and legislation, and public and professional outreach and education (IOM, 2010).

After reviewing the 2010 IOM report, the FDA published “Approaches to Reducing Sodium Consumption: Establishment of Dockets” on September 15, 2011 in the *Federal Register*. The FDA and Food Safety and Inspection Service wanted to establish dockets to provide interested individuals the opportunity to submit comments, research data, and other information that would help the agencies better understand the current and emerging practices used by the food industry (FDA, 2011). The establishment of dockets would help the agencies to better grasp current consumer understanding of the role of sodium in chronic illnesses such as hypertension. The dockets also provided the agencies insights on sodium consumption practices and issues associated with the development of targets for sodium reduction in foods (FDA, 2011). In theory, the establishment of these dockets would assist lawmakers in establishing policies to reduce sodium in the American diet.

The year 2010 had a significant impact on sodium reduction policy with the passage of The Healthy Hunger-Free Kids Act on December 13, 2010. This legislation reauthorized many child-nutrition programs including School Lunch and Breakfast programs, Special Supplemental Nutrition Programs for Women, Infants and Children (WIC), the Child and Adult Care Food Program (CACFP), the Summer Food Service Program, the After School Meal program, and the Supplemental Nutrition Assistance Program Education (SNAP-Ed) (USDA, 2013). These programs targeted sodium reduction in federal school meals and provided the necessary funds and resources to help achieve such goals (USDA, 2013). Prior to this legislation, schools were not required to adhere to a federal standard for sodium targets in the School Lunch and Breakfast Program. In 2010, the Office of Disease Prevention and Health Promotion launched the Healthy People 2020 initiative (ODPHP, 2019d). Healthy People 2020 was created to provide science-based objectives for Americans and establish benchmarks and monitor progress over time

(USDA, 2013). One of the ODPHP's specific goals was to help Americans limit their sodium consumption (ODPHP, 2019d).

The influence of non-federal government legislation in Sodium Reduction Policy

The city of New York played an instrumental role in drawing awareness to the public health need for reducing sodium in the American diet. In 2009, the city of New York initiated the National Salt Reduction Initiative (NSRI) which is now the National Salt and Sugar Reduction Initiative (NSSRI) (NYC, 2019). This initiative was formed in partnership with over 100 organizations and health authorities from across the country (NYC, 2019). On April 26, 2010, New York Mayor Bloomberg, Deputy Mayor Gibbs, and Health Commissioner Farley announced the first companies to commit to the National Salt Reduction Initiative (NYC, 2019).

On October 8, 2014, the city of New York wrote a letter to Sylvia Burwell, the Secretary of the United States Department of Health and Human Services (NYC 2019). The letter was signed by 31 state and local health agencies and organizations urging the federal government to take federal action toward reducing sodium (NYC, 2019). New York City continued to take action to reduce sodium by requiring warning labels next to food menu items containing high levels of sodium (NYC, 2019). The NYC rule applies to all food establishments that require a Health Department Permit and are part of a chain (NYC, 2019). The rule went into effect on December 1, 2015 and violations were issued starting June 6, 2016 (NYC, 2019). Two days after the New York City sodium warnings went into effect, the National Restaurant Association sued NYC, citing the rule as costly, arbitrary, and unnecessary (CSPI, 2019). In 2016, the National Restaurant Association appealed the New York State Supreme Court's decision on warning labels, ultimately putting enforcement on hold (CSPI, 2019). Later in 2016, the battle between

the state of New York and the National Restaurant Association continued when the request for a preliminary injunction by The National Restaurant Association was denied by the Appellate Division of New York State's Supreme Court (CSPI, 2019). In 2017, the Appellate Division of the New York State Supreme Court ruled that sodium warnings must stay on restaurant menus. The National Restaurant Association eventually dropped its suit (CSPI, 2019).

On October 8, 2015, CSPI sued the FDA for failure to act on a 10-year old citizen petition from 2005 (CSPI, 2019). CSPI argued the FDA had failed to take action toward reducing salt in the food supply and that the lack of action resulted in thousands of preventable deaths each year (CSPI, 2019). On June 2, 2016, the *Federal Register* finally published "Draft Voluntary Sodium Reduction Goals: Target Mean and Upper Bound Concentrations for Sodium in Commercially Processed, Packaged, and Prepared Foods" (FDA, 2016). The language in this guidance described voluntary short-term and long-term goals for sodium reduction in a variety of commercially processed, packaged, or prepared food categories (FDA, 2016). These published goals aimed to reduce sodium in the current population and promote improvements in public health (FDA, 2016). The FDA specifically stated its intention was not to conduct a rulemaking on sodium reduction, but rather to provide voluntary guidelines (FDA, 2016). Although not mandatory, the FDA believed that these voluntary goals could be an effective means to benefit public health (FDA, 2016).

These proposed FDA guidelines were intended to increase the amount of food choices for consumers looking to follow a diet consistent with the 2015-2020 Dietary Guidelines for Americans (FDA, 2016). The FDA stated that the proposed Draft Voluntary Sodium Reduction Goals are aligned with the 2015-2020 Dietary Guidelines for Americans and Healthy People; they recommended Americans consume less than 2,300 mg of sodium per day (FDA, 2016).

These guidelines are category-specific in order to focus on the total amount of sodium in a food product rather than an individual sodium-containing ingredient (FDA, 2016). The proposed Draft Voluntary Sodium Reduction Goals do not recommend specific methods and technologies for reducing sodium in food products, nor do they recommend how much of each sodium-containing ingredient should be used to achieve the proposed targets (FDA, 2016). These targets are not intended for foods that inherently contain sodium (such as milk) and do not address the reality that individuals may add additional sodium to their food products by choice (FDA, 2016).

The Draft Voluntary Sodium Reduction Guidelines consider the many functions of sodium in food (FDA, 2016). The FDA acknowledges that the functionality of salt plays a crucial role in the taste, texture, microbial safety, and stability of food and therefore a one-size-fits-all solution for sodium reduction does not exist (FDA, 2016). Recognizing that more than 75% of the total sodium consumption in the American diet is derived from commercially processed and packaged foods, the FDA selected sixteen overarching categories of processed food products with individual targets for approximately 150 subcategories of foods (FDA, 2016). These categories included dairy cheese, fats/oils/dressings, fruits/vegetables/legumes, nuts/seeds, soups, sauces, gravies, dips/condiments, cereal, bakery products, meat/poultry, fish/seafood, snacks, sandwiches, mixed ingredient dishes, salads, other combination foods, and baby/toddler foods (FDA, 2016). When determining the proposed targets, the FDA weighted the sodium values of each food by sales volume to establish baselines that are more representative of the sodium in the food supply that makes the greatest impact on the population.

The baseline sodium targets for the approximately 200 subcategories were determined based on the food labeling and restaurant nutrition data from 2010 (FDA, 2016). The baseline was included to serve as a starting point for measuring sodium levels in the food supply and for

crediting companies on sodium reduction progress already made (FDA, 2016). The targets were established so as to apply to their respective food categories in the entirety of the food supply and were not tied to any one manufacturer's portfolio (FDA, 2016). However, the targets could be used as a tool for food manufacturing companies to measure their own progress (FDA, 2016).

In the Draft Guidelines, the FDA listed the upper-bound sodium concentrations for each food category including both the short-term and long-term concentrations (FDA, 2016). Food manufacturers had two years, between 2016 and 2018, to achieve the short-term concentration goals (FDA, 2016). For the long-term concentration goals food manufacturers had ten years to achieve the proposed sodium reduction targets (FDA, 2016). The upper-bound sodium concentration goals differed from the target mean concentrations because they could be applied to every individual product in any given category, whereas target mean concentrations only applied to each food category as a whole, as opposed to each individual food item (FDA, 2016). These proposed guidelines caused the food industry to evaluate the sodium concentration of processed food products and put pressure on manufactures to comply with the voluntary guidelines.

Economic Impact of Sodium Reduction Policy

The public health issue associated with excessive sodium intake is serious, directly affects large numbers of people, and is associated with high healthcare and quality-of-life costs. In a world where cost drives most decisions, it is important to evaluate the financial efficacy of the proposed sodium reduction policies. The direct relationship between sodium intake, blood pressure, and cardiovascular disease risk has sparked the interest of many researchers resulting in several cost-effectiveness analyses.

In 2009, Danaei et al. concluded that two of the highest risk-factors in the United States that result in the greatest number of deaths are smoking and high blood pressure and are responsible for approximately 395,000 deaths annually. They estimate that reducing sodium in the United States could prevent more than 100,000 deaths annually (Danaei et al., 2009). Compared to other dietary risk factors such as low omega-3 fatty acids, high trans fatty acids, alcohol use, low intake of fruits and vegetables, and low polyunsaturated fatty acids (as an indicator of high saturated fat intake), high dietary sodium has been associated with more deaths than any other single dietary factor (Danaei et al., 2009).

According to a study conducted by Palar and Sturm (2009), reducing the average population sodium intake to 2,300 mg/d from current intake levels could potentially reduce cases of hypertension by 11 million saving approximately \$18 billion in health-care dollars. This would result in a gain of 312,000 quality adjusted life-years that are worth \$32 billion annually (Palar & Sturm, 2009). A similar study was conducted by Smith-Spangler et al. in 2010 and suggests that by decreasing the average sodium intake by 9.5 percent for the population America would prevent 513,885 strokes and 480,358 myocardial infarctions over the lifetime of adults currently aged 40–85 years, saving \$32.1 billion in medical costs (IOM, 2010).

In a study conducted by Pearson-Stuttard et al. (2018) in an optimal scenario the sodium-reduction policies currently in place by the FDA would result in a \$31 billion reduction in total net costs by the year 2036. The more pessimistic scenario would yield an approximate \$9.7 billion reduction which is about one-third of the savings (Pearson-Stuttard et al., 2018). It is estimated that more than 95% of the policy costs would be attributable to the industry cost of reformulation and less than 5% would be attributable to government costs (Pearson-Stuttard et al., 2018). In both scenarios, optimistic and pessimistic, the largest health-related cost savings

would be generated from hypertension medical and productivity costs (Pearson-Stuttard et al., 2018).

Chapter 3 - Sodium Reduction Policy and the Food Industry

The Food Industry's Response to Sodium Reduction

The sodium reduction policies adopted by the U.S. government have a direct impact on food manufactures and consumers. This section examines how consumers and food manufacturing leaders have responded to the changes in sodium reduction policy. Removing salt can create a multitude of challenges. This section discusses strategies used remove salt, while still maintaining food safety and quality.

Food manufacturers play an essential role in reducing the American population's sodium intake. It is imperative that these manufacturers reduce sodium in their product line portfolios, so that most consumers can reduce their personal sodium intake. Many large food manufacturers have made commitments to reduce sodium in their products, especially if their products are among those called out in the proposed dietary guidelines. These companies include Nestlé, Mars, Walmart, PepsiCo, General Mills, and Unilever.

Nestlé announced their sodium reduction commitment in 2005. Since then, Nestlé has continued to improve their sodium reduction commitments by aligning with the recommendations set by the World Health Organization (WHO) (Nestlé, 2017). Nestlé aims to reduce the sodium added to products that are not compliant with the WHO recommendations by an average of 10% of the total sodium content between 2017 and 2019 (Nestlé, 2017). The Mars corporation set sodium reduction goals to reduce total sodium in their product portfolio by 25% between 2007 and 2012 (Mars, 2019). The company is going above and beyond these targets and aims to reduce sodium by an average of 20% across their entire product portfolio by 2021 (Mars, 2019).

Between 2009 and 2019, Walmart decreased the amount of sodium their product portfolio by 16% (Walmart, 2019). They made an official commitment in 2011 to reduce sodium in their products by 25% (Walmart, 2019). Walmart made significant strides by reducing sodium 13% across the commercial bakery category between 2008 and 2011 (Walmart, 2019). The Bentonville, AR-based company estimates this is equal to eliminating more than 1.5 million pounds of salt from the grocery baskets of their shoppers (Walmart, 2019).

PepsiCo has committed to reducing salt in three-fourths of its global food portfolio by 2025 (PepsiCo, 2019). The company's goal is to produce food products with 1.3 milligrams of sodium or less per calorie (PepsiCo, 2019). In 2018, PepsiCo reported that 58% percent of their food volume across their top twenty-three global markets, which represents 89% of their global food volume (PepsiCo, 2019). PepsiCo also has formed an agreement with Partnership for a Healthier America (PHA), an organization that works with the private sector to help improve the health of youth in the United States (PepsiCo, 2019). As part of their agreement PHA conducts an independent review of PepsiCo's progress against their sodium goal (PepsiCo, 2019). On December 15, 2015 General Mills reported on progress it had made towards its stated commitment to reduce sodium by 25% across 10 key United States retail product categories by the end of 2015 (General Mills, 2015). The company had met or exceeded its stated goal in seven of ten categories with reductions across the categories ranging from 18 to 35% (General Mills, 2015). The three categories that didn't make their stated targets were ready-to-serve soups, Mexican dinners, and cereals (General Mills, 2015). The company has not released a statement indicating whether they will revisit the three unmet sodium reduction goals.

In 2003, Unilever created its Nutrition Enhancement Program, which it states is continuously assessed (Unilever, 2019). As part of the program, Unilever set to reduce salt levels

in their products to an interim target of no more than 6 grams of salt per day, requiring up to 25% salt reductions (Unilever, 2019). By the end of 2010, Unilever achieved their target and set a goal to reduce salt in 70% of the foods in their portfolio to meet their target of no more than 5 grams of salt per day (Unilever, 2019). Unilever's policy states the company is supportive of salt reduction strategies in which government agencies, NGOs, academics, media, and the food industry collaborate where necessary to develop food reformulation programs (Unilever, 2019). Unilever supports many programs including those with gradual reduction, consumer awareness/education campaigns, and external monitoring practices put in place and led by government agencies (Unilever, 2019). Most of these large food manufacture made commitments to reducing sodium in their food products prior to the voluntary guidelines from the FDA. However, it could be argued that the voluntary guidelines influenced these large food manufacturers to set greater sodium reduction goals to remain competitive.

Consumers' Response to Sodium Reduction

By identifying consumer perceptions, we can gain insight into how sodium reduction is impacting consumers. For food manufacturers, understanding how consumers perceive nutrition labels is important, because labels can impact consumer purchasing decisions. If claims made on the nutritional label are negatively impacting the consumer's decision to purchase a low-sodium product, they may not be worth calling out. On the other hand, if claims made on the nutritional label are positively impacting the consumer's decision to purchase a product, it may incentivize manufactures to meet their sodium reduction goals.

In 2012, Kim et. al conducted a study to characterize consumer knowledge and awareness of sodium and salt reduction in foods. This study revealed that consumers with a general

understanding of how much sodium is typically in a product were accurately able to predict the salt taste (Kim et al., 2012). This is important because it shows consumers have expectations for salt flavor in food products. In this same study, consumers were asked if they frequently read nutritional labels (Kim et al., 2012). Results found that both frequent label readers and non-label readers felt a label must have the salt content listed (Kim et al., 2012). Sodium content was one of the few items that could negatively impact the satisfaction of consumers who rarely read nutritional labels (Kim et al., 2012). This study also found that more than 75% of consumers answered that reduced and low-sodium claims would positively influence purchase intent, but only 52% of consumers responded that salt-free would positively influence purchase intent (Kim et al., 2012).

Liem, Aydin, and Zandstra (2012) found that soup labeled “Now with reduced salt”, decreased perceived salt intensity of soup, even though all the soups in the study had the same salt content (Zandstra et al., 2016). A follow-up study conducted by Liem, Miremadi, Zandstra and Keast (2012) showed that a slight variation of the label “Now reduced in salt, great taste,” did not negatively impact the taste perception of the reduced salt soup (Zandstra et al., 2016). These studies show that by making a slight modification to the label, manufacturers can promote reduced-sodium products and meet their sodium reduction goals.

In December 2018, Cargill conducted a research study entitled “Ingredient Tracker 2019” to determine consumer perceptions of food ingredients (Cargill Salt, 2019). This study included both ingredients Cargill supplies as well as ingredients the company does not supply. The objective of this study was to identify which ingredients on a package label generate negative reaction and determine where consumer concern leads to avoidance (Cargill Salt, 2019). One-hundred and seventy-three ingredients, or combinations of ingredients, were assessed by over

9,000 consumers (Cargill Salt, 2019). Eleven of the ingredients, or combination of ingredients, were related to consumer perceptions of salt (Cargill Salt, 2019). These ingredients, or combination of ingredients, included salt, sodium, sea salt, potassium, kosher salt, potassium salt and sea salt, potassium chloride and sea salt, potassium salt and salt, potassium chloride and salt, potassium chloride, and potassium salt (Cargill Salt, 2019).

The questions in the survey focused on specific topics including ingredient familiarity, health perceptions, and purchase impact (Cargill Salt, 2019). The consumers were asked “How familiar are you with each ingredient, if at all?” (Cargill Salt, 2019). Over 40% of consumers responded that they were familiar with salt, sodium, sea salt, potassium, and kosher salt (Cargill Salt, 2019). The answers to the familiarity question revealed that consumers are not generally familiar with common salt-replacement ingredients (Cargill Salt, 2019). The results of the familiarity question also indicated that combining potassium-based salt and sodium-based salt increases familiarity (Cargill Salt, 2019). For example, consumers reported they were familiar with potassium salt, but when listed with sea salt familiarity increased by 21% (Cargill Salt, 2019).

To determine health perception, the consumers were asked to “Please indicate how good or bad for you each of these ingredients is, in your own opinion” (Cargill Salt, 2019). The answers to the health perceptions revealed consumers view potassium as “very good for you” and when combining potassium-based salt ingredients with sea salt, health perceptions increase significantly (Cargill Salt, 2019). According to reports, listing potassium salt with sea salt increased the belief the ingredient is “good for you” by 29% and listing potassium chloride with sea salt makes 18% of consumers believe the ingredient is “good for you” (Cargill Salt, 2019). The results of the health perception question also showed that sea salt and kosher salt continue to

have a predominant “halo effect,” and that 59% of consumers believe that sea salt is better for you than salt (Cargill Salt, 2019).

Lastly, consumers were asked the following question regarding purchase impact “If you were doing your grocery shopping and noticed the following ingredients on a food or beverage ingredient list, do you think it would make you more likely to purchase the product, less likely to purchase the product, or would it make no difference in your decision?” (Cargill Salt, 2019). The results showed that sea salt, potassium, and kosher salt are highly sought-after ingredients and consumers are 39% percent more likely to purchase a product if it is made with sea salt rather than standard granulated salt (Cargill Salt, 2019). The responses to the purchase impact question revealed consumers will seek out potassium salt (KCl) if sea salt is also on the label (Cargill Salt, 2019).

Potential Consequences of Removing Salt from Processed Foods

The functional role of salt in food is difficult to replace because it provides flavor, texture and stability (Zandastra et al., 2016). Salt improves the sensory properties of food and is inexpensive. Although salt is used across most food categories, it has a specific role for each product application. This makes it challenging for both ingredient suppliers and food manufacturers to find sodium-reduction solutions that work across multiple food categories.

For bread products, salt makes the wheat gluten more stable and less extendable creating a less sticky dough (Hutton, 2002). Salt also reduces fermentation of bread products; when salt is removed from a bakery application more gas is released during the fermentation process which results in a more porous open grain and undesirable texture (Hutton, 2002). The texture and quality of meat products are highly dependent upon adequate salt levels. Salt enhances water-binding and fat-binding capacity, improves yield, and has a tenderizing impact on raw meet

(Hutton, 2002). Salt also has a binding capacity in non-whole muscle meats and works to extract the actin and myosin proteins to develop desirable tacky texture in meat production (Hutton, 2002). In conjunction with fat, salt plays a major role in flavor liking (Hutton, 2002).

Salt plays a critical role in the manufacturing of both hard and soft cheeses (Hutton, 2002). The application method of salt will vary depending on cheese type(Hutton, 2002). Salt is either added by dry salting, which is when salt is applied directly to the cheese curds (Hystead et.al, 2013), brining, which is when whole wheels or blocks of cheese are submerged in a salt brine, or dry rub salting, when whole wheels or blocks of cheese are covered in salt (Hutton, 2002). In every case, salt has the most impact on the ripening and maturation of the cheese product (Hutton, 2002). During cheese production, salt inhibits spoilage microorganisms, promotes enzymatic activity, reduces available water, and controls the final pH of the cheese (Hutton, 2002).

Fifty percent of consumers reported that they would like to decrease their sodium intake, but they do not want to sacrifice taste (Kim et al., 2012). Finding strategies to reduce sodium in the American diet is important to prevent disease without sacrificing the quality of food products. In instances where salt cannot simply be removed or processing conditions cannot be altered (baking, freezing, curing, etc.), it is important to examine alternative strategies such as stealth reduction, modified crystal structures, and salt replacers.

Industry Strategies: Stealth Reduction

Awareness of the harmful effects of excessive salt intake does not always translate into behavioral changes (Zandastra et al., 2016). Research has shown it can be difficult to convince consumers to change their eating behaviors, even if they are aware of the harmful effects of their

diet (Busch et al., 2013). Stealth reduction is a technique used to lower sodium intake by reformulating products gradually over time (Busch et al., 2013). Some research indicates that preferred levels of saltiness can be modified by repeated exposure (Zandstra et al., 2016). Such studies indicate it can be more impactful to the population to gradually decrease the amount of sodium in commercially prepared and manufactured foods, because that is the means by which most consumers excessively consume salt.

There is significant variation between sodium levels within food product groups. If all foods in a product line do not take the stealth reduction approach, the reduction may be more apparent to the consumer. For instance, if one manufacturer chooses to reduce sodium in their product and their competitor does not, the consumer may notice a difference in the food quality and decide to purchase the higher-sodium product. A potential risk of using stealth reduction is the consumer may compensate for the missing salt and add salt back at the table (Zandstra et al., 2016). There is conflicting research regarding this potential risk.

One study by Beauchamp, Bertino, and Engelman (1987) shows that even when placed on a clinically prepared reduced-sodium diet, the amount of salt used to compensate for the missing salt in the diet was less than 20% (Zandstra et al., 2016). Another, more recent study by Liem et. al (2012) showed that when a single soup product had a thirty-percent salt reduction, would overcompensate with salt at the table (Zandstra et al., 2016). Similarly, Zandstra, De Kock, Sayed, and Wentzel-Viljoen (2014) conducted a study where South African participants were given reduced-salt chicken stew and nearly one-fifth of the participants overcompensated with table salt (Zandstra et al., 2016). Based on this conflicting research, it is difficult to say if stealth reduction could be a successful solution for sodium reduction. Regardless, it would take a significant amount of time to be effective.

Industry Strategies: Modifying the Crystal Shape

Altering the crystal structure of the salt product is another strategy to reduce salt in a food product. The size and shape of a salt crystal can impact the functionality of a food application (Busch et al. 2013). There are a few different options for modifying a salt crystal structure. For instance, Cargill offers a salt product called Alberger® salt that uses open-pan evaporation to produce salt crystals that have a hollow pyramidal shape (Cargill Salt, 2019b). In contrast, Morton offers a Star Flake® Dendritic salt product that uses a saturated brine of yellow prussiate of soda to create a porous star-shaped crystal (Morton, 2019). Both the Cargill Alberger® and Morton Star Flake® Dendritic salt are superior to standard granulated salts in adhesion, bulk density, and solubility.

Standard granulated salt is typically cubic in nature and does not adhere well in topical applications. The unique divots of the Cargill Alberger® and Morton Star Flake® Dendritic salt allow the salt to adhere to the product (Cargill Salt, 2019b and Morton, 2019). The increased solubility of modified crystal salts allows the products to dissolve more quickly on the tongue, resulting in a burst of saltiness (Busch et al. 2013). Decreasing the size of the salt crystal can also increase solubility (Busch et al. 2013). In theory, smaller crystals will cover more surface area on one's tongue resulting in an increased salty perception.

Industry Strategies: Salt Substitutes

Salt has been used in meat production for centuries. As sodium reduction targets continue to be published, the meat industry responds by developing a variety of salt replacement techniques. Products such as sausages and deli meats can use functional proteins (soy, milk, etc.), hydrocolloids, and starches to replace some of the functionality of salt in meat products

(Desmond 2006). These salt replacement ingredients have supplanted some of the functionality of the salt-soluble proteins that form a gel network and effectively “glue” the meat pieces together in higher-salt products (Desmond, 2006).

Another solution to reducing sodium is to use salt substitutes. Salt substitutes include sodium chloride, lithium chloride, calcium chloride, magnesium chloride, and magnesium sulfate (IOM, 2010). Potassium chloride is one of the most commonly used salt substitutes. A benefit of using potassium chloride is that it has the same preservative effect as sodium chloride (Desmond, 2006). This preservative effect is especially important in meat products because a lack of preservation can result in unwanted food safety incidents (Desmond, 2006).

Studies have found that potassium chloride could potentially provide the approximate technological functions of NaCl in dough and breads, such as increasing dough strength, improving bread texture, and inhibiting microbial growth (IOM, 2010). Apart from the technological need to reduce sodium, potassium chloride could help bakery manufacturers meet their potassium targets (IOM, 2010). In a study conducted by Chen, G., Ruijia, H., Yonghui, L., potassium chloride had a similar impact as potassium chloride on specific volume, texture profile, crumb cell structure, and thermal phase transition properties (2018).

Potassium chloride has also been used in cheese manufacturing. A study by Grummer J., Bobowski N., Karalus M., Vickers Z., and Schoenfuss T., showed that producing a low-sodium cheddar style cheese with potassium chloride at levels to maintain water activity can be made in a way that results in high consumer acceptance, low bitterness, and an equivalent of saltiness (2012). In a study conducted by Hystead and others (2013), the results showed there was a slight microbial disadvantage to using only potassium chloride in cheddar cheese production. However, there was no significant difference between cheddar cheese made with potassium chloride

compared to sodium chloride in the event of post-processing contamination of *L. monocytogenes* (Hystead et.al, 2013).

Potassium chloride can be a challenging ingredient, because it does not provide the same flavor-profile as sodium chloride. The human mouth is full of taste buds that are comprised into taste receptors (Busch et al. 2013). The sodium and chloride ion are required to activate the salt receptor (Busch et al. 2013). Potassium chloride is known to impart a bitter and metallic flavor. Studies have shown poor consumer acceptance when using potassium chloride as a direct replacement of sodium chloride (Kim et al., 2012).

Product developers must consider the flavor-profile difference when utilizing potassium chloride. Both Cargill Salt and Morton Salt carry blends of potassium chloride and sodium chloride. Cargill showed how using a blend of 50% sodium chloride and 50% potassium chloride to reduce sodium in a fried mozzarella stick by 22.7% (Cargill, 2019c). A trained descriptive sensory panel reported no significant difference between the full-sodium and reduced-sodium mozzarella sticks (Cargill, 2019c). To overcome the bitter flavor often associated with potassium chloride, developers have investigated adding monosodium glutamate, hydrolyzed vegetable proteins, yeast extract, disodium inosinate, disodium guanylate, and sweeteners such as sucrose, taumatin, and trehalose (Grumer et. al 2012). Additional options for overcoming the bitter taste of potassium chloride include adding flavors and herbs, umami, or masking agents (IOM, 2010).

Potential Alternate Name for Potassium Chloride

The FDA has stated interest in allowing “Potassium Salt” to appear on ingredient labels, and a handful of companies (NuTek, Nestle, Walmart, etc.) have expressed support for the alternate name (FDA, 2019a). On May 20, 2019 the Federal Register published notice for “Draft

Guidance for The Use of an Alternate Name for Potassium Chloride in Food Labeling: Guidance for Industry” (FDA, 2019e). Sodium chloride and potassium chloride are defined as “an ionic chemical compounds formed by replacing all or part of the hydrogen ions of an acid with metal ions or other cations” (FDA, 2019e). Although potassium chloride is a type of salt, the common or usual name for this ingredient is “potassium chloride,” as established by longstanding common usage (FDA, 2019e).

The FDA has considered how a declaration of alternative names for potassium chloride such as “potassium chloride salt” may alert consumers that potassium chloride was added to the product as a substitute for salt (FDA, 2019e). This information could help guide the consumer to purchase a product that reduces sodium in their diet (FDA, 2019e). Potassium chloride and salt have many functional similarities and can be substituted in some applications (FDA, 2019e). The FDA reasons that adding the term “salt” to the common or usual name “potassium chloride” may help consumers understand the similarities between potassium chloride and salt (FDA, 2019e). The label “potassium chloride salt” includes the entire common or usual name, therefore the FDA acknowledges it would be unlikely for a consumer to confuse it with salt or other potassium-containing salts (FDA, 2019e). Therefore, the FDA considers it appropriate to exercise enforcement discretion for the declaration “potassium chloride salt” in the place of “potassium chloride” in the ingredient statement of food labels when potassium chloride is used as an ingredient in said food (FDA, 2019e).

Conclusion

Salt reduction is an important public health issue and additional research must be conducted to continue exploring alternative strategies for replacing salt in food products.

Reducing salt intake has the potential to prevent many illnesses such as cardiovascular disease, hypertension, cancer, and osteoporosis. Preventing these life-threatening illnesses will positively impact the global population.

Although the strategies of stealth reduction, modifying crystal structures, and salt substitutes have been studied, there is still more work to be done in this space. Salt impacts the functionality of applications differently and there is not a one-size-fits-all solution for salt replacement. It is important to continue to push food manufacturers to adopt sodium reduction strategies in order to reduce overall sodium in the food supply.

Improving research on potassium chloride could be transformational for sodium reduction. This ingredient could be a very impactful tool for reducing sodium chloride if it were to be paired with a bitter blocker or other flavor-masking agents. Potassium chloride is abundant and can increase potassium in the diet. This ingredient is currently not ideal for reducing salt in the diet but has potential to be the overarching solution for salt reduction.

Promoting consumer awareness of the over-consumption of sodium, combined with the effective labeling of products, can help consumers make healthful choices. Consumer education will help to prevent diseases caused by overconsumption of sodium and save individuals and society-at-large health care costs. Apart from nutritional labeling, it is critical that scientists look for additional ways to determine a person's daily sodium intake. Currently, consumers are fascinated by tracking their health patterns through devices such as Apple Watch, Fit-Bit, and other health-tracking applications. If consumers have the power to understand how much sodium they are placing in their bodies, they may be willing to alter their behavior. This will also help researchers identify products that have excessive amounts of added salt. As we wait for technology to advance it is critical to keep industry stakeholders and government officials

engaged in sodium reduction strategies that continue to prevent harmful diseases caused by excessive salt intake.

In conclusion, sodium reduction is a relevant public health issue. By consuming less sodium in the diet, we can prevent diseases such as high blood pressure, cardiovascular disease, and osteoporosis. The governmental policies in place support the stealth reduction strategy. As the food industry slowly removes sodium from the diet, consumers will begin to develop lower thresholds for salt intensity. The goal is that over time consumer will prefer lower salted foods, thus reducing their risk for harmful diseases.

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Appendix A - Sodium Reduction Policy Summary

Figure 1a: Policy Milestones between 1958 and 1983

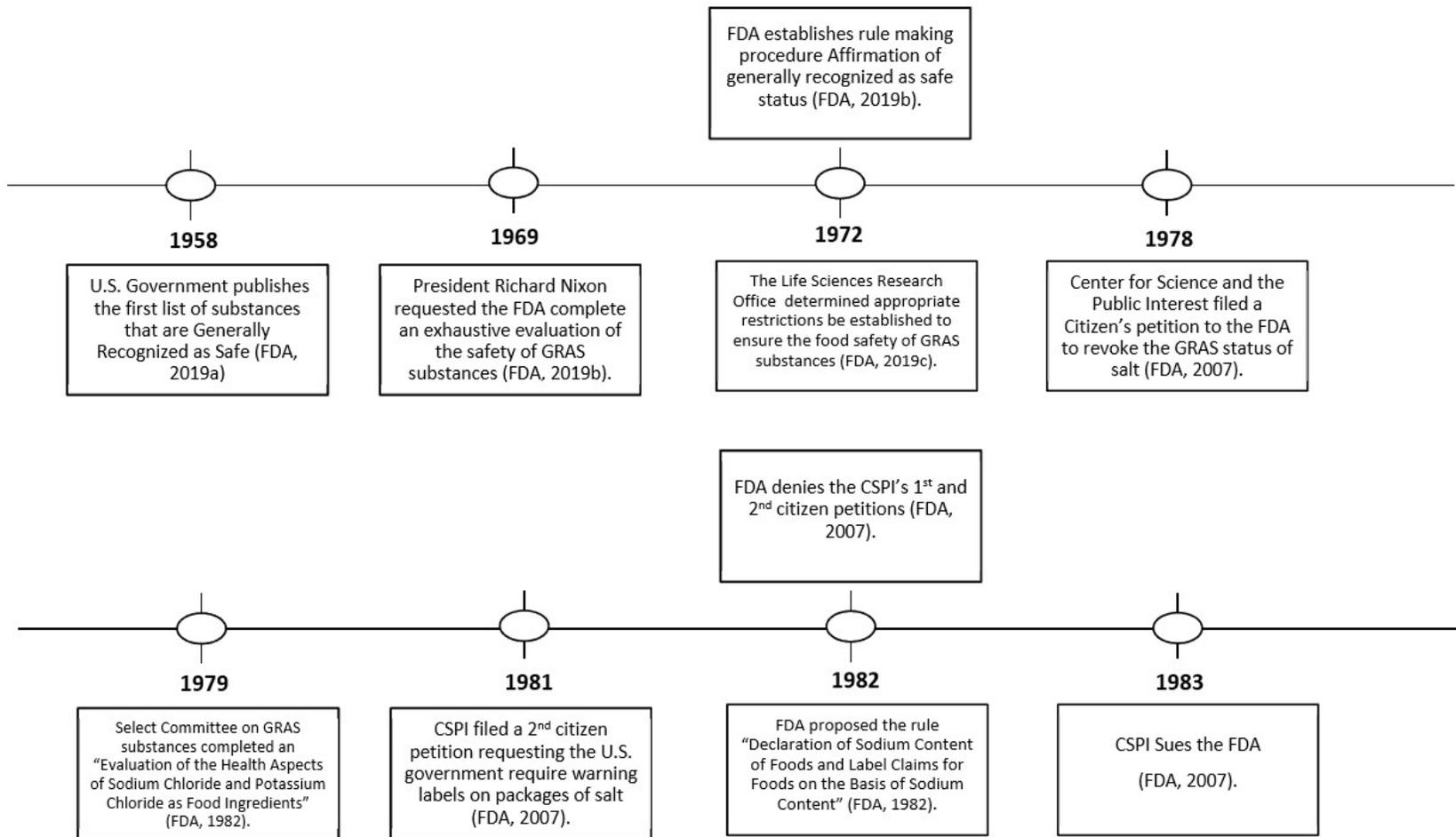


Figure 1b: Policy Milestones between 1984 and 2016

