Reformulation of products to reduce sodium:

Salt Reduction guide for the Food Industry

CTAC
Conseil de la transformation agroalimentaire et des produits de consommation

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Excessive sodium intake is a contributing factor to hypertension and is linked to cardiovascular disease and stroke. [1] A high sodium diet thus represents a serious health risk for human beings according to many organization such as the World Health Organization,[2,3,4] Health Canada, the NHLBI,[5,6], the CDC[7,8,9,10] and the USDA[11,12,13] in the United States, the FSA[14,15,16] in the United Kingdom, the THL[17,18] in Finland, the AFSSA[19,20] in France, and the European Union's Health and Consumers Directorate general.[21] Canadians in all age groups consume twice as much sodium as is considered to be adequate,[22,23,24] i.e., much in excess of the tolerable upper intake level. More specifically, health specialists are very concerned about excessive salt doses consumed by children.[25,26]

Changing a population's dietary habits is complex. Choice of foods depends on physiological, social, and cultural factors.[27] Processed foods are the source of three quarters of the sodium consumed [3], especially in the form of salt (sodium chloride). The food industry will have a key role to play in the strategy to reduce salt intake in the Canadian population. Many products will have to be reformulated, which will be a difficult task since salt changes the properties of food significantly, especially the taste, the texture, and the appearance. Salt is also a preservative agent that protects against contamination by pathogenic microorganisms, especially in cold meats and cheese.

Many ingredients exist to replace sodium chloride, such as yeast extracts, hydrolysed vegetable proteins, aromas, etc. Human resources devoted to research and development of these products will likely to run up against several major obstacles. For example, certain substitute ingredients are not permitted in standardized foods in Canada. In coming years, dietary sodium reduction could become more important with processes that facilitate regulatory changes, technological advances, and changes in people's eating habits.

This guide is above all provided for those who process food, to help them understand the technological challenges involved in developing low-sodium formulations.

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ABOUT SALT

1.1. WHAT IS SALT AND WHERE IS IT FOUND?

Salt, or sodium chloride (NaCl), comprises a sodium atom and a chlorine atom representing respectively 39.33 % and 60.67 % of its mass. That is why it is necessary to multiply the sodium content by 2.5 to obtain the "salt equivalent." It is among the most abundant elements on earth. Seawater contains between 30 and 40 g/l.

There are several types of salt depending on the origin (sea salt; rock salt mined from the earth), the degree to which it is refined (refined; unrefined), and the size or the appearance of the salt grains (coarse; crystal; fine). Refined salt is the most widely used in food and usually comes from mined rock salt. Refining makes it possible to obtain white salt, comprising almost pure NaCl. It can contain anti-caking agents (to prevent caking of crystals) and inverted sugar (to prevent yellowing due to exposure to the sun and loss of iodine through vaporization). In Canada, table salt is very fine and must be iodine-enriched to prevent the onset of diseases such as goiter. Natural salt (unrefined) includes salt flower, salt-marsh salts, and unrefined rock salt. Coarse salt, which is less refined, can be used in the food industry when speed of solubilization is not important, such as for marinades.

As shown in Figures 1 and 2, most salt consumed comes from processed, pre-packaged, ready-to-serve foods (3) which have a wide variety of sources.

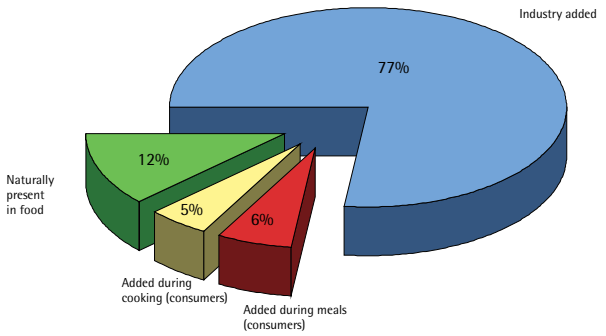

Figure 1. Salt intake in the Canadian diet.

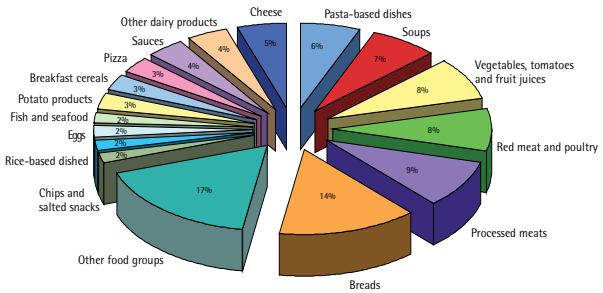

Figure 2. Salt content in the main food groups in the Canadian diet.

1.2. EFFECTS OF SALT ON HEALTH

THE WHO RANG THE ALARM [2, 3, 4]

At the request of the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO), a group of about thirty experts prepared a report in 2002 with recommendations to help governments fight chronic disease, including cardiovascular disease which is rapidly increasing throughout the world. In 2001, these types of disease were responsible for 60 % of the 57 million deaths recorded in the world and 46 % of world morbidity. Many of the deaths and chronic disease were linked to easily avoidable risk factors such as high blood pressure, hypercholesteremia, obesity, and lack of physical exercise. Unbalanced diets, including high salt intake, which has a negative impact on blood pressure, were identified as the cause of much chronic disease. The WHO and the FAO hope that each country will develop its own strategy with specific, simple, realistic, and concrete instructions for citizens. In order to have a tangible impact, this report encourages governments and the agro-food industry to work together.

The WHO report cites measures taken by Finland[2] to change the dietary habits and behaviour of the population who were consuming 5,500 mg of sodium a day in 1970.[28,29,30] A 30 to 35 % reduction in salt intake over the past 30 years contributed to a 75 % drop in cardiovascular mortality caused by coronary heart disease in adults under 65. Moreover, a one-point drop in average blood pressure in the Finish population was observed.

On a world scale, deaths caused by stomach cancer are second in importance among the various types of cancer. Some studies suggest links between salt intake, Helicobacter pylori infections, and mortality due to stomach cancer [31,32,33].

IMPACT OF SALT REDUCTION ON HEALTH

Many studies show that sodium intake reduction among people said to be "salt-sensitive" (hypertensive, obese, aged), or about one third of Canadians, contributes to reducing high blood pressure. Reduction of average salt intake should induce a drop in blood pressure and in the risk of heart failure. Excessive dietary salt is likely the cause of high blood pressure among at least one million Canadians and gives rise to annual medical expenses of 430 million dollars. However, in the general population, the response to salt intake reduction might not result in measurable benefits among the people whose salt intake is low (within "normal" limits).

The 2004 Canadian Community Health Survey revealed that an 1840-mg sodium intake reduction would lower blood pressure by about 5 mmHg and would prevent :

- 14 % of deaths due to CVA;
- 25 % of deaths caused by coronary heart disease;
- 7 % of deaths due to other causes.

The *British Medical Research Concil* states that a daily reduction of average sodium intake from 3800 mg to 2400 mg would result in (He and McGregor, 2004) :

- A 13 % drop in CVA;
- A 10 % drop in heart disease/failure.

The *Scientific Advisor Committee on Nutrition (SACN)* published a report on salt and health that established a link between high salt intake and high blood pressure. In relation to "normal" blood pressure, high blood

pressure is said to double the probability of suffering a CVA or triple the probability of suffering from heart failure.

PHYSIOLOGICAL IMPORTANCE OF SODIUM CHLORIDE AND ITS LINKS TO OTHER MINERALS

A) Sodium and chlorine. Sodium and chlorine are essential to life and health. They stabilize the internal hydrous environment (liquids and electrolytes) and blood pressure in the human body. They ensure the proper functioning of muscles and nerves. Sodium facilitates absorption of nutriments such as glucose (sugar) and amino acids (protein constituents). A daily salt intake of about 400-500 mg is enough to ensure the organic functions of an adult. In the human organism, half of the salt is found in the blood and body liquids, more than a third is in the bones, and the rest is in the cells.

B) Iodine. Table salt, which must be iodine-enriched in Canada (but not in all countries), lowers the chances of iodine deficiency in the population, which is linked for exeample to goiter, cretinism, and myxedema. It prevents hypo thyroid hormonal production (hypothyroidism).

C) Potassium. Potassium and sodium play similar roles, but potassium is mainly found in the cells of the organism. [34] The increase in potassium intake makes it possible to reduce blood pressure. This phenomenon can be explained by potassium's capacity to increase excretion of sodium and by the vasoactive effects (on blood vessels). The equilibrium between potassium (K) and sodium (Na) is fundamental. The ability of the kidneys to excrete or conserve sodium is a determining factor in blood pressure regulation. Sodium and potassium ingestion; (Na: K) has changed with dietary evolution. It went from a ratio of 1:7 (ancestral diet) to 3:1 (contemporary diet). As a result, the kidneys retain sodium and release potassium. Too much sodium retained in the water in the body is thus stored and it expands the body fluids, and this increases blood pressure and affects the kidney and heart functions. Potassium is present in many foods. The best sources of potassium are fresh foods that have undergone little processing. Fruit and vegetables are excellent sources. In addition, raw foods are usually low in sodium. Certain sodium chloride substitutes contain potassium salts. These can have a major influence on potassium intake [35].

D) Calcium. High salt intake is accompanied by the combined excretion of sodium and calcium as the organism tries to balance cell liquids. In other words, excessive salt consumption could result in bone embrittlement caused by calcium deficiency in the organism.

1.3. GUIDELINES ON SALT INTAKE

For sodium, dietary reference intakes (DRI) were established by the *Standard Committee on the Scientific Evaluation of Dietary Reference Intakes of the Food and Nutrition Board* de l'*IOM* américain,[43] with Health Canada's help in order to update, broaden, and replace the old recommended dietary allowances (RDA). The DRIs are used to plan and evaluate the diets of Canadians and Americans considered to be in good health. The RDA were based on quantities required to protect against disease that could be caused by nutritional deficiencies. Three of the six DRI values (or categories) are described below: recommended dietary allowance (RDA), adequate intake (AI), and tolerable upper intake level (TUIL).

RDA : RECOMMENDED DIETARY ALLOWANCE

Average daily dietary intake required to meet almost all needs (97 to 98 %) of people in good health belonging to a group established according to the stage in life and sex. They are based on an estimate of the average requirements plus an increase to compensate for a variation within a particular group.

AI: ADEQUATE INTAKE

Recommended average daily intake of a nutriment based on approximations observed or determined experimentally or on estimates of the nutriment intake among one or many groups of people considered to be in good health. AI is used when it is impossible to establish the RDA, when adequate scientific evidence is unavailable to estimate average requirements. The AI values are obtained using data that tend to provide a desired health indicator (e.g., bone calcium retention, etc.). Healthy people who follow AI run a low risk of inadequate intake.

TUIL: TOLERABLE UPPER LEVEL INTAKE

The highest daily intake that is unlikely to result in undesirable health risks or impacts for most members of a specific group. The more that intake exceeds the TUIL, the greater is the risk of undesirable impacts. The TUIL is not a proposed consumption level and there is no advantage in consuming nutriments at levels exceeding the RDA or AI. The term TUIL was chosen to avoid giving the impression that there was any possible beneficial effect.

1.4. SODIUM INTAKE BY CANADIANS AND AMERICANS

In Canada, as in the United States, high blood pressure is the most frequent diagnosis among adults during consultation with general practitioners (family doctors). One Canadian adult in four is said to have high blood pressure. If salt consumption does not change, more than 90 % of the adult population will likely develop high blood pressure problems (*Joffres et Campbell, 2007*).

INTAKE BY CANADIANS

In 2004, a survey was conducted jointly by Statistics Canada and Health Canada to evaluate the health of Canadians. Data were gathered from 33,000 respondents from all age groups in all Canadian provinces (excluding the territories). In order to meet statistical study modelling requirements, the 8874 foods and recipes listed were classified in 63 groups. Their salt intake was determined using statistical tools and databases [36,37,38,39].

The survey revealed [23] that :

- The average Canadian (all age groups) consumes more than 3100 mg of sodium a day, or 7.9 g of salt.
- More than 90 % of adult men and 66 % of adult women (19 and over) consume much more than the tolerable upper intake level (TUIL), which puts them above the risk threshold for developing chronic disease. In the majority of cases, Canadians consume approximately twice the amount of salt they should (Figure 3). Almost all individuals in each age group consume salt in excess of the Adequate Intake

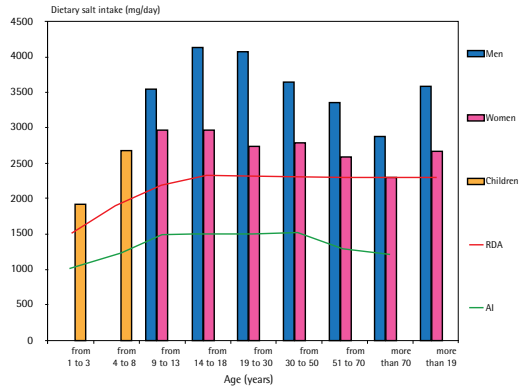

Figure 3. Average daily sodium intake by age group among Canadians [23].

INTAKE BY AMERICAINS

The United States Centers for Disease Control and Prevention (CDC) operated by the Department of Health and Human Services analysed data from the NHANES survey.[9] The report was published by the Morbidity and Mortality Weekly Report. The results indicate that for the year 2005-2006 :

- The average American (all age groups) consumes more than 3436 mg of sodium a day, or 8.8 g of salt.
- The recommendation to use the Adequate Intake (AI) of 1500 mg/day as a target would be desirable for about 69 % of the adult population in the United States.

The CDC commissioned a study by IOM aimed at deploying strategies to reduce sodium intake to levels recommended in the *Dietary guidelines for Americans*. That study is scheduled to be completed in February 2010.

1.5. SODIUM INTAKE REDUCTION STRATEGY

Health Canada is studying political scenarios for dietary sodium. A dietary sodium reduction strategy was proposed in 2007 as part of the *National Sodium Policy*. That policy aimed for sodium intake among Canadians to be within the acceptable limits by January 1, 2020. It made an urgent appeal to the federal government to :

1. Set gradual sodium targets based on food categories;
2. Monitor progress and report by 2012 and 2016;
3. Establish an efficient system to monitor the sodium intake in the diet of Canadians;
4. Educate Canadians on the health risks of diets too rich in sodium and ways to reduce intake;
5. Provide incentives to the food industry and;
6. See that health professionals understand the necessity of reducing dietary sodium intake and that their respective associations educate members on the health risks and ways to reducing them.

The Working group on Dietary Sodium Reduction [40] was created in Canada. It is headed by Health Canada and includes representatives from national health organizations and the food processing industry. Its goal is to reduce the daily sodium intake among Canadians within ten years to between the Adequate Intake and the Tolerable Upper Intake Level. Canada is thus following the example set by countries such as Finland, Japan, and the United Kingdom

1.6. DIETARY SODIUM REDUCTION TARGETS

Considering that daily sodium intake of 1500 mg is usually an adequate intake, four quartiles in the population were defined. The first quartile includes those who consume very little salt (about 1300 mg/day) and the fourth quartile includes those who consume a lot of salt (about 5400 mg/day). The fourth quartile obviously represents the portion of the population who are most likely exposed to hypertension-related risks. The food groups contributing to sodium intake in the average diets of these two quartiles are different.

A study on salt content in food and its contribution to the diet of Canadians was conducted jointly by *Health Canada* and *Statistics Canada*. During the development of the 2007 guide *Eating Well with Canada's Food guide*,[41] with foods that Canadians usually eat, it was practically impossible to model the diet with a sodium intake under the TUIL., Moreover, for all segments of the Canadian population, [23] the proportion of people whose intake exceeds the AI and especially the TUIL is too great.

Salt reduction targets must approach 50 % and apply to a very broad group of salt-contributing foods (e.g., the first 30), in order to result in an average daily intake under the TUIL for a large proportion (about three quarters) of adult men (based on their current dietary habits).

Part 2

REFORMULATION OF FOOD PRODUCTS

2.1. MAIN CHALLENGES

Manufacturers are faced with a dilemma: "How do you reduce sodium content in food without modifying taste too much?" Although trends indicate that consumers opt more and more for "healthy" food, taste remains the most critical purchasing factor. For many food products, the tendency has been to steadily increase salt content and as a result Canadians are used to eating very salty food that would seem tasteless without salt.

Certain manufacturers choose simply to reduce salt content (NaCl) without changing the taste profile. Most food companies are nonetheless concerned about the possible loss of customer interest [27] because of taste changes and they thus keep abreast of technological alternatives. For instance, a review of invention patents for salt reduction in food was published in 2009. [124]

Salt is a relatively inexpensive ingredient. What's more, there is a supplementary economic interest in it because it makes it possible to retain more water in certain products (formulation cost reduction), stimulate the feeling of thirst, and mask tastelessness at little cost.

2.2. ROLE OF SODIUM IN FOOD

2.2.1. EFFECTS ON FOOD SAFETY

Salt inhibits the multiplication of pathogenic microorganisms. The microbiological risks linked to reformulations aimed at reducing sodium can thus be significant in such foods as meat products (cold meats), sauces, mayonnaise-type products, etc. Use of tools such as predictive modelling and microbiological testing require care and rigour.

In order to survive and multiply in food, microorganisms require :

1. available water;
2. nutriments;
3. environmentally favourable factors.

It is necessary to have one or several barriers to prevent growth of pathogenic microorganisms. The more numerous they are, the better it is. These barriers can concern formulation (water activity, pH, acidity, NaCl, preservative agents, competition of micro-organisms) or not (thermal processing, high pressure processing, absence of oxygen, preservation temperature, etc.). They can work in synergy and have a limiting impact on microorganisms identified during risk evaluation depending on product type.

Microorganisms need water to be active. As a result, water availability (a_w) is an essential factor to their survival or growth. The main effect of sodium chloride on microorganisms is a reduction in the activity of water (a_w) in the food. This stress prevents the multiplication of microorganisms but it is possible that they will adapt to the presence of salt if it is not too concentrated. During the latency phase, there is no cell division since the micro-organisms try to adapt to their environment.[42] In addition, low water activity slows their growth when speed is highest (exponential phase). Therefore, microbial changes and development of certain pathogenic microorganisms are favoured when a_w is of the order of 0.70 (moulds) and 0.83 (certain bacteria). The mechanisms and tools linked to these barriers are dealt with in Appendix 1.

2.2.2. EFFECTS ON TASTE

Taste is a chemical or physical stimulus that provokes specific responses from sensory receptors in the human organism. Sensory acuity is the capacity and the fineness with which sensorial organs manage to separate stimuli quantitatively or qualitatively.

If salt concentration in a food product varies, it is possible that consumers will detect the change. A salt reduction of the order of 10 to 25 % might be imperceptible for the "salt taste receptors." However, it takes three of four weeks for consumers to really adapt to less salty food. To minimize the marketing risk, it is important to do the necessary pre-testing using sensory analysis tests, such as with consumer groups. The taste for salt is innate and its perception is affected by several factors including :

- pH;
- temperature;
- chemical composition of the food;
- consumer age;
- cigarette smoking.

Basic tastes

The tongue has three types of taste buds. Taste cells have specific gustatory receptors on the surface to recognize basic tastes and transmit the information to the brain via the gustatory nerves.[43] Sodium chloride (NaCl) increases the palatability of foods, i.e., it intensifies the perception of tastes. The Na^+ ions stimulate the taste buds while the Cl ions give the salty taste. [44] Salt therefore brings out the perception of the taste of certain foods with an initially bland profile and thus has an impact on the overall profile of the finished product and usually makes it more pleasant. The non volatile chemical compounds are dissolved by the saliva and detected by several parts of the tongue, palate, and throat. Sodium chloride can have an impact on basic tastes :

- reducing bitterness and sweetness;
- balancing bitterness / sourness;
- building the intensity of the umami.

As described below, salt affects the perception of bitterness and umami, the metallic and astringency sensation, the Kokumi effect, as well as specific aromas.

Bitterness

Because of the substitutes frequently used to replace sodium chloride (e.g., potassium chloride), it is difficult to determine accurately the intensity of the bitterness of a food, such as when foods are reformulated to reduce sodium content. For products containing coffee or chocolate, bitterness is a quality, but for others it is not. Individual sensitivity to bitterness is determined genetically, which means it is more difficult to characterize than other basic tastes. The "Caucasian" (white race) is said to have an average sensitivity to this basic taste,[45] with half being hypersensitive to it while the others are sensitive or insensitive to it.

Umami [46]

Umami is a Japanese term that was officially recognized in the 1980s as the fifth taste. In 1908, Professor Ikeda discovered that an alga rich in glutamic acid had a unique and distinctive taste. This taste can be

used to counter the tasteless profile of low-sodium products. The compounds that induce this taste can be found in almost all foods, in variable proportions (e.g., peas, tomatoes, etc.). This taste is related to some families of substitution ingredients, such as yeast extracts, high nucleotide concentration ingredients, MSG, pure vegetable oil, etc.

"Metallic" and Astringency Sensation

Sodium chloride substitutes can have a taste profile that includes astringency and/or a metallic taste. The metallic sensation likely comes from a stimulus stemming from a co-product attributed to the degradation of fat.( ) The astringency sensation is similar to dehydration and the loss of lubricating substances that come from protein precipitation present in saliva caused by the phenol compounds in the food [48].

Kokumi effect

The term Kokumi refers to the Japanese concept relating to the capacity of an ingredient to raise the taste of food. It is different however from umami. Three sensory dimensions are attributed to this term: fullness, initial impact, and mouthfulness. [49] This term can be attributed to the glutathione content of certain indgredients such as yeast extracts. [50].

Specific flavours

Several flavours are developed to partially replace salt. Thousands of chemical compounds can stimulate the ofactive epithelia in nasal cavities.

2.2.3. EFFECTS ON THE APPEARANCE AND PHYSICAL PROPERTIES OF FOOD

Table 1 summarizes the impact of salt on food properties. For example, it significantly modifies their texture and colour. Additional information will be presented below about the effect of salt on cold meats and bread.

TABLE 1 I ROLES OF SALT (SODIUM CHLORIDE) IN CERTAIN FOOD PRODUCTS

	Taste	Texture	Ferment activity	Enzyme activity	Preservative (preservative agent)	Prevention of functional failures	Carrier of other ingredients
Bread	X	X	Reduces activity of yeasts		X		
Breakfast cereals	X	X					
Margarine	X				X	X	
Sauces	X				X		
Marinated vegetables	X	In storage (pre-packaging)			X	Can inhibit opacification	
Chips and snacks	X				X		X
Meat products	X	Retains water; binds ingredients			X		
Cheese	X		Reduces lactic ferment activity	Changes maturation	X		

2.2.4. EFFECTS OF SALT ON MEAT PRODUCTS

A) Water retention

Adding salt to raw meat lowers the pH and increases the water retention capacity of the proteins. Certain proteins are solubilized and can thus better play their role in emulsions, which improves the cohesion of ground products and the yield of cooked products. However, if there is more than 5 % salt in the water phase the proteins are denatured and they lose their properties. Longer maturation times improve salt fixation on proteins. The dissolution speed of salt depends largely on its grain size distribution, its pureness, and the absence of calcium and/or magnesium in the water. The acidity of the product reinforces the salt taste. Salt penetrates the meat by osmosis until an internal/external concentration equilibrium is reached. Absence of fat on the surface, salt concentration, temperature, and contact surface are some of the factors that influence penetration speed.

Salt tenderizes meat, partly because it increases the water retention capacity. For example, the myofibrils expand with high concentrations (3-9 %) of NaCl. Phosphates improve water retention through synergetic action with NaCl.[51] With ground products (e.g., hamburger meat), "formed" products (e.g., ham), and emulsified products (e.g., sausages), the NaCl enhances the binding capacity of the protein matrix by increasing the quantity of myosin extracted, thereby forming a complex with salt (NaCl) and changing the pH, which creates a more cohesive structure to solidify the protein matrix. In emulsified products, salt separates the myofibril proteins and enhances their ability to emulsify fat, more specifically at pH values approaching their isoelectric point (pH for which a molecule is electrically neutral).

B) Conditions of use

Since salt is not soluble in fat but rather is water soluble, it is not recommended to pre-salt meat fat because it can oxidize. As a result, certain meat products are more exposed to deterioration by oxidation of their fats than fresh meat, such as dried fermented meats. It is possible that salt will accelerate an enzyme-catalyzed reaction in muscle, which leads to the development of rancidity. To replace salt in meat preparation, there are several ingredients, such as phosphates, nitrites, and different binding agents that can compensate in part for certain salt functions. This however goes beyond the purview of this report.

Moreover, several studies on sodium reduction in meat products were conducted and are briefly described in Appendix 4. These technical options have to be validated with the Canadian regulatory authorities.

2.2.5. EFFECTS OF SALT IN BREAD-MAKING

In bread dough, salt reinforces the gluten proteins, which enhances the strength of the dough and its gas-retention capacity during fermentation and baking. Salted dough absorbs more water and this reduces sticking properties and obviously increases the quantity of dough produced and the amount made into bread.

During fermentation, salt slows down the activity of yeasts and evens out the fermentation activity. The more salt there is in the dough, the slower it ferments, and this extends the rising time. During baking, salt contributes to give colour to the crust. The texture of the crumbs is more cohesive and this improves the sensation in the mouth. The more salt there is in the bread, the more the crumbs retain water, and this indirectly delays bread staling. Owing to the high humidity levels in salted breads (the current standard is about 2 % of salt in relation to flour added), it is certain that humidity retention can be accompanied by the multiplication of problems of mould. That is why sodium propionate is usually added to prevent deterioration of commercial breads.

As a salt substitute, potassium chloride (10-20 %) has a similar functional effect to that of sodium chloride (NaCl). However, in Canada, bread is a standard food in which KCl is not allowed.

2.3. REFORMULATION STAGES AND STRATEGIES

Table 2 proposes a commercialization process for reducing dietary sodium. The stages are determined by the nature of the responsibilities (R&D, commercial responsibility, consumer research or regulation).

To replace salt, sometimes it is necessary to introduce additional barriers (or to reinforce them) against pathogenic microorganisms. (0) Certain manufacturing practices must be changed too in order to compensate for the loss of the preserving effect of sodium chloride, such as revising the transformation process (e.g., pasteurization, modified atmosphere packaging, ultraclean slicing) or using other techniques to enhance preservation (reduce a_w, lower pH, use vegetable extracts such as rosemary, etc.) The sensory aspect needs to be validated with customers. If the product is likely to represent a risk because of its microbiological sensitivity (e.g., meat products, etc.) microbiology tests and/or conservation length studies must be conducted to ensure food safety.

TABLE 2 | DIETARY SODIUM REDUCTION STAGES AND STRATEGIES

Stage	Taste	Safety	Function	Process	Research and Development	Commercialization	Consumer research	Canadian regulatory aspect
1					Compare salt content of product portfolios			
2						Analyse products on market		
3						Prioritize product reformulation projects		
4						Position products to be reformulate: claim, Health Check		
5					Determine target salt content for reformulation			
6					Identify sodium sources in formulation			
7					Target the main sodium contributing ingredients			
8					Determine the role of the ingredients to be reduced or replaced			
9					Assess the microbiological risk of reformulation			
10					Identify replacement solutions (formulation parameters, ingredients, processes)			
11					Identifier des solutions de remplacement (paramètres formulation, ingrédients, procédés)			
12a								Standardize product – check that ingredients are allowed (if **applicable**) **(yes=13a, no=12b)**
12b								Request IMA from Health Canada (HC) **(obtained=13a, no=11)**
13a								Verify authorization to use the ingredient in Canada: title 16 **(yes=14, no=13b / 11)**
13b								Take initiative to HC (ingredient supplier: title 28) **(yes=14, no=11)**
14					Generate reformulated prototype series (lab or pilot)			
15					Evaluate prototypes (in-house panel) **(Go=16, NoGo=11)**			
16							Conduct sensory analysis of prototypes with customers **(Go=18, NoGo=14)**	
17					Modify process or processes: transformation, conditioning and or packaging **(as required)**			
18					Validate modifications to processes implemented **(if applicable)**			
19					Generate prototypes (industrial)			
20					Validate food safety by microbiological testing and conservation length studies **(Go=21, NoGo=11)**			
21							Conduct sensory analysis of prototypes with customers **(Go=22, NoGo=14)**	
22					Assess the "risk" of commercializing the product			
23					Commercialize			

2.4. QUANTITY OF SODIUM TO REDUCE

Linked to stages 5 and 6 in Table 2

VOLUNTARY REDUCTION TARGETS IN THE UNITED KINGDOM

The United Kingdom's Food Standards Agency (FSA) defined targets (maximum content) for reducing sodium as incentives to food industry leaders to reduce salt in processed food. The targets are voluntary. In 2006, the agency had grouped the foods into 85 categories and the first targets were identified.[52] In several businesses, initiatives were taken. [53] In fact, most industry leaders committed to reduce the salt content in their respective food categories. Active collaboration and ongoing dialogue with industry enabled the agency to pinpoint targets, generally lower but sometimes higher. Technological constraints and safety risks, points raised by industry, will increase the target value for certain products but for other categories the real impact in the daily intake by the average population usually lowers the targets. New targets will be defined in 2010 and 1012.[54] The list of targets by product can be found in Appendix 2. Since there are no reduction targets in Canada, it would appear reasonable to use UK targets as a starting point.

SITUATION IN CANADA

Although sodium reduction is currently voluntary, the development of reduced sodium products is tending to increase. Moreover, certain manufacturers reduce salt content in an extended product line aimed at providing healthier processed food. What's more, existing regulation on sodium content can be an incentive for some to rapidly initiate sodium reduction projects so as to be able to include a nutritional claim on their label. [55]

Sodium content to be achieved is thus currently determined by nutritional claims defined by Health Canada (Tables 3 and 4) or by criteria in the *Heart and Stroke Foundation's Health Check* program.[56] This program is the only one in Canada that is publicly recognized by health professionals as a way to enhance the nutritional profile of processed foods and lower sodium content. The *Health Check* symbol indicates that certain criteria have been met, including the sodium concentration. Modifications made to the criteria for all the products already registered with Health Check should be in force in 2010 or, with a few exceptions, en 2009.[57] On the indicated dates all the products already involved in a program have to meet the future criteria. However, any product submitted for first-time registration in the program must meet the new criteria right away. The Health Check criteria and the FSA targets have been grouped together by food category (Appendix 2).

TABLE 3 | COMPLETE NUTRITIONAL CLAIMS ON SODIUM (CANADA)

Subject	Conditions -Food	Conditions-Label or Advertisement	Claims
Free of sodium*	The food contains: a) less than 5 mg of sodium per reference amount and serving of stated size; or b) less than 5 mg of sodium or salt per serving of stated size, if the food is a pre-packaged meal		"free of sodium" "sodium-free" "no sodium" "0 sodium" "zero sodium" "without sodium" "contains no sodium" "free of salt" "salt-free" "no salt" "0 salt" "zero salt" "without salt" "contains no salt"
Low in sodium or salt*	The food contains: a) 140 mg or less of sodium per reference amount and serving of stated size and, if the reference amount is 30 g or 30 mL or less, per 50 g; or b) 140 mg or less of sodium per 100 g, if the food is a pre-packaged meal.		"low in sodium" "low sodium" "low source of sodium" "little sodium" "contains only (number) mg of sodium per serving" "contains less than (number) mg of sodium per serving" "low salt" "low in salt" "low source of salt" "little salt" "contains only (number) mg of salt per serving" "contains less than (number) mg of salt per serving"
Reduced in sodium*	1) The food is processed, formulated, reformulated or otherwise modified so that it contains at least 25 % less sodium : a)) per reference amount of the food, than the reference amount of a similar reference food; or b) per 100 g of a similar reference food, if the food is a pre-packaged meal (2) The similar reference food does not meet the conditions set out in column 2 of the subject "low in sodium or salt" set out in item b) of this table.	The following are identified: a) the similar reference food; b) the amounts of the food and the similar reference food being compared, if those amounts are not equal; and c) the difference in sodium content with the similar reference food, expressed by percentage or fraction or in milligrams per serving of stated size.	"reduced in sodium" "reduced sodium" "sodium-reduced" "less sodium" "lower in sodium" "reduced in salt" "reduced salt" "salt-reduced" "less salt" "lower salt" "lower in salt"
Lower in sodium	1) The food contains at least 25 % less sodium a) per reference amount of the food, than the reference amount of a reference food of the same food group; or b) per 100 g, than 100 g of a reference food of the same food group, if the food is a pre-packaged meal. 2) The reference food of the same food group does not meet the conditions set out in column 2 of the subject "low in sodium or salt" set out in item b) of this table.	The following are identified: a) the reference food of the same food group; b) the amounts of the food and the reference food of the same food group being compared, if those amounts are not equal; and c) the difference in sodium content with the reference food of the same food group, expressed by percentage or fraction or in milligrams per serving of stated size.	"lower in sodium" "less sodium" "lower sodium" "lower in salt" "less salt" "lower salt"
No added sodium*	1) The food contains no added salt, other sodium salts or ingredients that contain sodium that functionally substitute for added salt. 2) The similar reference food does not meet the conditions set out in column 2 of the subject "low in sodium or salt" set out in item b) of this table and contains added salt or other sodium salts		"no added sodium" "without added sodium" "no sodium added" "no added salt" "without added salt" "no salt added" "unsalted"
Lightly salted	1) The food contains at least 50 % less sodium added than the sodium added to the similar reference food. 2) The similar reference food does not meet the conditions set out in column 2 of the subject "low in sodium or salt" set out in item b) of this table.	The following are identified: a) the similar reference food; b) the amounts of the food and the similar reference food being compared, if those amounts are not equal; and c) the difference in sodium content with the similar reference food, expressed by percentage or fraction or in milligrams per serving of stated size.	"lightly salted" "salted lightly"

* Sodium or salt

TABLE 4 | COMPARATIVE SUMMARY OF NUTRITIONAL CLAIMS ON SODIUM (OR SALT) CONTENT

Nutritional claim on sodium	Health Canada *	United States	United Kingdom	European Union	Codex Alimentarius
Free of	≤ 5 mg / serving	≤ 5 mg / serving	-	≤ 5 mg / 100 g	≤ 5 mg / 100 g
Very low (content)	-	≤ 35 mg / serving	-	≤ 40 mg / 100 g	≤ 40 mg / 100 g
Low (content)	≤ 140 mg / serving	≤ 140 mg / serving	≤ 40 mg / 100 g	≤ 120 mg / 100 g	≤ 120 mg / 100 g
Little salt	-	-	≤ 100 mg / 100 g	-	-
No salt added	No NaCl added, Na salt compounds or NaCl substitutes	No NaCl added, Na salt compounds; can contain intrinsic Na	-	-	-
Lightly salted	≥ 50 % less Na added than a similar reference product	-	-	-	-
Reduced sodium content	≥ 25 % less Na than the "earlier version"	≥ 25 % less Na than "earlier version"	-	≥ 25 % less Na than a similar product	-
Less sodium	≥ 25 % less Na than a reference product (e.g., regular)	-	-	-	-
High sodium content	-	-	≥ 500 mg / 100 g	-	-

*Consult Table 3 for details on all Canadian nutritional claims

2.5. IDENTIFICATION OF SODIUM SOURCES IN FORMULATION

Linked to stages 7 and 8 in Table 2

- From sodium chloride (salt) added;
- Intrinsic sodium in the food;
- From other ingredients added that contain sodium (emulsifier, dough conditioner, chemical preservatives, etc.). This type is often mentioned as sodium that is "hidden" from consumers

The definitions and the functions of additives are described summarily in Appendix 3 (A and B). In most cases, dietary sodium comes largely from sodium chloride (salt). Appendix 3 B will inform users about the presense of "hidden" sodium in ingredients other than salt itself, even if they contribute little sodium to the formulation.

Three questions can be asked at the beginning of the sodium reduction process :

1. **"Why is sodium added to the product?"**
2. **"What is the sodium content?"**
3. **"What can be done to reduce sodium?"**

2.6. REGULATORY QUESTIONS

Stages 12 and 13 in Table 2

Although Health Canada has identified a list of substances considered to be additives, certain other substances (not included in this list) are ingredients but not additives. In non standard products, the dose and conditions of use of ingredients are regulated little or not at all. However, it is possible that these substances are considered to be additives in other countries. Since each country has its own regulations on additives, it is possible to obtain information on these substances by consulting the Dictionary of food additives permitted in Canada, [58] Table 3 of the *Codex Alimentarius* [59,60] or the site of the JECFA (joint WHO/FAO committee of experts on food additives).[61] The nomenclature, the characteristics, and the doses of additives (in the food) in different countries is generally based on the Codex Alimentarius. It might also be useful to know the regulatory restrictions of other bodies that regulate the use of additives or ingredients from a safety standpoint.[62] In Canada the Food and Drug Regulations defines the use of food additives.

Many technological solutions to reduce dietary salt or sodium have been defined by scientists throughout the world. However, Canadian regulations are the source several major obstacles to their use. For example, potassium chloride is not allowed in bread in Canada, which can greatly limit salt substitution options. If industry is required to reduce intake for Canadians, Health Canada and the CFIA must facilitate such initiatives and/or clarify vague regulations regarding salt substitutes. The experience of health and regulatory agencies in other countries (Finland, United Kingdom, etc.) could be used as a reference for participating Canadian departments.

2.6.1. FOOD AND DRUG REGULATIONS (FDR)

Table 5 provides the sections of Canadian legislation that could be linked to sodium reduction in food. To understand the differences between terms used, the details hereafter are taken from the FDR. [63].

Definition : ingredient

Is an individual unit of food that is combined as an individual unit of food with one or more individual units of food to form an integral unit of food that is sold as a pre-packaged product.

Definition : food additive

Is any substance the use of which results, or may be reasonably expected to result in it or its by-product becoming a part or affecting the characteristics of a food, but does not include :

a) any nutritive material that is used, recognized or commonly sold as an article or ingredient of food;

b) vitamins, mineral nutrients and amino acids other than those listed in the tables to Division 16;

c) spices, seasonings, flavouring preparations, essential oils, oleoresins and natural extractives

Certain food additives linked to dietary sodium reduction are presented in Appendix 3 B [58,64].

Definition : unstandardized food

Any food for which the FDR does not specify a standard.

Possibility of using ingredients or additives in a finished reformulated product

Stage 12a in Table 2

If in the reformulation of a product an ingredient not included in the food standard (in a standardized product) is added, the product can be commercialized under another common name (another denomination) than the standardized product (to which it refers). However, a product cannot be made into an unstandardized product by putting in an additive (permitted in Canada) that is not included in the standard. Details can be found in sections [B.01.042, B.01.043].

Regulations are vague regarding use of salt substitutes in food products.

Interim marketing authorization (IMA)

Stage 12b in Table 2

A manufacturer can present a written request for an IMA for "food for special dietary use" [B.24.001]. This is a food, a food additive, nutritive minerals, or amino acids present in or on a food. The request includes specific information. Any IMA can be revoked by the Minister if he or she concludes, after examining further information brought his or her attention, that the authorized food is or can be harmful to the health of the buyer or the consumer. Details can be found in section [B.01.056].

Novel food

Stages 13a and 13b in Table 2

It is possible that certain ingredients are not authorized in Canadian food by Health Canada. Examples include certain "salt substitute compound

ingredients". Their very specific character can be drawn from particular technologies. It is thus prohibited to sell a novel food unless the manufacturer or the importer has notified the Director in writing of their intention to sell or advertise for sale the novel food; and has received a written notice from the Director. Details can be found in Division 28 [B.28].

The requirement for this type of request can arise in any of the following cases :

1) "Novel food," depending on the case :

   a) substance with no safety-related history;

   b) that was processed or conditioned using a newly applied process for the food or by which a major change was made

   c) food derived (plant, animal or microorganism) that has been genetically modified such that characteristics have changed or certain characteristics are absent

2) "major change" to a food following which its properties are outside the acceptable limits of natural variations of that food (composition, structure or nutritional quality, physiological effects, metabolization in the body or safety).

3) "Genetically modified".

TABLE 5 I FDR SECTIONS AND DIVISIONS THAT CAN BE LINKED TO SODIUM REDUCTION

	FDR Reference
Definitions (See above)	B.01.001
Ingredients or components in the preparation of a mixture	B.01.009
Standard for a food: authorized ingredients and additives	B.01.042
Food without standard: authorized additives	B.01.043
Additives: specifications	B.01.045
Interim marketing authorization (IMA)	B.01.056
Rules for rounding of values in table of nutritional values – salt content	B.01.401(3)(e)(ii), table after section 8
Rules for rounding of values in table of nutritional values - potassium content	B.01.402(5), table after section 9
Table of nutritional values – claim of no salt or sodium added	B.01.503(2)
Nutritional claims – regarding sodium	B.01.508 et B.01.513, Table: section 31 to 36
Health-related claims – regarding sodium and potassium	B.01.601 à B.01.603, Table: section 1
Dairy products – standards	B.08
Flavour preparations – standards	B.10
Grain and bakery products – standards	B.13
Meats, its preparations and products - standards	B.14
Food additives permitted in Canada	B.16
Request to add a food additive permitted in Canada	B.16.002
Salt – Standard	B.17
Marine and freshwater animal products – standards	B.21
Poultry, Poultry Meat, Their Preparations And Products – standards	B.22
Low-acid foods packaged in hermetically sealed containers	B.27
Formulation indicating that the food is for "special dietary use" from the standpoint of sodium (salt) content	B.24.003. (1.1)
Sodium content for baby food	B.25.062, table 1 following
Novel foods	B.28
Addition of vitamins, mineral nutrients or amino acids to foods	D.03
Reference quantities	Schedules M and B.01.001, B.01.002A ,D.01.001

2.6.2. CANADIAN FOOD INSPECTION AGENCY (CFIA) – GUIDE TO FOOD LABELLING AND ADVERTISING

Nutrient content claims about sodium (Chapter 7)[55]

"Very low sodium"

This claim is not permitted on foods sold in Canada (see Table 3)

"Salted"

Reference to the addition of salt to a food is not considered to be a nutrient content claim. The word "salted", or a synonymous term, used to indicate that salt has been added (either as part of the common name or as a separate claim: e.g., "extra salt", "salt water taffy", "salt cod", "salted peanuts"), does not trigger the declaration of the Nutrition Facts table for foods exempted by Section B.01.402. Similarly, the representation "lightly salted" can be made on fish without triggering the Nutrition Facts table on exempted foods.

In addition, a reference to a "salty taste" is considered a taste claim and does not trigger the Nutrition Facts table on foods otherwise exempted under Section B.01.401(2).

Sodium claims on foods that contain added potassium salts

When the sodium claims in the table below are made on the label of a food (or in an advertisement for the food placed by or on the direction of the manufacturer) that contains added potassium salts, the potassium content per serving of stated size must be declared in the Nutrition Facts table. This includes any form of potassium salts, including food additives

Ingredients that functionally substitute for salt

The "no added sodium or salt" claim outlined in item e) of Table 7-10 below specifies that the food contains "no added salt, other sodium salts or ingredients that contain sodium that functionally substitute for added salt". These include ingredients that give a salty taste to foods such as hydrolyzed vegetable proteins, soy sauce, bouillon powder or cubes, soup mix, etc

Nutritional content claims about potassium

Linked to stage 5 in Table 2

They were not specifically dealt with in the 2002 FDR modifications concerning claims about nutritional value. See Table 6 below.

TABLE 6 | SUMMARY OF NUTRIENT CLAIMS ABOUT POTASSIUM

Claim	Criteria – Food (by serving of stated size	Criteria – Label or advertisement
a) "source of potassium" "contains potassium"	At least 200 mg	Nutrition Facts table must include the amount of potassium per serving. Nutrition Facts table required on products otherwise exempted by B.01.401(2)(a) and (b)
a) "good source of potassium" "high in potassium"	At least 350 mg	See conditions set out for item a) of this table.
a) "excellent source of potassium" "very high in potassium"	At least 550 mg	See conditions set out for item a) of this table

Rounding rules for sodium and potassium in nutritional facts table :

Sodium quantities must be rounded :	***Scale***
to 0 mg	when less than 5 mg
to the nearest multiple of 5 mg	when between 5 and 140 mg
to the nearest multiple of 10 mg	when above 140 mg

Details can be found in Sections [B.01.401, Section 8 of following table] and [B.01.402, Section 9 of following table].

Health claims about sodium and potassium

Linked to stage 5 in Table 2

The FDR now allows six claims [B.01.601, B.01.603], in cases in which conditions regulating labelling and the composition of the product are met. They all deal with the relationship between a low-salt diet that is high in potassium and high blood pressure risk reduction

For example :
"A healthy diet containing foods high in potassium and low in sodium may reduce the risk of high blood pressure, a risk factor for stroke and heart disease. (Naming the food) is low in sodium."

2.7. SALT SUBSTITUTION ALTERNATIVES

2.7.1. 1st SOLUTION: REDUCE SALT GRADUALLY

Linked to stages 4 and 5 in Table 2

The simplest solution consists in adding less sodium chloride without any other changes. Sometimes salt concentration exceeds the amount required to meet its functions (preservation, texture or appearance). If this strategy is deployed gradually over several years, the consumer might not perceive the difference. Care must be taken to ensure that the consumer does not run into the taste threshold. [65] Certain studies mention that after three months of a low-salt diet, some respondents – but not the average buyers – prefer reduced salt products.

2.7.2. 2nd SOLUTION : REPLACE SALT BY OTHER NGREDIENTS

Stages 4, 5 and 11 in Table 2

A 30 to 50 % sodium reduction can be envisioned. This alternative is more complex, but its impact is quicker and often superior on sodium intake from transformed products. Tests are required to select substitute ingredients with a taste profile that best corresponds to the food.

Modify formulation to adjust basic tastes using the following ingredients :

- Sodium chloride substitutes (other salts or additives);
- Yeast extracts;
- Hydrolysed vegetable proteins (HVP);
- Autolysed dry yeast;
- Flavour (primary taste and reaction taste);
- Monosodium glutamate (MSG);
- Guanylate or inosinate;
- Peptide-based compounds;
- Spices;
- etc.

Several examples of these ingredients are presented in Table 7 (at the end of this section). The following model [66] explains visually how to assemble a taste profile using several types of potential ingredients destined to replace the sodium chloride in a food partially or completely. Certain ingredients (HVP and certain yeast products) are usually used for certain desired functions (HVP and certain yeast products for basic taste; flavour/taste for the specific volatile profile; salt, guanylate, inosinate, MSG or other salts for their taste enhancing capacity). Specific ingredients can accomplish the combined functions in more than one of the three dimensions of the taste profile (e.g., certain yeast extracts) illustrated in Figure 4 below.

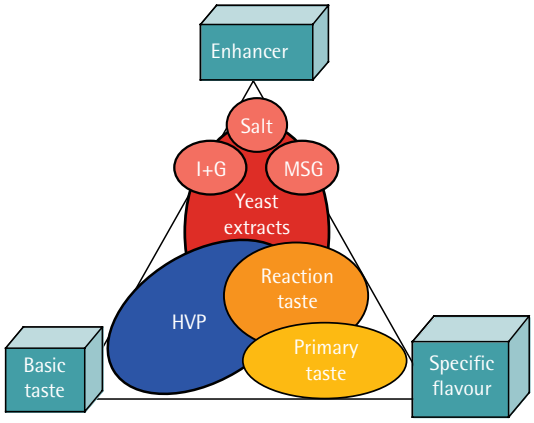

Figure 4. . Taste profile of certain ingredients

2.7.3. ADD TASTE ENHANCERS [67]

A taste enhancer is a substance that, without having a pronounced taste, does not modify the taste but increases the intensity of how the smell and taste of a food is perceived. Taste enhancers work by activating receptors in the mouth and throat, which helps compensate for salt reduction.

They stimulate receptors linked to the umami taste by improving the balance of taste perception in foods. They also help mask undesirable tastes. The umami taste can be used to counter the bland profile of low sodium products. Compounds that induce this sensation exist in almost all foods in different proportions.

Some peas and tomatoes naturally contain a large dose of glutamic acid. Shitake, mushrooms, and tuna naturally contain other compounds such as nucleotides that function in synergy with glutamic acid. Certain ingredients have umami characteristics

- Soy sauce;
- Yeast extracts;
- Monosodium glutamate (MSG);
- Nucleotide concentrated ingredients

In Canada the ingredients below are considered to be taste enhancers according to FDR [B.01.009(3)]. However, in some places in the world (e.g., EU), some of these ingredients are also considered to be food additives :

- Ribonucleotide (disodic or calcic);
- Sodium or calcium guanylate;
- Sodium or calcium inosinate;
- Monopotassium or monosodium glutamate;
- Hydrolysed vegetable protein

Glutamates

Monosodium or monopotassium glutamate (MSG) is the most common and most widely used taste enhancer in the world. It easily raises the salty taste of a wide variety of food products. In 2003, a million and a half tonnes of MSG were produced, of which about 80 % was destined for the Asian market. Generally known as glutamate or MSG, it adds an umami profile by providing a taste dimension that reminds one of a broth or meat.

The chemical name of MSG is: sodium (S)-2-amino-5-hydroxy-5-oxo-pentanoate ($C_5H_8NNaO_4$). In pure form, MSG is a white crystalline powder. MSG is the sodium salt in glutamic acid, an amino acid found naturally in many foods (dairy products, meats, fish, and certain vegetables) Foods such as mushrooms and tomatoes contain high levels of glutamate. Maternal milk contains ten times as much glutamate as cow's milk. The human body also produces glutamate [68], which is essential to normal functioning. Today, MSG is produced using molasses in an industrial fermentation process. It used to be extracted from protein-rich foods such as algae. Since MSG contains almost three times as much sodium as salt, it is possible to reduce sodium by from 20 to 40 %.

According to the European Union,[69] it is entirely safe to use it as a taste enhancer. However, MSG has earned a bad reputation because its use is very controversial (e.g., headaches or nausea for people with vitamin B6 deficiency). Although a small number of people have declared reactions to MSG, scientific studies suggest that there is no direct link between glutamate and these undesirable effects. Other studies appear to have established that other ingredients consumed during the meals, such as shrimps, peanuts, spices, or herbs, most often caused the allergic reactions. Information is available on the Health Canada website. [68].

Soy sauce

Soy sauce contains more than 300 flavour compounds including glutamic acid. It raises the sweetness profile of bitter foods and can be used to balance the acidic taste of finished products.

Yeast products

"Dietary" yeast is a microscopic mushroom, most often unicellular, that can ferment organic plant substrates (usually sugar). Yeast strain Saccharomyces cerevisiae is frequently used in industrial fermentation of food. As a main product (baker's yeast) or co-product (brewer's yeast) of fermentation, it is usually obtained by centrifugation or filtration; it can be preserved active or inactive and fresh or dry.

This type of yeast is often found as a palatability ingredient, known as **"inactive dry yeast"**, **"yeast autolyzate"** or **"yeast extract."** The first type is partially autolyzed while the second is completely autolyzed. The third type ("yeast extract") is entirely autolyzed and the yeast's cell walls are eliminated. Autolysis techniques involve activation of intracellular enzymes after moderate thermal shock and addition of certain adjuvants.

Yeast extract is rich in glutamic acid, peptides, nucleotides, glutathione, group B vitamins, minerals or other flavour compounds. Depending on the profile of these components, the extract is used to provide a specific "basic taste" to the product (lactic, grilled, toasted notes, etc.), to provide a salt and umami flavour enhancer (because of glutamic acid and nucleotide concentration) or it can have a Kokumi effect (specific depending on its glutathione concentration).

Used at concentrations of 0.25 to 2 %, these ingredients provide the option of a "natural" connotation and can be used to reduce or replace HVP, MSG or salt in foods. Because of their high solubility, they can be used without changing food texture. With their high protein content, they can be used as a basic ingredient. Their taste profile is very broad. A very wide range of products are available off the shelf, and are often developed for the following categories of food and applications :

- soups, broths and sauces;
- salted drinks;
- snacks;
- ready-made meals;
- meat products;
- fish derivatives;
- bakery products;
- dairy products.

High nucleotide ingredients

In several cases, addition of nucleotides induces a synergy with certain salt substitution ingredients that alone do not provide the full umami profile (e.g., MSG). High nucleotide enhancers can strongly amplify the intensity of the umami taste.

A) Disodic guanylate

Disodic guanylate or disodium 5'-guanylate is a guanosine monophosphate (GMP) soda salt. It is a umami type taste enhancer and is produced using yeast (mainly), fish (e.g., sardines) or dried algae. It can be used in developing flavours to replace salt. Very low concentrations are generally used for human foods. For more information, it is recommended to consult Health Canada.

B) Disodic inosinate

Disodic inosinate or disodium 5'-Inosinate (short form (IMP) is as inosinic acid disodic salt. It is an enhancer that provides the umami effect as does disodic guanylate.

C) Calcium inosinate

Inosinic acid, derived from its disodic salt, is unstable in hot water or is degraded by the phosphatase in certain foods. Calcium inosinate does not have this negative reactivity linked to his hydrosoluble nature so that it widely used in meat and fish products, preserves, instant noodles, etc.

D) Disodic ribonucleotide

This is a mixture comprising two flavour enhancers: disodic guanylate and disodic inosinate. It is widely used by the food industry. It is found in the form of an odourless white powder. It acts in synergy with MSG. A mixture comprising 98 % of MSG and 2 % of disodic ribonucleotide has four times the intensity of MSG used alone.

E) Calcium ribonucleotide

Calcium ribonucleotide is a mixture comprising two taste enhancers: calcium guanylate and calcium inosinate. The latter two must comprise 95 % of the mixture. Unlike disodic ribonucleotide, it does not have the negative reactivity with hot water. Applications are the same as those of calcium inosinate.

Hydrolysed vegetable proteins (HVP)

LHydrolysed vegetable proteins (HVP) are broken down into amino acids by a chemical or enzymatic process (acid hydrolysis). Normally, they are neutralized, filtered and spray dried. They bring two dimensions to the taste profile of a food by contributing to build a basic taste (e.g., light

meaty taste) and have a flavour enhancer. The primary factors below contribute to vary the HVP taste profiles [66].

- Level of discolouration;
- Protein source (soy, corn, canola or wheat);
- Added ingredients;
- Transformation method (operational parameters);
- Drying method.

These ingredients are often available in powder, paste, or liquid form. They are relatively heat stable. HVPs are inexpensive and provide food with a good taste profile.

2.7.4. ADD INGREDIENTS THAT MODIFY TASTE PERCEPTION

Adenosine monophosphate (bitterness inhibitor)

Adenosine monophosphate (AMP) blocks the bitterness of several bitter ingredients by reducing the activation of certain sensory receptors. [70,71] The US firms Linguanen amd RedpointBio[72] use patented technologies and use AMP (US 6,540.978; US 7,452,563; US 7,555,872) under the brand Betra™. This type of product/component is also said to have a positive effect on the salt taste and the umami taste. These firms do not sell ingredients, but market their patented technology to certain food processing or ingredient manufacturing companies among others. Addition of this component could be used for salt substitution ingredients, such as in potassium chloride mixtures

Menthol, menthyl-lactate and other by-products

Menthol, menthyl-lactate, TK-10, WS-3 and WS-23 are usually associated with a refreshing sensation. They can be used in salt substitution ingredients at doses from 0.001 to 0.005 ppm. The firm givaudan applied for a patent in 2008 for this type of application (WO2008148234).

Peptides and amino acids

Peptides are short-chain proteins. Most are bitter. Some have a sweet or bitter taste. Of the 1000 evaluated for this type of application, less than 5 % have a salt taste:

- ornithyl-β-alanine.OH•HCl [73,74];
- glycine ethyl ester.HCl.

They are not widely commercialized and approval can take several years. Certain amino acids are obtained by fermentation. [75] Certain commercial substitution ingredients use the enhancing effects of L-lysine and or L-arginine that have a salty and astringent characteristic.

2.7.5. ADD SALT-FLAVOURED INGREDIENTS

A) Minerals

The "mineral" option can also involve mixing different salts to avoid the inconvenience of using potassium chloride alone. Calcium or magnesium salts of have a bitter taste when used alone. It is difficult to combine them to neutralize or balance their taste.

Potassium chloride (KCl)

Use of KCl is the most frequent sodium-reduction solution for replacing NaCl. Potassium chloride has a similar salty taste to that of salt itself. The intensity of its salty characteristic is however of the order of 30 % compared to that of NaCl. Nonetheless, KCl often leaves a bitter and metallic (unpleasant) after taste that makes it different from NaCl. Its use can cause problems for people suffering from Type 1 diabetes, such as liver and heart problems caused by high potassium levels, which means that these people must limit their consumption of this type of salt.

It is difficult to use it alone but its taste can be masked using taste enhancers (glutamate, yeast extracts) or flavours. Masking agents can all be added to counter the bitterness and the metallic sensation (such as Pansalt (KCl+Mg sulphate+amino acid +hydrochloride de L-lysine):

- tricalcium phosphate;
- citric acid;
- magnesium sulphate;
- potassium iodide;
- cream of tartar.

Potassium sulphate

It has an impact on the salt taste, acidity, bitterness, and sweet taste. As the sulphate concentration increases, the sweet taste tends to decrease in intensity unlike the other attributes.

Calcium chloride

Calcium chloride has a bitter, sour and sweet profile. [76] Sodium chloride (salt) enhances its salty taste. Sucrose and citric acid have a suppressant effect, which gives calcium salts their sapid characteristic. [77] At certain concentrations, calcium chloride can leave metallic, astringent, and irritation sensations (e.g., "hot" peppers). Restrictions on certain uses are described in Tables VI, X and XIV of Division 16 of FDR [B.16. 100].

Magnesium sulphate

It provides foods with a bitter and salty taste. [78] However, at certain NaCl concentration, it has a suppressant effect on the salty taste. Its use as a salt-substitution ingredient mixed with other salts is patented under certain forms. [79,80,81] It is considered to be an additive by Health Canada, particularly as a pH adjusting agent. Use of magnesium salts is often restricted in Canada. Restrictions to certain uses are described in Tables VIII, X and XIII of Division 16 of FDR [B.16. 100].

B) Mycoscent

Mycoscent is a mycoprotein derivative and is a source of ribonucleotides. It appears to be the only one in its category. This ingredient is manufactured by Marlow Foods in the United Kingdom where it is considered to be a flavouring preparation. It is declared as a flavour. No Canadian suppliers currently distribute it. Reformulation work has been conducted (FSA) for breads, meat products, snacks, sauces, soups, and prepared dishes. [82,83] This product is linked to a patent.[84] It provides a salty taste because of its enhancer role. It has a low sodium contribution (depending on average dose: 0.2-0.2 %).

C) Trehalose

Trehalose (alpha-D-glucopyranosyl-alpha-D-glucopyranoside, dihydrate) is a non-reducing sugar; it is a holoside formed with two glucose molecules. It is a compound that can reduce, or even eliminate, bitterness attributes and astringent, and metallic sensations. According to JEFCA (Joint FAO/WHO Expert Committee on Food Additives), it is a texturing, stabilizing, moistening, and sweetening agent. [61] It is recognized for its capacity to stabilize proteins and enhance taste. According to Health Canada and the FDR, it is not an additive permitted in Canada. [58] Its application is linked to a European patent. (EP083820) The firm Cargill commercializes it under the brand Ascend™ and claims that it comes from cornstarch and that it has a sweet taste without an after taste. Applications mentioned are energy bars and sports drinks. [85]

D) Lactates

According to the FDR, lactic acid salts are additives. They enhance food taste. Potassium and sodium lactates are used in meat and poultry products as preservative agents and additives. [86] Calcium lactated has a tart (sour) profile. [87]

E) Glycine

Health Canada considers that glycine is an additive with a sequestering agent function. Restrictions to its use are described in Table XII of Division 16 in the FDR (B.16. 100). Its functions can also be those of a water activity depressor and salty taste enhancer in meat products. Work on sausage matrices has shown that glycine decreases the perception of salt and tart tastes [88,89] but it is possible to use them in other food products. [88]

F) Concentrated dairy minerals

LactoSalt Opti Taste® d'*Armor Proteines* [92] is obtained through a milk fractioning process and contains 80 % dairy minerals. It contains 8-10 % of sodium (four times less than NaCl), 28-30 % potassium, 40-45 % chloride, and 2.5 % calcium. Currently, this product is not distributed in Canada where it is declared to be a modified dairy product. It could be a natural taste enhancer in certain food products

G) Dairy taste enhancer

The Dairy Farmer of America cooperative (in the United States) and *Fonterra* (in New Zealand) commercialize the ingredient *Savoury Flavor Enhancer MD 36490* under *DairiConcepts, L.P.®* [93]. In the United States, the ingredient declaration is: fully fermented milk, maltodextrin and milk protein concentrate. The ingredient contains about 250 mg of sodium, 5 g of potassium, and 460 mg of calcium per 100 g. This ingredient comes from a process using fermentation. The supplier claims that it provides a whole milk taste profile that reinforces the tastes of a wide range of food systems.

A poll of certain manufacturers with representatives in Canada (Agropur, Parmalat Canada and Saputo), France (Ingrédia) and Sweden (Arla Foods) was conducted. According to information gathered, these manufacturers do not offer salt-substitution ingredients in their product lines, which suggests that this market sector is very specialized.

2.7.6. 3th SOLUTION : USE FINER SALT

Once it is disolved, sodium chloride induces a salty taste. With certain technologies, it is possible to obtain very small-sized crystals with a particular crystal shape (cubic, dentitric, etc.) and a large contact or exposed surface. In certain cases, finer salt crystals can be used a lower concentration than conventionally sized crystals. (94) For example, vacuum-granulated dentitric salt (macroporous crystals) and "cubic" salt dissolves almost twice as fast as conventional salt. Among other features, this makes possible for water to bind better with microfibrillar proteins in meat products (e.g., sausages). In addition, it has been observed that the salty taste is released faster, based on their salt-perception intensity curve as a function time. The density of the ingredient can be an indicator of these attributes (ratio surface/modified crystal volume). Applications for these salts can include snacks, chips or certain meat products.

2.7.7. 4th SOLUTION : ADD PRESERVATIVE AGENTS

See Appendix 1.

TABLE 7 | SALT SUBSTITUTION INGREDIENTS AND CHEMICAL PRESERVING AGENTS

Supplier (Distributed by)	Manufacturer	Parent company of manufacturer or origin	Range	Name of ingredient	Ingredient components									Potential or indicated application‡					
					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
***Enhancers (chemical or other)**																			
Cambrian Chemicals	ND†			Monosodium glutamate			X								X	X	X	X	
Cambrian Chemicals	ND†			IMP, GMP ou I&G (50 % or 60:40 % mixtures)			X								X	X	X	X	
	Shanghai Xianlei Bioscience and Biotechnology Co., Ltd	Chine		Inosinates, guanylates et ribonucleotides (Ca, Na)			X								X	X	X	X	
Canada Colors and Chemical Ltd.	Deasang America Inc			Disodic ribonucleotide			X								X	X	X	X	
	Sensient	Canada		HVP - CVP 103 REG							X				X	X	X	X	
	Sensient	Canada		HVP - KERA WC2							X				X	X	X	X	
	Sensient	Canada		HVP - LITESATE 1							X				X	X	X	X	
	Sensient	Canada		HVP - OVP L							X				X	X	X	X	
***Yeast products**																			
René Rivest	Springer	France	Springer 4100®	Springer 4102/ 0-MG-L				X								X	X	X	
René Rivest	Springer	France	Springer 2000®	Springer 2020/ 0-MG-L				X	X							X	X	X	
René Rivest	Springer	France	Springer 2000®	Springer 2012/20-MG-L				X	X							X	X	X	
René Rivest	Springer	France	Springarom®	Springarom 7004/30-PW				-		X						X	X	X	
René Rivest	Springer	France	ND†	Springer 0402/20-PO-L				X			X					X	X	X	
René Rivest	Springer	France	ND†	Springer 1401/20-PO-L				X			X					X	X	X	
	Sensient	Canada		Veepro B-6301				X			X					X	X	X	
	Sensient			Flavormate 958				X	X										
	Sensient	Canada	Sensirome Ultra	Different profiles (Cheese SRUC40AG, Dark Meat RSUDM40AG, Light Meat RRULM40AG, vegetable SRUV40AG, etc.)				X								X	X	X	

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† Not determined
‡ The list of potential indicated applications is not necessarily complete and exhaustive. For information on potential applications, it is necessary to contact supplier directly.

Supplier (Distributed by)	Manufacturer	Parent company of manufacturer or origin	Range	Name of ingredient	Ingredient components									Potential or indicated application‡					
					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
Canada Colors and	Savoury Systems international			#1070 YE LS/HP enhancer				X							X				X
Chemical Ltd.	Savoury Systems internatonal			#0863 salt replacer/ enhancer				X		X						X	X	X	
Nealanders	ABF Ingredients - Ohly			Brumani® 817 (PN72000)				X						X			X	X	
Nealanders	ABF Ingredients - Ohly			Chet's cheese				X									X	X	
Nealanders	ABF Ingredients - Ohly			Flav-R-Max				X						X		X	X	X	
Nealanders	ABF Ingredients - Ohly		Provesta®	Provesta® 512 (PN30100)				X	X					X	X	X	X	X	X
Nealanders	ABF Ingredients - Ohly		Provesta®	Provesta® 208 (PN21700)				X			X			X		X	X	X	
Nealanders	ABF Ingredients - Ohly		Provesta®	Provesta® 224 (PN60201)				X									X	X	
Nealanders	ABF Ingredients - Ohly		Provesta®	Provesta® 029 (PN50101)		X		X						X	X				
Nealanders	ABF Ingredients - Ohly		Provesta®	Provesta® 222 (PN60101)	X	X		X									X	X	
Synergy Flavors Inc. (USA)	Carbery - Synergy Flavors	Ireland / United States		YEL501-000	X			X			X					X	X	X	
Dempsey Corporation	DSM	The Netherlands	Maxarome® Standard					X											
Dempsey Corporation	DSM	The Netherlands	Maxarome® Pure					X											
Dempsey Corporation	DSM	The Netherlands	Gistex®	Gistex® HUM LS				X											
Dempsey Corporation	DSM	The Netherlands	Gistex®	Gistex® standard range				X											
Dempsey Corporation	DSM	The Netherlands	Gistex®	Gistex® XII PDR. 2463	X			X								X	X	X	X
Dempsey Corporation	DSM	The Netherlands	Maxarome® Plus	Maxarome® PLUS 2491	X			X	X										
Dempsey Corporation	DSM	The Netherlands	Maxarome® Select	Maxarome® SELECT 9447	X			X	X							X	X	X	
Dempsey Corporation	DSM	The Netherlands	Savorkey®	BC et BB (paste, concentrate or powder)															

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					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
Dempsey Corporation	DSM	The Netherlands	Expresa®	Expresa® 2200															
Dempsey Corporation	DSM	The Netherlands	Maxavor®	RYE (A, AS, ABLS, B, C, D, T) et YB															
	Food Source International, Inc.	United States		Salt substitute/ enhancer 1201490	X			X	X		X					X	X	X	
	Food Source International, Inc.	United States		YE LS HP enhancer 1201310	X			X	X							X	X		
	Kohjin Co Ltd.	Japan		Aromild				X	X						X				
	Lallemand		LBI	LBI LS55				X								X	X	X	
	Lallemand		LBI	LBI Q 35				X	X							X	X		
	Lallemand		LBI	LBI Q 83				X	X							X	X	X	
	Lallemand		LBI	LBI 4007	X			X											
	Lallemand		LBI	Different profiles (chicken LS70. chicken/ umami P173, meat/ salted P16, meat/salted SD20. chicken/salted SD38, etc)				X								X		X	
Calico Food Ingredients Ltd.	PTX Food Corp	United States		PTX Intense-2 arôme						X	X				X	X	X	X	X
	Ungerer & Company	United States	Unsal 20	Different profiles (Beef V6194, Cheese Z7137, Chicken V6192, garlic Z7142, Lamb V6646, Mushroom V6193, onion Z7144, Pork V6252, Tomato V6667, Vegetable V6195, etc.)						X						X	X	X	
***Diverse: ingredients, additives or salt-substitution components**																			
Canada Colors and Chemical Ltd.	Essential Fine Ingredients			Glycine			X						X		X				
«aucun / ND†»	Marlow Foods	United Kingdom		Mycoscent						X	X				X	X	X	X	
	Cargill			Ascend®			X												
Synergy Flavor Inc. (USA)	Carbery - Synergy Flavors	Ireland / United States	SaltMate																
HT griffin				Soy sauce							X								
Thomas Large	Aji-no-moto®	Japan		Kojiaji															
	Wild Flavors	United States		Light shield															

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					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
ND†	Kohjin Co Ltd.	Japan		Aromild															
	PTX Food Corp	United States		PTX - salt eliminator															
	Linguanen et/ou RedpointBio		Betra™ (technologie)	Does not sell ingredients, but markets their technology															
*Lactates																			
PURAC America Inc.	Purac	The Netherlands	Purasal®	Purasal powder s98								X	X						
Cambrian Chemicals	ND†			Lactate de sodium								X	X						
PURAC America Inc.	Purac	The Netherlands	Purasal®	Purasal lite S/3								X	X		X				
PURAC America Inc.	Purac	The Netherlands	Purasal®	Purasal lite S/6								X	X	X					
PURAC America Inc.	Purac	The Netherlands	Purasal®	PURASAL HIPURE P Plus								X	X		X				
Cambrian Chemicals	ND†			Potassium lactate								X	X						
PURAC America Inc.	Purac	The Netherlands	Purasal®	Purasal OPTI.FORM PD PLUS								X	X		X				
PURAC America Inc.	Purac	The Netherlands	Purasal®	Purasal OPTI.FORM PD4 ULTRA								X	X		X				
Cambrian Chemicals	ND†			Calcium lactate								X	X						
PURAC America Inc.	Purac	The Netherlands	Puracal®	Calcium lactates								X	X						
*Dairy ingredient based substitutes																			
«Aucun au Canada / ND† »	Armor protéines	France		Lactosalt optitaste		X								X	X	X	X	X	X
	Dairy Concepts (Fonterra et DFA)			Savory flavor enhancer MD 36490							X			X		X	X	X	
*Mineral substitutes																			
Nealanders	ND†			KCL (K7904)		X								X	X	X	X	X	X
	Wild Flavors	United States		KCL - DABC666		X													
ALMAT	Dr Paul Lohmann	Germany	LomaSalt	RS 100		X								X	X	X	X	X	X
ALMAT	Dr Paul Lohmann	Germany	LomaSalt	RS 50 classic	X	X								X	X	X	X	X	X
ALMAT	Dr Paul Lohmann	Germany	LomaSalt	RS 50 extra	X	X								X	X	X	X	X	X
ALMAT	Dr Paul Lohmann	Germany	LomaSalt	RS 50 neutral	X	X								X	X	X	X	X	X

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					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
	Sensient			Salt replacer SN1000020171		X		X		X	X					X	X	X	
Debro Chemicals	Jungbunzlauer	Switzerland		Sub4salt®	X	X								X	X	X	X	X	
Cargill Ltd. (Canada)	Cargill		SaltWise®	Saltwise- Plus 0029		X								X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		SaltWise®	Saltwise- Plus 1029		X								X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		SaltWise®	Saltwise- Plus 1529		X								X	X	X	X	X	X
Danisco	Firmenich			Saltprint (Firmenich)		X													
Debro Chemicals	The Low Sodium Sea Salt Co Ltd	United Kingdom		Solo® sea salt	X	X								X		X	X	X	X
Accord International	Oriola Oy	Finland		Pansalt® (retail market)		X													
Calico Food Ingredients Ltd	PTX Food Corp	United States		PTX Zalt-ND substitut	X	X				X					X	X	X	X	X
Canada Colors and Chemical Ltd.	Jarchem Industries Inc.			Chlorure de calcium (94 % anhydre: 2X+ soluble que flocon)		X						X							
Canada Colors and Chemical Ltd.	Specialty Minerals	Canada		Vicality ALBAGLOS PCC									X						
Canadian Salt Company or Univar Canada	Morton Salt	United States		Lite salt®	X	X								X	X	X	X	X	X
"ND‡ in Canada"	Morton Salt	United States		Lite Salt® Mixture (retail market USA)	X	X					X								
"ND‡ in Canada"	Morton Salt	United States		Salt Balance™ (retail market USA)	X	X													
"ND‡ in Canada"	Morton Salt	United States		Salt Substitute™(retail market USA)		X													
	Advanced Food Systems	United States		Salt replacer T#16	X	X				X				X	X	X	X	X	X
	Advanced Food Systems	United States		Salt substitute CL t#1		X				X				X	X	X	X	X	X
	Advanced Food Systems	United States		Sea salt replacer T#2	X	X				X				X	X	X	X	X	X
	Alexander Flavour	United Kingdom		Salt rite substitute - 10246		X				X	X			X		X	X	X	
	Danisco			Salboost															
	Ingredients Inc.	United States		Salt substitute (100 %) 0092-R-03		X					X			X	X	X	X	X	X

‡ *Not determined*

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Supplier (Distributed by)	Manufacturer	Parent company of manufacturer or origin	Range	Name of ingredient	Ingredient components									Potential or indicated application‡					
					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
	Food Source International, Inc.	United States		Salt replacement enhancer kcl (pn 1201540)		X		X		X	X			X	X	X	X	X	X
	Eurogerm	France	Altosel®	Elite altosel 1,5 %		X					X			X					
	Nutraceutics D&S			Ksalt®		X								X	X	X	X	X	X
	Prime Favorites			Neutralfres - KCL blend		X				X						X	X	X	
	Selako Oy	Finland	Flavomare®			X													
	Swagger Food Corp US			50 % Reduced sodium salt replacer	X	X		X			X			X	X	X	X	X	X
	Wixon Inc.	United States		Kclean Salt 12007414	X	X				X	X			X	X	X	X	X	X
	Wixon Inc.	United States		Bonded KCL MIMIC 11004279		X				X				X	X	X	X	X	X
Canada Colors and Chemical Ltd.	Savoury Systems internatonal			#0864 salt replacer/ enhancer															
Canada Colors and Chemical Ltd.	Savoury Systems internatonal			#0886 salt replacer		X		X		X				X	X	X	X	X	X
	Givaudan		Taste Essentials (technology)	Lite Salt™ Mixture (does not sell ingredients, but markets their technology)	X	X													
	Givaudan		Taste Essentials (technology)	Salt Balance™ Salt Blend (does not sell ingredients, but markets their technology)	X	X													
*Crystalline form sodium chloride																			
Cargill Ltd. (Canada)	Cargill		Alberger®	Coarse topping flake salt	X						X			X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Fine flake improved salt	X						X			X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Fine flake iodized salt	X	X					X			X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Fine flake prepared salt	X						X			X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Fine flake salt	X						X			X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Fine flake supreme salt	X						X			X	X	X	X	X	X

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					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
Cargill Ltd. (Canada)	Cargill		Alberger®	Fine flour salt	X							X		X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Shur-Flo® fine flake salt	X							X		X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Shur-Flo® fine flour salt	X							X		X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill		Alberger®	Special flake salt	X							X		X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill			Microsized® 95 extra fine salt	X							X		X	X	X	X	X	X
Cargill Ltd. (Canada)	Cargill			Premier™ fine prepared flour salt	X							X		X	X	X	X	X	X
Société Canadienne de sel ou Univar Canada	Morton Salt	United States		Star Flake® Dendritic	X									X	X	X	X	X	X
Société canadienne de sel ou Univar Canada	Morton Salt	United States		Star Flake® Dendritic ES salt	X									X	X	X	X	X	X
	Kerry - Mastertaste			CM.232 salt Fine	X						X								
*Chemical preservatives (preserving agents)																			
Cambrian Chemicals	ND†			Calcium ascorbates								X							
Cambrian Chemicals	ND†			Sodium ascorbates								X							
Canada Colors and Chemical Ltd.	Rhodia Food			Calcium carbonate								X	X	X					
Canada Colors and Chemical Ltd.	Kissner			Ammonium hydrogencarbonate								X							
Cambrian Chemicals	ND†			Sodium citrate								X							
ND†	Cargill			Sodium citrate								X							
Rudolph 2000	ND†			Potassium citrate - (2410)								X							
Canada Colors and Chemical Ltd.	Cargill			Potassium citrate								X							
Cambrian Chemicals	ND†			Potassium citrate								X							
Canada Colors and Chemical Ltd.	Rit-Chem Co.			Calcium citrate								X							
Canada Colors and Chemical Ltd.	Rit-Chem Co.			Calcium citrate								X							
Rudolph 2000	Jiangbei Additive Company	China		Calcium citrate - (2864)								X							

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					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
Cambrian Chemicals	ND†			Calcium citrate								X							
Cambrian Chemicals	ND†			Citric acid								X							
Rudolph 2000	Shihezi City Changyun Biochemical Company	China		Citric acid - (4900)								X							
Cambrian Chemicals	ND†			Benzoates (Na)								X							
ND†	DSM	The Netherlands	Purox®	Purox S								X							
Canada Colors and Chemical Ltd.	Emerald Kalama Chem LLC			Potassium benzoate								X							
Rudolph 2000	Nanjinj Zongheng Bioscience and Technology	China		Granulated sodium benzoate (0691)								X							
ND†	DSM	The Netherlands	Purox®	Purox B								X							
	Kerry - Mastertaste			Sodium erythorbate CM.459								X							
Cambrian Chemicals	ND†			Sodium erythorbate								X							
Rudolph 2000	Zhengzhou Tuoyang Bioengineering Company	China		Sodium erythorbate (0867)								X							
Rudolph 2000	ND†			Sodium propionate - (8155)								X							
Rudolph 2000	Niacet Corporation	United States		Calcium propionate - (2418)								X							
Rudolph 2000	Macco	Canada		Sodium propionate - (0224)								X							
Cambrian Chemicals	ND†			Sodium propionate								X							
Cambrian Chemicals	ND†			Sodium propionate								X							
Canada Colors and Chemical Ltd.	Rugao Changji-ang Food Co.			Potassium sorbate - powder 757310								X							
Canada Colors and Chemical Ltd.	Rugao Changji-ang Food Co.			Granulated potassium sorbate - 757305								X							
Rudolph 2000	Zhejiang Bosson Ingr. Company	China		Potassium sorbate (4275)								X							
Cambrian Chemicals	ND†			Potassium sorbate								X							

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					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
Cambrian Chemicals	ND†			Sodium stearates															
Cambrian Chemicals	ND†			Sodium stearates															
PURAC America Inc.	Purac	The Netherlands	Purac®	Purac powder 60								X	X	X		X	X	X	
PURAC America Inc.	Purac	The Netherlands	Purac®	PURAC lactic acid (50. 80 ou 88)								X							
Unipex (Multi-Chem)	Purac	The Netherlands	Purac®	PURAC lactic acid 88								X							
Cambrian Chemicals	ND†			Lactic acids (50. 80. 88)								X							
*Flavours																			
	Wild Flavors	United States		Salt TRIM						X	X			X	X	X	X	X	
	Wild Flavors	United States		Savorcrave						X	X			X		X	X	X	
	Wixon Inc.	United States		Magnifique Mimic Natural Powder 61004212						X	X			X		X	X	X	X
	Wixon Inc.	United States		Magnifique Mimic liquid 11004200						X				X		X	X	X	X
	Alexander Flavour	United Kingdom	Nalow®	Nalow salt substitute flavour - af 1765						X				X	X	X	X	X	X
	Essences & Fragrances Bell			#11.9743 enhancer Flavour nat						X	X				X	X	X	X	X
	Essences & Fragrances Bell			#11.9743a enhancer Flavour nat SD						X	X				X	X	X	X	X
	Food Source International, Inc.	United States		Organic salt substitute (pn 1201830)							X								
	Food Source International, Inc.	United States		Salt replacer (pn 1201770)							X								
	Kerry - Mastertaste			Salt enhancer 708819						X						X	X	X	
	Kerry - Mastertaste			Salt enhancer 711047						X									
	Flavor Dynamics, Inc.			Natural salt replacer / enhancer						X	X					X	X	X	X
Calico Food Ingredients Ltd.	PTX Food Corp	United States		PTX intense 101 arôme		-				X	X				X		X	X	X

** This is not an exhaustive list of all suppliers, manufacturers and existing products*
† Not determined
‡ The list of potential indicated applications is not necessarily complete and exhaustive. For information on potential applications, it is necessary to contact supplier directly.

Supplier (Distributed by)	Manufacturer	Parent company of manufacturer or origin	Range	Name of ingredient	Ingredient components									Potential or indicated application‡					
					Nacl	Mineral substitute	Chemical enhancer	Yeast product	High nucleotide concentration	Flavour	Other	Preserving agent	Functional agent	Baking or pastry	Meat products	Soups or sauces	Prepared foods	"Savoury" applications	Produits laitiers
Calico Food Ingredients Ltd.	PTX Food Corp	United States		PTX Savory flavour enhancer 201 arôme						X					X	X	X	X	X
Calico Food Ingredients Ltd.	PTX Food Corp	United States		PTX Savory flavour enhancer 101 arôme						X					X	X	X	X	X
Calico Food Ingredients Ltd.	PTX Food Corp	United States		PTX SW 101 arôme						X	X				X		X	X	X
*Phosphates																			
Cambrian Chemicals	ND†			Phosphates								X	X		X				
Canada Colors and Chemical Ltd.	ICL Performance products			Phosphates (tous)								X	X		X				
Canada Colors and Chemical Ltd.	Innophos			Phosphates								X	X		X				
Cambrian Chemical	ND†			Calcium monophosphate									X						
Canada Colors and Chemical Ltd.	Innophos			Cal-Rise® (capp)		X						X	X	X					
Canada Colors and Chemical Ltd.	Innophos			Regent 12 XX		X						X	X	X					
	Kerry - Mastertaste			Sodium tripolyphosphate cm.013		X						X	X			X	X	X	
*Several functional ingredients (binders and others) that can be used in meat products																			
Dempsey Corporation	SunOpta			Oat fiber 770									X		X		X		
Dempsey Corporation	SunOpta			Org soy fiber p710									X	X	X				
Newly Weds ou René Rivest	Parmalat			Dairy-LO 35 (wpc)									X		X				
Thomas Large	Aji-no-moto®	Japan		Transglutaminase Activa gS	X						X	X	X						
Thomas Large	Aji-no-moto®	Japan		Transglutaminase Activa RM (meat)							X		X		X				
Thomas Large	Aji-no-moto®	Japan		Transglutaminase Activa TI							X		X		X				
Dealers Ingredients Inc.	Fiber Star		Citri-Fi	100							X		X	X	X				X
Dealers Ingredients Inc.	Fiber Star		Citri-Fi	100-M40							X		X	X	X				X
Dealers Ingredients Inc.	Fiber Star		Citri-Fi	101-FD							X		X	X	X				X

** This is not an exhaustive list of all suppliers, manufacturers and existing products*
† Not determined
‡ The list of potential indicated applications is not necessarily complete and exhaustive. For information on potential applications, it is necessary to contact supplier directly.

Part 3

Examples of applications

3.1. PRESENTATION OF THE APPROACH FOR THE SEVEN PRACTICAL CASES

(Appendix 5)

The sodium-reduction exercise was conducted for the following seven products: two prepared frozen dishes (a quiche and a lasagne), a fresh sausage, an oatmeal muffin, a chocolate chip cookee and an onion soup. For each food, the details are presented individually in Appendix 5. The general approach adopted for each application was as follows:

1. Develop a formulation called "positive control," i.e., a prototype with a list of ingredients and the sodium content are based on products available in grocery stores.
2. Select the salt reduction percentage based on the Health Check program *, the Health Canada nutrition claims, and the reduction targets of the United Kingdom's Food Standards Agency (FSA) [†].
3. Identify the sodium sources and the function of those ingredients and evaluate the microbiological risk of reformulation.
4. Select the most relevant substitution ingredients for the target application.
5. Formulate low-sodium prototypes and evaluate them with an internal panel in comparison with a positive control (not low sodium) and a negative control (less sodium but without substitution ingredients).

This approach is illustrated in Figure 5 and corresponds to stages 6 to 11 and 14 to 15 in Table 2 (low-salt product commercialization stages). Validation of the dietary safety (stage 20) is not addressed in theses application examples.

To limit the number of reformulation tests, five to ten salt substitution ingredients were used to provide an idea of the possibilities for each family of substitution ingredients, based on the hypothesis that similar ingredients give equivalent results [‡]. In most cases, one or two concentrations were tested, starting with the highest dose recommended by the manufacturer.

EVALUATION OF PROTOTYPES BY AN INTERNAL PANEL

Stage 15 in Table 2

When the developers considered that a reformulated product was acceptable, the members of the internal team evaluated the prototypes in order to guide the evolution of the formulations. The evaluation focused on the salt characteristic as well as on the persistence of the salt taste, the softness or the spiciness, on an intensity scale of 1 to 5; the value 1 corresponded to a low intensity (e.g., low salt) and 5 indicated high intensity (e.g., very salty). This evaluation was performed in comparison with the positive control (not low sodium) and the negative control (less sodium but without substitution ingredients). The level of the positive control was set at 4.0 and only those prototypes with a similar level were retained

REFORMULATION COSTS

It is possible that reduced sodium formulations cost more than regular products. Several factors can change the cost of the salt substitution ingredients. These include supply, demand, volume purchased, exchanger rates, etc. The question of supply is different for each company.

Stages 6 to 11, 14 and 15 in Table 2

* *It is important to note that the Health Check program establishes nutrition criteria linked particularly to fats and sugar, as well as sodium. However, only salt was taken into account in the preparation of this guide.*

[†] *Information gathered in April 2009*

[‡] *All substitution ingredients listed, classified in families, is provided in Table 7*

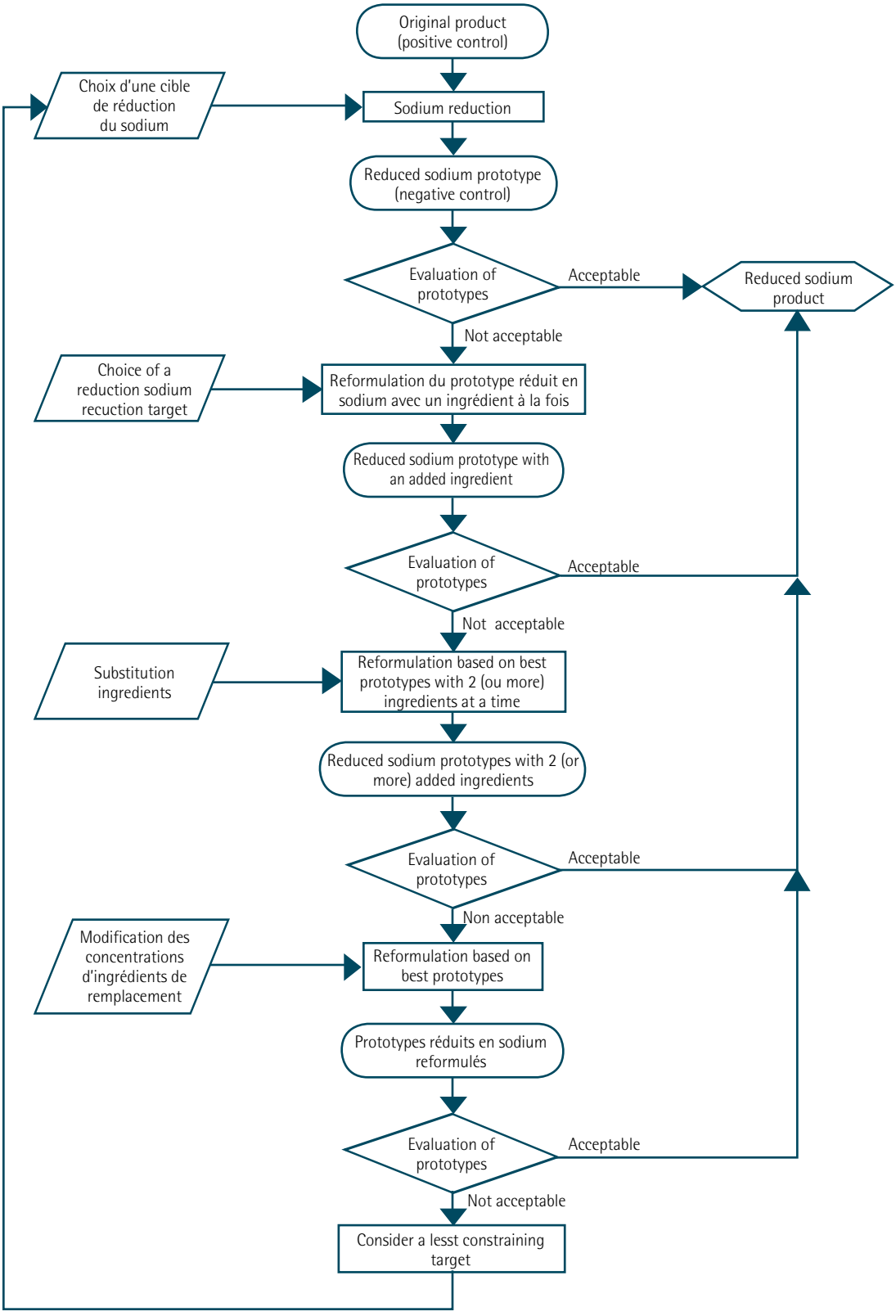

Figure 5. Reduced-sodium food reformulation stages

Appendices

Appendix 1 I Barriers to microorganisms and formulation safety

Several barriers exist to prevent development of microorganisms in food. Risk studies using tools such as predictive microbiology [95] and microbiological tests are required before final conclusions can be drawn. [96,97,98,99,100] The main barriers are: 1) decreased water activity, 2) increases in acidity and pH, 3) addition of antimicrobial agents, 4) oxygen exclusion, 5) heat treatment, 6) other (cold, drying, fermentation, etc.).

(1) WATER ACTIVITY

Development of certain microorganisms in food represents a health risk. Controlling the water activity (a_w) of food is critical. Water activity is the ratio between the water vapour pressure and pure water vapour pressure at the same temperature. This value is expressed on a scale of 0 (anhydrous substance) to 1 (pure water). Several moulds develop when a_w values exceed 0.70 and certain pathogenic bacteria appear at 0.83. To decrease the a_w of a food, water can be removed by drying it or by adding ingredients such as salt or sugar. In salt substitution projects, it must be remembered that salt (NaCl) is more efficient than sugar for reducing water activity, but also that potassium chloride (KCl) is also good for reducing a_w.

(2) INCREASING ACIDITY AND PH

Weak acids, including many organic acids (from a chemical standpoint), are usually better for penetrating the cells of microorganisms than strong acids (such as phosphoric acid). In comparison, the structure of foods is more affected by strong acids (for the same pH value). In general, bacteria develop or survive at pH values between 4 and 8. In the case of yeasts and moulds, the range can encompass pH values between 2 and 11. Table 8 (herein) describes the effect of acidity and pH on the growth and survival of the main pathogenic microorganisms.

Organic acids (weak acids)

Most organic acids are weak acids. Unlike strong acids, they are not completely dissociated when dissolved. They therefore exist in a dissociated form ($A^- + H^+$) or not so (AH), in proportions that depend on their pK_a (p function of their acidity constant K_a), and the pH of the surrounding environment. The pKa value corresponds to the pH in which half of the acid molecules are in the dissociated form. The dissociated form (A^-) of an acid frees a hydrogen ion (H^+) that acidifies the environment, but only the dissociated form (AH) enters the bacteria cells to modify their internal pH. Depending on the product's pH, the type of acid has to be chosen depending on its pK_a. Certain acids have more than one acid grouping and thus have a pK_a value for each of them. The main organic acids used in the food industry are acetic acid, citric acid, lactic acid, malic acid and tartaric acid

TABLE 8 I PK_A OF CERTAIN ACIDS

	1ST acid group	2nd acid group	3rd acid group
	pK_a	pK_a	pK_a
Acetic acid	4,76	--	--
Benzoic acid	4,20	--	--
Citric acid	3,12	4,76	6,40
Lactic acid	3,86	--	--
Malic acid	3,46	5,10	--
Proprionic acid	4,87	--	--
Sorbic acid	4,80	--	--
Tartaric acid	3,04	4,37	--

(3) ANTIMICROBIAL AGENTS

Certain organic acids and their salts make it possible to inhibit microorganism growth in other ways than intracellular pH reduction. For an organic acid salt to be efficient, the food matrix pH to which it is added must be near the pK_a value of the corresponding organic acid. The lower the ratio pH to pK_a is, the higher the efficiency of the organic acid salt. For example, potassium sorbate is more efficient with a pH value of 3 than with a pH of 5 because the sorbic acid, which has a pK_a of 4.8, it almost completely in its non dissociated form (more bactericidal) with a pH of 3, whereas at a pH of 5, it is only 40 % in it dissociated form

A) Lactates

Lactates (sodium or potassium) significantly reduce water activity (aw) of foods, more than sodium chloride. When pH is low, lactates take on the form of non-dissociated lactic acid that spreads bacteria through cell membranes, which has an inhibiting effect that is added to the drop in aw. That is why lactates are useful in salted meat products (sausages, etc.) for inhibiting growth of Clostridium botulinum and Listeria monocytogenes. Lactates are useful for formulation of reduced-sodium products

B) Sorbates and sorbic acid

Sorbates and sorbic acid are usually more efficient for inhibiting yeasts and moulds than for bacteria, especially organisms that require oxygen (aerobic). Therefore, their action is selective and does not inhibit growth of lactic bacteria useful for fermented products. They are efficient in countering certain pathogenic microorganisms such as moulds including *Aspergillius* and *Fusarium* types, as well as bacteria of the *Bacillus*, *Clostridium*, *Pseudomonas* and *Salmonella* types. They can also be used for example in dried fish products, mayonnaise, baking products, and certain cheese products

C) Benzoates

Benzoates are widely used in low pH formulations and their antimicrobial action mainly targets yeasts and moulds, including those that produce aflatoxins (carcinogenic mycotoxins). Although several bacteria are inhibited by benzoates, lactic bacteria and the *Clostridium* bacteria species are resistant to them.

Benzoic acid is naturally present in certain berries such as cranberries or blueberries. Sodium benzoate and potassium sorbate are often used in synergy in mayonnaise and salad dressing types of formulations. Indeed,

the combination of these two preserving agents is more efficient than either one used individually.

D) Propionates

Propionate functions at less acidy pH values (higher) than other chemical preserving agents and this makes its use adequate for bakery or pastry products. Moreover, its relatively low impact on yeast does not limit the activity of yeast. In addition, it is often used to prevent growth of mould on the surface of certain cheeses

E) Nitrites and nitrates

Nitrate has no direction antimicrobial action but it can represent a source of nitrites. These compounds contribute to the health safety of a product preserved for a long period, such as dried fermented sausages. Like many food preservatives, nitrites function best in an acid environment, when non dissociated acids affect the bacteria. In salted meat products (ham, sausage, etc.), nitrites play a major role in inhibiting *Clostridium botulinum* and in the length of time food products can be preserved. Nitrite concentration necessary to inhibit spore germination of this type of bacteria depends a lot on factors such as pH value, sodium chloride concentration, heat treatments, storage conditions, etc. Nitrites have synergy effects with sodium chloride in inhibition *C. botulinum*. Nitrite concentration is critical and must be approximately 100 ppm. It is important to refer to FDR for the maximum nitrite and/or nitrate doses for food products. Ascorbic acid (or the acid characteristic of a food) can influence the decrease in the dose. To control contamination by this pathogen in this type pf meat product, it is recommended to take the residual nitrite content into account

F) Phosphates

Phosphates favour general hygiene of products by decreasing the residual microbial flora (e.g., meat products). In Canada, phosphate doses are regulated. The pH in an aqueous solution varies according to each of the types of sodium phosphate frequently used in industry

G) Natural antimicrobial agents

Several projects focused on research for a natural substance to replace the preserving agents described above. Certain natural compounds have antimicrobial properties. However, the activity of these compounds is not well understood, relatively speaking. Their action seems inhibited in certain formulations. These ingredients require microbiological verification and regulations on standardization of certain foods must be taken into account.

Most of these ingredients are essential oil extracts from plants. Substances recognized to have an antimicrobial potential include rosemary extract,[101] grapefruit seed extract, garlic extract, thymol from thyme or oregano, cinnamaldehyde from cinnamon, and eugenol from cloves. Some of these compounds however are difficult to find commercially

(4) EXCLUSION OF OXYGEN

When oxygen is removed by vacuum or by replacement using mixture of gases (nitrogen and/or CO_2), the growth of aerobic microorganisms such as *Pseudomonas* is decreased in refrigerated products. However, this type of environment changes the type of bacteria that can develop, such as yeast, lactic bacteria, and enterobacteria. In addition, absence of oxygen fosters the growth of anaerobic pathogens like *Clostridium botulinum*. It is thus strongly recommended to avoid exceeding ten days storage in refrigeration unless a particular type of pasteurization has been used to destroy this type of spore. The presence of residual nitrites in meat products is thus desirable in products where this technology is used. Reduction of sodium chloride can thus have a major impact on food safety as regards *C. botulinum*. The survival, growth, and sporulation conditions of this microorganism need therefore to be reviewed

(5) HEAT TREATMENT

With salt substitution, the range of microorganisms that can develop expands and this can sometimes require greater heat treatments in accordance with the changing heat-resistance characteristics of the type of flora that can develop. Pasteurization (short time) consists in heating a product to 72 to 75°C for 15 to 20 seconds to destroy pathogenic microorganisms. This way of preserving foods thus does not destroy all the microorganisms, such as the bacterial spores that are usually more heat resistant. The "heat-resistance" of microorganisms can be higher or lower depending on the environment. The more acid there is in the environment, the lower is the heat resistance, which means that the heat treatment is milder. A more neutral food requires a more significant heat treatment. Short-time pasteurization aims thus at eliminating (excluding post-process contamination) non sporulating pathogens and is very specific to each product. Contemporary technologies often exceed 75°C. When 85°C exceeded, the chemical integrity of certain elements of the food can be attacked. Moderate heat treatment involved in pasteurization must be followed by refrigerated storage.

Long-time pasteurization (90°C for 10 minutes or its equivalent "D") is suited for foods that are vacuum-packed or packed in a modified atmosphere, which makes it possible to preserve them for ten days. This heat treatment can inhibit a vast quantity of bacterial spores of the *Clostridium* species. The time-temperature relationship can be modified depending on the food's acid profile.

The UHT acronym means that the process is conducted at ultra-high temperatures, at 135-150°C for two to three seconds. This treatment prolongs the preserving period of the product that can be stored at room temperature.

The time-temperature relationship for each product is usually different. The **pasteurization value "PV"** is therefore used to compare the different pasteurization levels. For example, a PV of 100 could correspond to a 100-minute treatment at 70°C, 10 minutes at 80°C or even one minute at 90°C. The **decimal reduction duration "D"** is the time required to reduce the quantity of the most important pathogenic microorganisms in the product by a factor of 10 (90 % reduction of the microbial population). A multitude of temperature and time combinations is thus possible for reducing them. For instance, at 121°C, the "D" of Clostridium botulinum is 13 seconds

(6) OTHER BARRIERS

It is possible to create barriers for microorganisms by using conditioning or processing technologies, such as freezing, refrigeration, drying, fermentation, high-pressure treatments, etc.

Appendix 2 | Targets and criteria for salt reduction in food [52,54,57]

Information gathered in April 2009

Food category	subcategory	FSA (UK) 2006 target (mg/100g)	FSA (UK) current 2010 target (mg/100g)	FSA (UK) proposed 2010 target (mg/100g)	FSA (UK) 2012 target (mg/100g)	Current Health Check criterion (mg/portion)	Current Health Check criterion portion (g)	Health Check criterion 2010 (mg/portion)	Health Check criterion 2010 portion (g)
GRAIN PRODUCTS									
Ready-to-eat breakfast cereals (20 g to 42 g per 250 ml)						480	30	240	30
Ready-to-eat breakfast cereals (43 g or more per 250 ml)						480	55	240	55
Breakfast cereals very high in fibre (28 g or more fibre per 100 g)						480	50	240	30
Hot breakfast cereals						480	40	240	40
Breakfast cereals		300	300		400				
Other cereals		300	300		250				
Bread						480	50	360	50
Other types of bread (bagels, pita, English muffins)						480	55	360	55
Pre-packaged or rolled bread		430	430		370				
Pre-packaged or rolled bread with dressing		500	500		450				
Bakery products (morning goods)		500	500		400				
Waffles and pancakes						480	50	140	15
Pasta						480	85	140	85
Pasta except ready-to-serve meals		200							
Pasta and noodles, natural and flavoured P			200		150				
Rice cake						480	50	140	15
Rice (except minute rice); grains nature						480	45	140	45
Natural instant rice						480	45	140	45
Rice (without flavour), as eaten		87	87		80				
Flavoured rice, tel que consommé		300	300		180				
Flour						480	50	140	30
Croutons						480	50	140	20

Food category	subcategory	FSA (UK) 2006 target (mg/100g)	FSA (UK) current 2010 target (mg/100g)	FSA (UK) proposed 2010 target (mg/100g)	FSA (UK) 2012 target (mg/100g)	Current Health Check criterion (mg/portion)	Current Health Check criterion portion (g)	Health Check criterion 2010 (mg/portion)	Health Check criterion 2010 portion (g)
DAIRY PRODUCTS AND SUBSTITUTES									
Milk and dairy drinks						480	250 (ml)	240	250 (ml)
Yoghurts						480	175	140	175
Yoghurt drinks						480	250 (ml)	140	250 (ml)
Vegetable drinks (soy drinks)						480	250 (ml)	240	250 (ml)
Cheddar and other pressed cheese	Mild cheddar and other typical or similar mild pressed cheese	670	670		720				
Cheddar and other pressed cheese	Old cheddar and other typical or similar mild (ou old) pressed cheeses	750	750		750				
Cheese						480	30	240	30
Vegetarian cheese						480	50	240	30
Fresh flavoured cheese						480	100	240	100
Fresh cheese	Mild white cheese (cream cheese)	320	320		300				
Fresh cheese	Natural cottage cheese	215	215		220				
Fresh cheese	Flavoured cottage cheese	250	250		250				
Natural cottage cheese						480	125	360	125
Natural ricotta cheese						480	55	240	55
Mozzarella		700	700	600	550				
Blue cheese					840				
Processed cheese	Cheese spreads	800	800		650				
Processed cheese	Other processed cheese (sliced, cheese strings or sticks)	1170	1170		750				
MEAT AND SUBSTITUTES									
Natural, seasoned, breaded meat / poultry	Natural raw meat/ poultry					480	125	0	125
Natural, seasoned, breaded meat / poultry	Seasoned, breaded raw meat/poultry					480	125	360	125
Natural, seasoned, breaded meat / poultry	Natural cooked meat/ poultry					480	100	0	100
Natural, seasoned, breaded meat / poultry	Seasoned, breaded cooked meat/poultry					480	100	360	100

Meat/poultry in sauce						480	140	360	140
Ground meat	Raw ground meat					480	100	360	100
Ground meat	Cooked ground meat					480	60	360	60
Meat patties, meatballs, etc.	Raw meat patties, meatballs, etc.					480	100	360	0
Meat patties, meatballs, etc.	Cooked meat patties, meatballs, etc.					480	60	360	60
Cooked vegetarian meat patties and meatballs						480	60	360	60
Bacon		1400	1400	1300	1150				
Ham/other cold meat		1000	1000	850	700				
Cold meat/ham						480	55	360	55
Sausages	Cooked sausages					480	55	360	55
Sausages	Raw sausages					480	75	480	75
Sausages	Sausages	550	550		450				
Sausages	Cooked sausages and sausage meat products	700	700	650	600				
Meat pies	*Delicatessen, pork pies and rolled sausages*	600	600	550	450				
Meat pies	Cornish and crusted pies	500	500	450	400				
Meat pies	Other meat-based pies, including sliced meat pies	450	450	400	300				
Vegetarian or meat pies						480	140		
Terrines, spreads or vegetarian pâtés						480	55	360	55
Quiches		300	300		280				
Other egg-based processed products		300							
Scottish eggs		400	400		350				
Fresh cooked meat		400							
Fresh cooked meat	With all muscle or reformed muscle				300				
Fresh cooked meat	Ground or reformed ground				500				

Food category	subcategory	FSA (UK) 2006 target (mg/100g)	FSA (UK) current 2010 target (mg/100g)	FSA (UK) proposed 2010 target (mg/100g)	FSA (UK) 2012 target (mg/100g)	Current Health Check criterion (mg/portion)	Current Health Check criterion portion (g)	Health Check criterion 2010 (mg/portion)	Health Check criterion 2010 portion (g)
Hamburgers, grill steaks, etc.	Fresh and frozen standard hamburger products and grill steaks	400	400		300				
Hamburgers, grill steaks, etc.	Specialty and high quality hamburgers	500	500		350				
Breaded chicken		400							
Franks, hot-dogs and hamburgers	Preserved Franks, hot-dogs and hamburgers	550	550		500				
Franks, hot-dogs and hamburgers	Refrigerated Franks			650	600				
Tuna, preserved		400	400		400				
Salmon, preserved		470	470		370				
Other preserved fish		600	600		500				
Fish and seafood (natural)	Raw fish and seafood (natural)					125	480	125	360
Fish and seafood (natural)	Cooked fish and seafood (natural)					100	480	100	360
Fish and seafood (seasoned or breaded)	Raw fish and seafood (seasoned or breaded)					125	480	125	360
Fish and seafood (seasoned or breaded))	Cooked fish and seafood (seasoned or breaded)					100	480	100	360
Cooked fish and seafood (in sauce)						140	480	140	360
Fish and seafood, preserved (in broth or water)						55	480	55	360
Fish and seafood en conserve (seasoned, in sauce)						55	480	55	360
Processed fish (imitation crab, surimi)						55	480	55	360
Pork and beans in tomato sauce alone		300	300		250				
Pork and beans in tomato sauce with side dishes		400	400		300				
Prepared and preserved legumes						480	125 (ml)	360	125 (ml)
Frozen or preserved legumes (natural)						250 (ml)	480	360	250 (ml)
Natural bean curd						480	85	140	85
Unflavoured meat substitutes (bean curd)			280		280				
Egg substitutes						480	50	240	50

Nut and grain butter (peanut butter)						480	50	140	15
Cooked vegetarian meat substitutes (seitan, ground soy, imitation meat strips and other cuts)						480	60	360	60
Meat-free products			280		600				
Imitation bacon					850				
PROCESSED OR PRESERVED VEGETABLES									
Natural preserved vegetables						480	125 (ml)	240	125 (ml)
Preserved vegetables		50	50		50				
Preserved tomatoes						480	125 (ml)	360	125 (ml)
Frozen or preserved vegetables, seasoned, in sauce or fried	Preserved vegetables, seasoned, in sauce or fried					480	125 (ml)	480	125 (ml)
Frozen or preserved vegetables, seasoned, in sauce or fried	Frozen vegetables, seasoned, in sauce or fried					480	110	240	110
Tomato juice						650	250 (ml)	480	250 (ml)
Vegetable juice and juice						650	250 (ml)	480	250 (ml)
Olives						480	50	140	15
Processed-vegetable-based products		280							
Dehydrated potato purée, ready-to-eat		100	100	80	70				
Other processed potato products		195	195	350	300				
Marrowfat brand preserved peas		200	200		180				
SNACKS									
Snacks (popcorn, pretzels, chips)						480	50	240	50
Standard potato chips		600	600		500				
Extruded snacks		1100	1100	900	750				
Pellet-based snacks		1400	1400	1000	900				
Salt and vinegar products		1200	1200	950	850				

Food category	subcategory	FSA (UK) 2006 target (mg/100g)	FSA (UK) current 2010 target (mg/100g)	FSA (UK) proposed 2010 target (mg/100g)	FSA (UK) 2012 target (mg/100g)	Current Health Check criterion (mg/portion)	Current Health Check criterion portion (g)	Health Check criterion 2010 (mg/portion)	Health Check criterion 2010 portion (g)
FATS									
Oils						480	50	240	10 (ml)
Margarines	Regular margarines					480	50	140	10
Margarines	Light margarines					480	50	140	10
Margarines other		600	600	500	450				
Butter	Regional butters	1200	1200		800				
Butter	Salted butter	670	670		600				
Butter	Low-salt butter	470	470		450				
Butter	Salt-free butter	40	40		40				
Barres à base de céréales						480	50	140	30
DESSERTS									
Muffins / sweet breads						480	55	240	55
Buns		200	200		150				
Cakes		240	240	200	160				
Pastries		185	185		200				
Pies		130	130		130				
Dessert mixes, ready-to-eat		200	200		200				
Cheese cake		200	200		140				
Sponge-cake based puddings		400	400		300				
Other puddings		120	120		120				
Puddings, flans, frozen dairy desserts						480	125 (ml)	240	125 (ml)
Soy or bean curd desserts						480	125 (ml)	240	125 (ml)
COOKIES AND CRACKERS									
Cookies						480	50	140	30
Sweet cookies – without filling		416	416		270				
Sweet cookies – with filling		205	205		270				
Salty biscuits – without filling		860	860		550				
Salty biscuits – with filling		740	740		500				
Crackers and rusks						480	50	190	20
SAUCES, DRESSINGS AND MAYONNAISE									
Main course sauces (sauce for pasta)						480	125 (ml)	480 (2009)	125 (ml)

Sauces used in small quantities (pesto, pizza, cheese sauces, salsa, etc.)						480	60 (ml)	240	60 (ml)
All sauces for cooking and pasta (except pesto)		430	430		330				
Pesto and other thick sauces		1200	1200		600				
Thick paste (tomato paste)					2000				
Tomato Ketchup		1000	1000	900	730				
Potato or pasta salads						480	140	240	140
Other salads						480	100	240	100
Salad dressings (mayonnaise)						480	50	140	15 (ml)
Gravy		600	600		600				
Salad dressing		700	700		700				
Mayonnaise (not low fat)		600	600		500				
Mayonnaise (low fat)		1000	1000	850	750				
Vinaigrettes		1000	1000		700				
Dips						480	50	240	30
MEALS AND PREPARED DISHES									
Soups						650	250 (ml)	480	250 (ml)
Dehydrated soups		250	250		230				
Non dehydrated soups		250	250		230				
Pizzas						480	140		
		470	470		350				
Pizzas with high-salt dressing (cold meat, olives, anchovies).		400	400		350				
Pizzas without high-salt dressing						960	250	720 (2009)	250
Meals and prepared dishes		300	300		250				
Ready-to-eat Thai/Chinese/Indian meals		400	400		250				
Thai/Chinese/Indian main course		250	250		250				
Ready-to-eat Italian/traditional/other meals		300	300		250				
Italian/traditional/other main course						480	140	240	140
Side dishes	Seasoned rice, grains, or potatoes in sauce					480	125 (ml)	240	125 (ml)
Side dishes	Seasoned pasta or noodles in sauce	250	250		250				
Meat-based takeout meals		200	200		200				

Food category	subcategory	FSA (UK) 2006 target (mg/100g)	FSA (UK) current 2010 target (mg/100g)	FSA (UK) proposed 2010 target (mg/100g)	FSA (UK) 2012 target (mg/100g)	Current Health Check criterion (mg/portion)	Current Health Check criterion portion (g)	Health Check criterion 2010 (mg/portion)	Health Check criterion 2010 portion (g)
Vegetable and potato-based takeout meals		200	200		200				
Bean curd or meat or fish with vegetables						480	140		
Prepared sandwiches	With high-salt dressings (cold meat, olives, anchovies, etc.)	500	500		400				
Prepared sandwiches	Without high-salt dressing (chicken, vegetables, etc.)	400	400		300				
OTHER FOODS									
Dehydrated beverages		100	100		60				

Appendix 3A | general description of additives*

By Health Canada

	Taste enhancers	Reinforce the taste and/or smell of a food.
	Baking powders	Release gases and thereby increases the volume of the dough
A	Antioxidants	Extend the duration that food can be preserved by protecting it against spoiling caused by oxidation, such as rancidification of fats and colour modifications.
Ad	Anti-sticking agents	Prevent food from sticking to surfaces during or after manufacturing. Mineral oil, for example, is applied to baking pans to facilitate no-crumb removal.
Ag	Anti-caking agents	Allow for free-flow of powder preparations; for example, salt tends to stick together in humid weather in the absence of an anti-caking agent.
BM	Dough bleaching, maturing and conditioning agents	Make it possible to obtain flour that yields lighter-coloured dough that is stronger, and this makes it easier to kneed and to work quickly and it also increases the volume of bakery products.
C	Preserving agents	Extend the time during which food can be preserved; prevent or reduce the deterioration of food due to microorganisms or enzymatic and reactions.
Em	Emulsifiers	Usually make it possible to maintain homogenous dispersion of several immiscible substances.
Ge	Gelling agents	Thicken and stabilize food texture.
M	Frothing agents	Ensure the formation of a stable mousse.
Ma	Starch modifying agents	Modify starch properties so that it can withstand heat treatment and freezing, and this allows food to keep their outside appearance and their consistency.
Mt	Texture modifying agents	Provide and preserve the desired consistency of food.
Nl	Yeast nutrients	Used as nutrients for yeast, such as those used to make bread and beer.
pH	PH adjusting agent	Modify or limit the acidity or alkalinity of food, and this can influence the development of bacteria, and finally determine the quality of the finished product, its taste and texture. Certain of these products are also used to make baking powder used in bakeries to provide light porous products.
R	Firming agents	Used to maintain the texture of many processed foods, such as fruit, vegetables, fish products that heat treatment could soften. They are also used to ensure the firmness of the curds in certain types of cheese.
S	Sequestering agents	Combine with metallic elements in food and prevent the food from participating in reactions that result in taste deterioration or unwanted changes. For example, the sequestering agent added to canned lima beans prevents the product from going brown because the traces of iron and other dissolved metals in the preserving water that produce this effect are bound by the additive and cannot react. .
Sem	Emulsifying salts	Disperse proteins contained in cheese and thus bring about a homogenous distribution of fats and other components, in order to prevent the separation of the fat.
St	Stabilizing agents	Help to prevent the deposit of suspended particles such as chocolate in chocolate milk.
X	Different food additives	Include a wide range of other food additives, such as carbonators for soft drinks, plastifiers in gum, filters and clarifiers in beer, deodorizers in fats and oils, frothers in drinks, and pill aggregation adjuvants.

**Ceci ne constitue pas une liste exhaustive des additifs disponibles.*

Appendix 3B | Functions of additives [58,64]

					Functionality according to Health Canada = X																			
	Contains sodium	Permitted as an additive in Canada	Possibly permitted as an additive outside Canada (ex. EU)	Salt-substitute component (mention)	Antioxidants / anti oxygen	Anti-sticking agents	Anti-caking agents	Dough bleaching, maturing and conditioning agents	Preserving agents	Stabilizing agents	Emulsifiers	Emulsifying salts	Gelling agents	Firming agent	Texture modifying agents	Frothing agents	PH adjusting agents	Sequestering agents	Modificateurs de l'amidon	Yeast nutrients	Miscellaneous – other	Taste enhansers	Poudre à lever
# table in Division 16 (FDR; B.16)							I	II	XI	IV	IV		IV	VI		VIII	X	XII	XIII	XIV	VIII		
Functionality – acronym					A	ad	ag	BM	C	St	Em	Sem	Ge	R	Mt	M	pH	S	Ma	Nl	X		
Sodium guanylate	✓		✓	✓																		•	
Sodium inosinate	✓		✓	✓																		•	
Sodium ribonucleotide 5'	✓		✓	✓																		•	
Sodium acetate	✓	✓															X		X				
Sodium diacetate	✓	✓							X														
Acetic acid		✓							X								X						
Sodium ascorbate	✓	✓			•				X														
Sodium isoascorbate	✓	✓							X														
Calcium ascorbate		✓							X														
Ascorbic acid		✓			X			X															
Sodium benzoate	✓	✓							X														
Potassium benzoates		✓							X														
Benzoic acid		✓							X														
Sodium bicarbonate	✓	✓															X		X		X		•
Sodium bicarbonate	✓	✓															X		X		X		
Calcium carbonate		✓															X			X	X		
Magnesium carbonate		✓		✓		X	X										X				X		
Calcium chloride		✓												X			X			X			
Potassium chloride		✓		✓						X							X			X			
Magnesium chloride		✓		✓						X											X		
Ammonium chloride		✓		✓																X			

L-lysine hydrochloride				✓																			
Sodium citrate	✓	✓							•	X		•		X			X				X		•
Sodium citrate tribasic, 2-hydrate				✓																			
Citric acid		✓		✓					X								X	X			X		
Sodium erythorbate	✓	✓			•				X														
Sodium gluconate	✓	✓		✓						X							X						
Glycine		✓		✓														X				•	
Glycine and sodium salt	✓		✓	✓																			•
Potassium iodate		✓						X															
Sodium lactate	✓	✓		✓					•			•					X						
Potassium lactate		✓		✓													X						
Calcium lactate		✓		✓										X			X			X	X		
Lactic acid		✓															X						
Sodium malate acid	✓		✓									•					•						
Sodium malate	✓		✓									•					•						
Malic acid		✓															X						
Sodium nitrate	✓	✓							X														
Sodium nitrite	✓	✓							X														
Potassium nitrate		✓							X														
Potassium nitrite		✓							X														
Monosodium phosphate (MSP)	✓	✓		✓							X	X					X	X					
Disodium hydrogenphosphate (DSP)	✓	✓		✓							X	X					X	X			X		
Trisodium phosphate e (TSP)	✓	✓		✓							X	X					X	X					
Sodium trimetaphosphate (STMP)	✓	✓		✓															X				
Sodium tripolyphosphate (STPP)	✓	✓		✓											X		X	X	X		X		
Sodium acid pyrophosphate (SAPP)	✓	✓		✓								X					X	X			X		•
Tetrasodium pyrophosphate (TSPP)	✓	✓		✓							X	X					X	X			X		
Sodium orthophosphates	✓		✓	✓								•											•
Sodium hexametaphosphate (SHMP)	✓	✓		✓							X	X				X	X	X			X		

# table in Division 16 (FDR; B.16)							I	II	XI	IV	IV		IV	VI		VIII	X	XII	XIII	XIV	VIII		
Functionality – acronym					A	ad	ag	BM	C	St	Em	Sem	Ge	R	Mt	M	pH	S	Ma	NI	X		
Monopotassium phosphate (MKP)		✓		✓														X		X			
Phosphate bipotassique		✓		✓											X		X	X		X			
Dipotassium hydrogenphosphate (DKP)		✓		✓								X					X	X		X			
Monocalcium phosphate (MCP)		✓		✓										X			X	X		X			
Tricalcium phosphate(TCP)		✓		✓			X				X						X	X		X	X		
Bicalcium phosphate		✓		✓								X		X			X			X	X		
Dicalcium Phosphate (DCP)		✓		✓							X			X			X			X	X		
Sodium propionate	✓	✓							X														
Calcium propionate		✓							X														
Sodium propionate		✓																					
Propionic acid		✓							X														
Sodium sorbate	✓	✓							X														
Calcium sorbate		✓							X														
Potassium sorbate		✓							X														
Sorbic acid		✓							X														
Sodium sulphite	✓	✓			•			X	X												X		
Sodium sulphite (sodium bisulphite)	✓	✓			•				X														
Sodium metabisulphite (sodium bisulphite)	✓	✓			•				X														
Hyposulfite de sodium	✓		✓																		•		
Sodium thiosulphate	✓	✓																			X		
Sodium methyl sulphate	✓	✓																			X		
Aluminum and sodium sulphate	✓	✓																			X		
Aluminum sodium sulphate	✓	✓												X			X				X		
Potassium sulphate		✓															X						
Aluminum potassium sulphate dodechydrate (alun)		✓												X			X				X		
Magnesium sulphate (Epsom salt)		✓		✓													X		X		X		
Calcium sulphate		✓												X			X			X	X		
Sodium acid tartrate	✓	✓															X						
Sodium tartrate	✓	✓										•			X								•

Potassium sodium tartrate (Rochelle salt)	✓	✓									X	X					X						
Potassium tartrate (cream of tartar)		✓		✓													X						
Potassium acid tartrate		✓															X						
Calcium tartrate		✓													X								
Tartaric acid		✓							X								X						
DIFFERENT ADDITIVES CONTAINING SODIUM																							
Sodium alginate	✓	✓											X										
Sodium carrageenan	✓	✓											X										
Sodium chlorite	✓	✓																	X				
Sodium ferrocyanide decahydrate	✓	✓					X														X		
Sodium dithionite	✓	✓							X														
Disodium EDTA (disodium versenate)	✓	✓																X					
Sodium fumarate	✓	✓															X						
Sodium furcelleran	✓	✓											X										
Sodium hydroxide	✓	✓														X	X				X		
Sodium hypochlorite	✓	✓																	X				
Sodium iodide	✓		✓																		•		
Sodium lauryl sulphate	✓	✓														X							
Sodium orthophenylpenoxide	✓		✓						•														
Sodium salt of –hydroxyl methyl benzoic acid	✓	✓							X														
Sodium salt of p-hydroxypropyl acid	✓	✓							X														
Monosodium salts of mono and diglyceride phosphorylates	✓	✓									X												
Sodium silicate	✓	✓																			X		
Aluminum sodium silicate	✓	✓					X																
Sodium stearate	✓	✓																			X		
Sodium stearoyl 2-lactylate	✓	✓						X			X					X					X		
Sodium Stearyl fumarate	✓	✓						X															

APPENDIX 4 | Projects and studies on salt reduction in meat products

These projects can provide technical insight. However, the possibility of using the compounds, additives or ingredients in this table remains to be validated with the Canadian regulatory authorities

Food	Comments	Référence	Linked to a patent	Sodium chloride	Potassium chloride	Magnesium chloride	Calcium chloride	Magnesium sulphate	Calcium sulphate	Potassium sulphate	Potassium sulphate	Calcium citrate	Sodium nitrite	Citric acid	Ascorbic acid	Sodium lactate	Potassium lactate	Potassium phosphate(many)	Phosphates de sodium (many)	Monosodium glutamate	Disodium ibonucleotide	Monophophate adenosine 5'	Glycine	L-lysine amino acid	Amio acid: l-phénylalanine	L-phenylalanine amino acid
Pork sausages	Use of different chlorides	102		X	X	X																				
Cooked meat products (6)	Extended preservation time due to formulation with lactate products	103															X									
Bacon, ham, and turkey (ham type)	Mix: now hydration of products. Reinforces the salt taste and masks the unpleasant magnesium and potassium notes.	ND	✓	X	X			X																X		
	Prototype with calcium or potassium sulphate	104	✓	X	X				X	X																
	Salt-free substitution mix with salts (mineral), citric acid, rice flour, ginger and garlic powder	105				X					X			X												
Cooked ham	Binding property superior to control, sensory acceptable	106		X	X																					
Ham (formed)	Evaluation of different chlorides (mixes); no differences with control: taste, tenderness, overall appreciation (for potassium and magnesium); decrease: pH, humidity, results, residual nitrites (for calcium)	107		X	X	X	X																			
Dried fermented meat (filet)	Possible to substitute part of salt with no negative sensory effects	108			X												X									
Ham (country)	Possible to substitute part of salt with no negative effects	109																								
Fermented sausages	Significant effect on volatile compounds linked to the maturation phase (1.5% VS control at 3.0 %)	110		X																						
Fermented meat products	Recommendation not to reduce below 2 % sodium chloride linked to aw.	111		X																						
Cooked ham	Sodium-reduced prototype; taste identical to control; patent	112	✓	X								X	X		X	X		X								

Meat products; smoked sausages (turkey)	Comparison between sodium phosphates (STPP, SHMP, SAPP) and potassium phosphates in meat products; performance SAPP phosphates (smoked sausage, turkey)	113																X	X							
Smoked sausage	Comparable results to that of control with sodium phosphate (STPP, TSPP, TTPP)	114																	X							
"Baloney" sausage and cooked ham	Reduction: 1.0 and 1.4 % salt	115		X																						
Processed meats	Sensory and results maintained with several phosphates at 0.4 % (STPP, SHMP, SAPP)	116																	X							
Meat products	Functional characteristics: results comparable with phosphates (TSPP, TTPP)	117																	X							
Ground beef patties	Potassium phosphate (TKPP); no significant effect on salt taste; losses in cooking; fat seems to influence the salt characteristics of the prototypes.	118																X								
"Baloney" sausage	No significant difference between prototype and control formulations	ND																		X	X					
Pork sausage patties	Co-crystallization of potassium and ribonucleotide chloride	119	✓		X																X					
	Umami effect of aromatic amino acids	120																							X	X
	Bitterness blocker: IMA	121	✓																			X				
	Possible to replace large portion of sodium chloride; little effect on functionality (lysine and succinic acid)	122																						X		
	Sodium or potassium lactates; sodium chloride reduction tends to maintain a certain salt taste	113		X													X	X								
Fermented meat (sausage and dried fermented filet)	Prototype glycine at -30 % max salt. Otherwise, sweet profile; potassium lactate and potassium chloride prototype at 40 % salt	108		X	X													X					X			
	Finer sodium chloride crystals; dissolution twice as fast; improved results linked to better solubilization of myofibrillar proteins (6-8 min mix and one-day post-mix storage)	123		X																						

Appendix 5 | Information about examples of applications

This Appendix presents the formulation of positive controls (non-reduced sodium products) for each of the seven examples of applications: quiche, lasagne, fresh sausage, oatmeal muffin, chocolate chip cookie and onion soup.

In addition, for each product, the prototypes developed are detailed in a table presenting the modifications with respect to the formulation of the positive control. This table also presents the marks obtained by the prototypes when they were evaluated by an internal panel. This evaluation was conducted in comparison with a positive control (not sodium reduced) and a negative control (reduced sodium without added substitution ingredients), and focussed on the salt characteristic as well as on the persistence of the salt taste, the firmness or the spicy taste. The evaluation was marked on an intensity scale of 1 to 5, 1 being the low intensity value (e.g., low salt) and 5, for a high intensity (e.g., very salty). Since the positive control evaluation mark was set at 4.0. The prototypes that were evaluated to be the closest to this value were retained as the most appropriate

Example 1 | Quiche (frozen prepared meal)

Positive control (existing product, not sodium reduced)

Produced with 1000 mg of sodium per serving of 250 g (Table 9).

TABLE 9 | FORMULATION OF POSITIVE CONTROL FOR THE QUICHE AND CONTRIBUTION TO SODIUM AND POTASSIUM CONTENT OF EACH INGREDIENT FOR A SERVING OF 250 g

	Formulation %	Per 250 g serving		
		Ingredients g	Sodium mg	Potassium mg
PASTRY				
Flour	13,53	33,83	1	36
Unhydrogenated shortening	7,22	18,05	0	0
Water	3,50	8,75	0	0
Sugar	0,27	0,68	0	0
Salt	0,24	0,59	229	0
Sodium bicarbonate	0,04	0,11	3	0
Vinegar	0,20	0,50	0	0
FILLING				
Milk	38,24	92,26	39	144
Liquid whole eggs	14,42	39,18	62	52
Spinach	9,23	23,08	18	129
Mozzarella cheese	9,23	22,84	85	15
Modified corn starch	0,77	2,40	0	0
Vegetable oil	0,67	1,68	0	0
Onions	0,87	2,16	0	3
Parmesan cheese	0,85	2,12	32	3
Salt	0,56	1,39	540	0
Garlic	0,08	0,19	0	1
Mustard powder	0,01	0,04	0	0
Worcestershire sauce	0,02	0,05	0	0
Spices	0,04	0,12	0	3
Total	**100 %**	**250 g**	**1011 mg**	**387 mg**

SODIUM REDUCTION TARGET

Decrease of 30 % of sodium: 700 mg of sodium per 250 g

As shown in Table 10 below, this reduction corresponds to the target proposed by the Food Standards Agency (FSA) in the United Kingdom for 2012 and was retained because it is both realistic and more constraining than the Health Canada criteria for the claim "Reduced sodium content" and the criteria for the Health Check program. Health Canada criteria for the claims "lightly salted" and "low sodium content" were not retained since they would require a reduction of between 50 and 82 % of the sodium respectively.

TABLE 10 | SODIUM REDUCTION TARGETS FOR THE QUICHE UNDER THE HEALTH CANADA CRITERIA, HEALTH CHECK PROGRAM AND THE UNITED KINGDOM FOOD STANDARDS AGENCY (FSA)

Organization	Health Canada			Health Check	FSA	
Claim, target or criterion to meet	*Low sodium content*	*Lightly salted*	*Reduced sodium content*	2009 criterion	Reduction target for 2010	Reduction target for 2012
Sodium quantities to be met	Not more than 140 mg of sodium per reference quantity of 195 g	50 % less sodium than the similar reference food	25 % less sodium than the similar reference food	720 mg or less per recommended serving of 250 g	300 mg of sodium per 100 g	280 mg of sodium per 100 g
Sodium reduction rate to reach	82 % sodium reduction	50 % sodium reduction	25 % sodium reduction	28 % sodium reduction	25 % sodium reduction	30 % sodium reduction

SOURCES OF SODIUM AND MICROBIOLOGICAL RISK

In the control quiche, salt is highest source of sodium (more than 75 % of total sodium) and was the only ingredient reduced in the formulation. Salt affects above all the taste of the quiche. Since it is a frozen dish, there is no microbiological risk if salt content is reduced.

SUBSTITUTION INGREDIENTS

Based on technical information gathered (table 7), the taste profile of each of the three salt replacement ingredient families is appropriate for prepared meal applications like quiches. Table 11 provides details about the mineral substitutes, yeast products, as well as the selected flavours for salt replacement tests in the quiche.

TABLE 11 | INGREDIENTS USED TO SUBSTITUTE PART OF THE SALT IN THE QUICHE

(TEST NUMBERS REFER TO PROTOTYPES DETAILED IN TABLES 12 AND 13)

Ingredient	Family	Characteristics	Manufacturer	Tests
Potassium chloride	Mineral substitute	KCl	Various manufacturers	A1
Salt Rite Natural 10246	Mineral substitute	KCl with natural taste	Alexander Foods	B1, B2, B3, D1, F1, E2, F1, I1
Provesta 029	Yeast product	Yeast autolysate with KCl	Ohly	C1, C2
Springer 4102/0-MG-L	Yeast product	Yeast extract	BIO SPRINGER	D1
FLAV-R-MAX	Yeast product	Nucleotide-rich yeast extract	Ohly	E1, E2, H1
SaltTrim (DABC665)	Flavour	Natural flavours	WILD Flavors	F1
Savory Enhancer 36490	Flavour	Cultured milk, milk protein concentrate	DairiConcepts	G1, I1

EVALUATION OF REDUCED SODIUM PROTOTYPES

Salt was only reduced in the quiche filling. In short, the first tests consisted in evaluating certain substitution ingredients individually in prototypes in which sodium was reduced by 30 %. Then the ingredients were combined in different ways and the concentrations were modified.

In these tests, Salt Rite flavoured KCl used alone (formulation B2) or combined with Ohly FLAV-R-MAX yeast extract (formulations E1 and E2) makes it possible to reproduce the taste profile of the positive control very satisfactorily (table 12). However, too high a dose of Salt Rite (formulation B3) tastes much more salty that the positive control. Yeast or autolysate extracts used alone, even at high doses (formulation C2 and H1), do not appear to enhance the taste of a food as neutral as a quiche. That is also the case when flavour is added (formulation F1, G1 and I1), which gives a salty sensation in the mouth (at the beginning) but whose effect disappears more quickly than with NaCl

TABLE 12 I MODIFICATIONS ALLOWING THE MOST ACCURATE REPRODUCTION OF THE TASTE PROFILE OF THE QUICHE NOT REDUCED IN SODIUM (POSITIVE CONTROL)

			Positive control	Negative control	Promising formulations		
					B2	E1	E2
Salt (NaCl) in filling		%	0,56	0,24	0,24	0,24	0,24
Salt Rite 10246		%			0,38	0,32	0,34
Flav-R-Max		%				0,01	0,02
Sodium content per 250 g		mg	1008	696	699	697	699
Potassium content per 250 g		mg	388	389	914	823	848
Evaluation	Intensity of salt characteristic	/5	4,0	2,8	4,2	4,6	3,9
	Persistence of salt taste	/5	4,0	3,0	4,0	3,4	3,8

TABLE 13 I REDUCED-SALT QUICHE PROTOTYPES: MODIFICATIONS COMPARED TO POSITIVE CONTROL, SODIUM AND POTASSIUM CONTENT, EVALUATION

(Salt was reduced and substitution ingredients were added only in the quiche filling)

			Positive control	Negative control	A1	B1	C1	D1	E1	F1	B2	B3	C2	E2	G1	H1	I1
Salt (NaCl) in filling		%	0,56	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,24	0,23	0,24	0,24	0,24	0,24
Potassium chloride (KCl)		%			0,32												
Salt Rite 10246		%				0,32		0,32	0,32	0,32	0,38	0,48		0,34			0,36
Provesta 029		%					0,50						0,67				
Springer 4102/0-MG-L		%						0,12									
Flav-R-Max		%							0,01					0,02		0,07	
SaltTrim		%								0,19							
Savory Flavor enhancer 36490		%													0,05		0,08
Sodium content per 250 g		mg	1008	696	696	697	697	698	697	697	699	699	700	699	697	699	700
Potassium per serving of 250 g		mg	388	389	823	823	605	823	823	822	914	1046	683	848	449	388	970
Evaluation	Intensity of salt characteristic	/5	4,0	2,8	2,4	2,9	2,9	4,0	4,6	3,2	4,2	4,6	2,8	3,9	3,6	2,8	3,4
	Persistence of salt taste	/5	4,0	3,0	2,3	3,4	2,7	2,5	3,4	2,2	4,0	4,6	2,8	3,8	3,0	2,6	3,5

Example 2 | Lasagne (frozen prepared meal)

Positive control (existing product, not sodium reduced)

1020 mg of sodium per serving of 320 g. Details on this formulation are presented in Table 14.

TABLE 14 | FORMULATION OF POSITIVE CONTROL FOR THE LASAGNE AND CONTRIBUTION TO SODIUM AND POTASSIUM CONTENT OF EACH INGREDIENT FOR A SERVING OF 250 g

	Formulation %	Per serving of 320 g		
		Ingredients g	Sodium mg	Potassium mg
Pasta	30,93	98,99	6	24
Canned tomatoes	30,35	97,13	252	201
Mozzarella cheese	10,00	32,00	235	21
Fromage cottage	3,94	12,60	41	12
Ricotta cheese	3,94	12,60	16	16
Parmesan cheese	1,17	3,75	51	5
Beef	5,03	16,10	10	37
Tomato paste	6,11	19,55	12	198
Milk	2,69	8,62	4	13
Modified corn starch	0,67	2,14	0	0
Flour	0,22	0,69	0	1
Onions	3,19	10,20	1	14
Salt	0,31	1,00	388	0
Sugar	0,10	0,32	0	0
Margarine	0,23	0,75	5	1
Canola oil	0,79	2,53	0	0
Garlic	0,30	0,96	0	4
Spices	0,03	0,08	0	2
Total	**100**	**320**	**1020**	**548**

SODIUM REDUCTION TARGET

The reduction target (Table 5) retained for the lasagne is a 30 % reduction in sodium, or 720 mg of sodium per 320 g. This reduction corresponds to Health Check criteria for 2009. It was retained because it is both realistic and more constraining tham the Health Canada criteria for the claim "Reduced sodium content" and the criteria of the FSA (Food Standards Agency in the United Kingdom). Health Canada criteria for the claims "Lightly salted" and "Low sodium content" were not retained for this exercise because they would require a drop of between 50 and 77 % of the sodium respectively.

TABLE 15 | SODIUM REDUCTION TARGETS FOR THE LASAGNE UNDER THE HEALTH CANADA CRITERIA, HEALTH CHECK PROGRAM AND THE UNITED KINGDOM FOOD STANDARDS AGENCY (FSA)

Organization	Health Canada			Health Check	FSA	
Claim, target or criterion to meet	*Low sodium content*	*Lightly salted*	*Reduced sodium content*	2009 criterion	Reduction target for 2010 and 2012	Cible de réduction pour 2012
Sodium quantities to be met	Not more than 140 mg of sodium per reference quantity of 195 g	50 % less sodium than the similar reference food	25 % less sodium than the similar reference food	720 mg or less per recommended serving of 250 g	250 mg of sodium per	280 mg de sodium par 100 g
Sodium reduction rate to reach	82 % sodium reduction	50 % sodium reduction	25 % sodium reduction	28 % sodium reduction	22 % sodium reduction	Diminution de 30 % du sodium

SODIUM SOURCES AND MICCROBIOLOGICAL RISK

In the control lasagne, salt is the highest source of sodium, with a contribution of more than 38 % of total sodium, followed by tomatoes (25 %) and mozzarella cheese (23 %). For convenience and to maintain the finished product aspect, the salt in the sauce was the only ingredient reduced in the formulation. The role of salt is to modify the taste of the lasagne. Since the product under study is a frozen prepared dish, sodium reduction does not represent a microbiological safety risk

SUBSTITUTION INGREDIENTS

Based on technical information gathered (table 7), the taste profile of each of the three salt replacement ingredient families is appropriate for prepared meal applications like lasagne. Table 16 provides details about the mineral substitutes, yeast products, as well as the selected flavours for salt replacement tests in the lasagne.

TABLE 16 I INGREDIENTS USED TO SUBSTITUTE PART OF THE SALT IN THE LASAGNE

(TEST NUMBERS REFER TO PROTOTYPES DETAILED IN TABLES 17 ET 18)

Ingredient	Family	Characteristics	Manufacturer	Tests
Potassium chloride	Mineral substitute	KCl	Different manufacturers	A1, A2, A3, D1, F1, g, H, I, J
KCl Blend NeutralFres	Mineral substitute	KCl with natural flavour	Prime favorites	B1, E1
Bonded KCl Mimic 11004279	Mineral substitute	KCl with natural flavour	Wixon	C1
Intense 101	Flavour	Natural flavour (whey)	PTX Food Corporation	I
UnSal20 Tomato Type Flavouring V6667 1NC1 2	Flavour	Natural flavour	Ungerer Limited	D1, I
Natural Flavour Nalow Salt Replacer Type AF1765	Flavour	Natural flavour	Alexander Flavours	G
Salt Replacer/Enhancer 0863	Yeast product	Yeast extract, natural flavour	Savoury System International	E1, J
Maxarome Select Powder 9447	Yeast product	Nucleotide-rich yeast extract	DSM Food Specialities	F1

EVALUATION OF REDUCED SODIUM PROTOTYPES

Salt was reduced in and substitution ingredients were added only to the lasagne sauce. Details on modifications are presented in the appendix. In short, the first tests consisted in evaluating certain substitution ingredients individually in the prototypes in which sodium was reduced by 30 %. Then the ingredients were combined in different ways and the concentrations were modified.

These tests showed that potassium chloride (KCl) is a basic salt substitution ingredient in a dish like lasagne. KCl provides a salt taste similar to that of salt with no after taste. When it is added at less than 0.31 %, KCl provides a satisfactory profile (formulation A2). This dose must nonetheless be less than 0.94 %, since saturation can be felt along with bitterness (formulation A3). Flavoured KCl-based ingredients tested provided as satisfying a profile as KCl, but added no value (formulations A1, B1 and C1).

During tests, use of flavour or yeast extract combined with KCl (formulations D1, E1, F1) made it possible to balance the taste and replace the salt with no compromises. Table 17 provides examples of formulations prepared using three different yeast extracts and flavours combined with KCl-based mineral substitutes. Other flavours or yeast extracts are likely to produce satisfactory results in foods like lasagne.

Moreover, in a complex matrix like that of lasagne, it is recommended to evaluate the prototypes in the full matrix, even if reformulation only affects a single component such as the sauce in this case. In fact, the interaction with the other ingredients in the lasagne affects the perception of the salt taste

TABLE 17 I MODIFICATIONS ALLOWING THE MOST ACCURATE REPRODUCTION OF THE TASTE PROFILE OF THE LASAGNE NOT REDUCED IN SODIUM (POSITIVE CONTROL)

			Positive control	Negative control	Promising formulations		
					D1	E1	F1
Salt (NaCl)		%	0,31	0,07	0,07	0,06	0,07
Potassium chloride (KCl)		%			0,31		0,25
KCl Blend NeutralFres		%				0,31	
UnSal20 Tomato Type Flavouring V6667 1NC1 2		%			0,05		
Salt Replacer/Enhancer 0863		%				0,12	
Maxarome Select Powder 9447		%					0,02
Sodium content per 320 g		mg	1020	718	718	720	720
Potassium content per 320 g		mg	548	548	1096	1008	987
Evaluation	Intensity of salt characteristic	/5	4,0	3,2	3,9	3,9	3,8
	Persistence of salt taste	/5	4,0	3,1	4,0	3,8	4,2

TABLE 18 I REDUCED-SALT LASAGNE PROTOTYPES: MODIFICATIONS COMPARED TO POSITIVE CONTROL, SODIUM AND POTASSIUM CONTENT, EVALUATION

(Salt was reduced and substitution ingredients were added only in the tomato sauce)

			Positive control	Negative control	A1	B1	C1	A2	A3	D1	E1	F1	Formulations for which only the sauce was tasted during evaluation			
														H	I	J
Salt (NaCl)		%	0,31	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,06	0,07	0,07	0,06	0,06	0,06
Potassium chloride (KCl)		%			0,24			0,31	0,94	0,31		0,25	0,22	0,06	0,06	0,16
KCl Blend NeutralFres		%				0,24					0,31					
Bonded KCl Mimic 11004279		%					0,24									
UnSal20 Tomato Type Flavouring V6667 1NC1 2		%								0,05				0,19		
Salt Replacer/Enhancer 0863		%									0,12					0,09
Natural Flavour Nalow Salt Replacer Type AF1765		%											0,02			
Intense 101		%													0,31	
Maxarome Select Powder 9447		%										0,02				
Sodium per serving of 320 g		mg	1020	718	720	720	720	719	719	718	720	720	720	711	719	720
Potassium per serving of 320 g		mg	548	548	974	907	907	1109	2190	1096	1008	987	933	658	652	828
Evaluation	Intensity of salt characteristic	/5	4,0	3,2	3,8	3,8	3,8	3,8	4,5	3,9	3,9	3,8	3,0	3,3	3,3	3,6
	Persistence of salt taste	/5	4,0	3,1	3,3	3,3	3,3	3,5	4,2	4,0	3,8	4,2	3,4	4,2	4,3	3,5

Example 3 | Fresh sausage

Positive control (existing product, not sodium reduced)

625 mg of sodium per serving of 75 g of raw sausage. Details of this formulation are presented in Table 19

TABLE 19 | FORMULATION OF POSITIVE CONTROL FOR THE FRESH SAUSAGE AND CONTRIBUTION TO SODIUM AND POTASSIUM CONTENT OF EACH INGREDIENT FOR A SERVING OF 75 g (RAW)

	Formulation %	Per serving of 75 g		
		Ingredients g	Sodium mg	Potassium mg
Pork	47,00	35,24	20	52
Beef	31,60	23,70	15	55
Water	14,50	10,87	0	0
Spices	0,87	0,65	7	17
Salt (NaCl)	1,90	1,42	556	0
Sodium erythorbate	0,05	0,04	6	0
Toasted wheat crumbs	4,10	3,07	22	6
Total	**100**	**75**	**626**	**130**

SODIUM REDUCTION TARGET

The sodium reduction target (Table 20) for the sausage is a 57 % sodium reduction to reach 270 mg of sodium per 75 g (raw). This reduction corresponds to the 2010 Health Check criteria for meat patties. It was retained because it is both realistic and more constraining than the Health Check criteria for sausages, the Health Canada criteria for the claim "Reduced sodium content", as well as Food Standards Agency (FSA) criteria in the United Kingdom. Health Canada criteria for the claim "low sodium content" were not retained since they would require a major reduction (more than 85 %) in sodium and this exercise was not considered relevant for the purposes of this guide.

TABLE 20 | SODIUM REDUCTION TARGETS FOR THE SAUSAGE UNDER THE HEALTH CANADA CRITERIA, HEALTH CHECK PROGRAM AND THE UNITED KINGDOM FOOD STANDARDS AGENCY (FSA)

Organization	Health Canada			Health Check		FSA
Claim, target or criterion to meet	*Low sodium content*	*Lightly salted*	*Reduced sodium content*	2010 criteron (for the sausages)	2010 criterion (for meat patties)	Reduction target for 2010
Sodium quantities to be met	Not more than 140 mg of sodium per reference quantity of 75 g (raw)	50 % less sodium than the similar reference food	25 % less sodium than the similar reference food	360 mg or less per recommended serving of 75 g (raw)	360 mg of sodium per 100 g (raw)	550 mg of sodium per 100 g (raw)
Sodium reduction rate to reach	78 % sodium reduction	50 % sodium reduction	25 % sodium reduction	42 % sodium reduction	57 % sodium reduction	34 % sodium reduction

SODIUM SOURCES AND MICROBIOLOGICAL RISK

In the sausage, salt is the highest source of sodium, with a contribution of nearly 90 % of total sodium, and was thus the only ingredient reduced in the formulation. One role of salt is to influence the taste of the sausage. In addition, during production of the sausage, salt plays an important technological role. It helps extract muscle proteins and is used as a binder to ensure cohesion of the grains of meat and to retain water and fat. Therefore, reduction in salt content can affect texture and reduce water and fat retention in the sausage. That can result in loss of liquids when preserved (in packaging) and during cooking. Reformulation must take these aspects into account.

Reduction in salt content can increase microbiological risk and is likely to decrease the length of time the sausage can be kept. After salt reduction and adjustment of the taste profile and water retention, additional studies will be required to identify measures for limiting microbiological risk. These studies are not addressed in this section of the guide

SUBSTITUTION INGREDIENTS

Based on technical information gathered (table 7), mineral substitutes and certain binding ingredients appear to be appropriate for reducing salt in meat products like sausages. Sausages are standardized foods (Food and Drug Regulations) and the Canadian Food Inspection Agency must be consulted before standardized foods incorporating these ingredients can be commercialized. In fact, regulations are vague regarding certain salt substitution ingredients. Table 21 provides details about the ingredients selected for the salt substitution tests for sausages.

TABLE 21 I INGREDIENTS USED TO SUBSTITUTE PART OF THE SALT IN THE SAUSAGE

(TEST NUMBERS REFER TO THE PROTOTYPES DETAILED IN TABLES 22 AND 23)

Ingredient	Family	Characteristics	Manufacturer	Tests
Potassium chloride	Mineral substitute	KCl	Different manufacturers	A1, A2, A3, E1, F1
AFS Salt Substitute CL T#1	Mineral substitute	Contains KCl	Advanced Food Systems	B1
100 % Salt Substitute	Substitut minéral	KCl, farine de riz, acide citrique	Ingredients Inc.	C1
0092-R-03	Mineral substitute	KCl, rice flour, citric acid	Ingredients Inc.	C1
Lactosalt Optitaste	Mineral substitute	Milk minerals	Armor Protéines S.A.S	D1
Canadian Harvest Oat Fiber 770	Functional agent	Processed oat product (binder)	SunOpta	E1
Dairy-Lo	Functional agent	Whey protein concentrate (binder)	Parmalat	F1

EVALUATION OF REDUCED SODIUM PROTOTYPES

Details on the modifications to the formulation of the positive control are presented hereafter (Tables 22 and 23). In short, the first tests consisted in evaluating the salt substitutes individually in the prototypes in which sodium was reduced by 57 %. Then the functional ingredients (binders) were added so as to reduce cooking losses.

Potassium chloride (KCl) shows the best performance as a salt substitute in fresh sausage. In fact, in addition to providing a salty taste, it was able to reproduce the texture (grain cohesion and firmness) of the positive control better than the other substitutes. However, the KCl must be adjusted so as to minimize bitterness. For example, in the formulation studied, the prototype with a KCl dose of 1.70 % (formulation A2) came closer to the taste profile of the positive control than the prototype with a dose of 2.20 % (formulation A3).

Adding oat fibres (Canadian Harvest Oat Fiber 770; formulation E1) or milk proteins (Dairy-Lo; formulation F1) to the binder made it possible to limit cooking losses. Soy proteins can accomplish this technological function.

TABLE 22 | MODIFICATIONS ALLOWING THE MOST ACCURATE REPRODUCTION OF THE TASTE PROFILE OF THE SAUSAGE NOT REDUCED IN SODIUM (POSITIVE CONTROL)

			Positive control	Negative control	Promising formulations		
					E1	F1	A2
Salt (NaCl)		%	1,90	0,69	0,70	0,70	0,70
Potassium chloride (KCl)		%			1,18	1,18	1,70
Toasted wheat crumbs		%	4,10	4,10	3,80	3,10	4,10
Canadian Harvest Oat Fiber 770		%			0,30		
Dairy-Lo		%				1,00	
Sodium per 75 g		mg	618	268	266	262	267
Potassium per 75 g		mg	124	885	646	645	874
Evaluation	Intensity of salt characteristic	/5	4,0	2,4	3,3	3,4	3,6
	Persistence of salt taste	/5	4,0	2,8	3,0	3,4	3,2
	Firmness	/5	4,0	3,6	3,1	3,3	4,1
Cooking losses		%	14	25	12	10	18

TABLE 23 | REDUCED-SALT SAUSAGE PROTOTYPES: MODIFICATIONS COMPARED TO POSITIVE CONTROL, SODIUM AND POTASSIUM CONTENT, EVALUATION AND COOKING LOSSES

			Positive control	Negative control	A1	B1	C1	D1	E1	F1	A2	A3
Salt (NaCl)		%	1,90	0,69	0,70	0,40	0,70	0,60	0,70	0,70	0,70	0,70
Potassium chloride (KCl)		%			1,18				1,18	1,18	1,70	2,20
AFS Salt Substitute CL T#1		%				0,60						
100% Salt Substitute 0092-R-03		%					1,00					
Lactosalt Optitaste		%						1,0				
Toasted wheat crumbs		%	4,10	4,10	4,10	4,10	4,10	4,10	3,80	3,10	4,10	4,10
Canadian Harvest Oat Fiber 770		%							0,30			
Dairy-Lo		%								1,00		
Sodium per serving of 75 g		mg	618	268	268	268	267	267	266	262	267	267
Potassium per serving of 75 g		mg	124	885	645	239	125	349	646	645	874	1094
Evaluation	Intensity of salt characteristic	/5	4,0	2,4	2,9	2,8	2,3	2,4	3,3	3,4	3,6	4,3
	Persistence of salt taste	/5	4,0	2,8	3,1	2,6	2,4	2,8	3,0	3,4	3,2	4,3
	Firmness	/5	4,0	3,6	3,3	3,0	2,1	2,8	3,1	3,3	4,1	3,4
Cooking losses		%	14	25	17	24	17	19	12	10	18	9

Example 4 | Oatmeal muffin

Positive control (existing product, not sodium reduced)

420 mg of sodium per serving of 90 g. Details of this formulation are presented in Table 24.

TABLE 24 | FORMULATION OF POSITIVE CONTROL FOR THE MUFFIN AND CONTRIBUTION TO SODIUM AND POTASSIUM CONTENT OF EACH INGREDIENT FOR A SERVING OF 90 g (100 g BEFORE BAKING)

	Formulation %	Per serving of 90 g (100 g before baking)		
		Ingredients g	Sodium mg	Potassium mg
Flour	22,00	22,00	0	24
Sugar	8,30	8,30	7	0
Brown sugar	13,70	13,70	5	47
Soy oil	7,00	7,00	0	0
Eggs	7,00	7,00	8	9
Oat bran	4,00	4,00	0	23
Oatmeal	12,50	12,50	1	44
Sodium bicarbonate	0,56	0,56	153	0
Baking powder	0,40	0,40	26	0
Salt (NaCl)	0,56	0,56	217	0
Vanilla flavour	0,30	0,30	0	0
Cinnamon	0,25	0,25	0	1
Water	23,40	23,40	0	0
Xanthan gum	0,03	0,03	0	1
Total	**100**	**100**	**420**	**149**

SODIUM REDUCTION TARGET

The sodium reduction target (Table 25) for muffins is a sodium reduction of 43 %, to reach 240 mg of sodium per serving of 90 g. This reduction corresponds to the Health Check program criteria and was retained because it is both realistic and more constraining than the Health Canada criteria for the claim "Reduced sodium content" and the target proposed by the Food Standards Agency (FSA) of the United Kingdom for 2012. Health Canada criteria for the claim "low sodium content" were not retained since they would require a major reduction (more than 65 %) of sodium and this exercise was not considered to be relevant for the purposes of this guide.

TABLE 25 | SODIUM REDUCTION TARGETS FOR THE MUFFIN UNDER THE HEALTH CANADA CRITERIA, HEALTH CHECK PROGRAM AND THE UNITED KINGDOM FOOD STANDARDS AGENCY (FSA)

Organization	Health Canada			Health Check	FSA	
Claim, target or criterion to meet	*Low sodium content*	*Lightly salted*	*Reduced sodium content*	2010 criterion	Reduction target for 2010	Reduction target for 2012
Sodium quantities to be met	Not more than 140 mg of sodium per reference quantity of 90 g	50 % less sodium than the similar reference food	25 % less sodium than the similar reference food	240 mg or less per serving of 90 g	400 mg of sodium per100 g	350 of sodium per100 g
Sodium reduction rate to reach	67 % sodium reduction	50 % sodium reduction	25 % sodium reduction	43 % sodium reduction	14 % sodium reduction	25 % sodium reduction

SODIUM SOURCES AND MICROBIOLOGICAL RISK

In the formulation of the muffin (positive control), salt is the highest source of sodium, with more than 50 % of total sodium, followed by sodium bicarbonate with a contribution of more than 35 %. Salt's role is to provide taste to the muffin; the sodium bicarbonate plays a functional role (rising, texture). In an aim to limit corrective action to the taste profile, salt was the only ingredient reduced in the formulation.

Since the product studied is not a micro sensitive food, sodium reduction does not represent a significant increase in microbiological health risk

SUBSTITUTION INGREDIENTS

For muffins, mineral substitutes and yeast products were used to replace salt. In addition, instead of adding new flavours, the doses of cinnamon and vanilla flavour (already present in the formulation) were increased as required. Table 26 presents the details of the ingredients selected for salt substitute tests with the muffins.

TABLE 26 | INGREDIENTS USED TO SUBSTITUTE PART OF THE SALT IN THE MUFFIN

(TEST NUMBERS REFER TO PROTOTYPES DETAILED IN TABLES 27 ET 28)

Ingredient	Family	Characteristics	Manufacturer	Tests
Potassium chloride	Mineral substitute	KCl	Different manufacturers	A1, A2
AFS Salt Substitute CL T#1	Mineral substitute	Contains KCl	Advanced Food Systems	B1, B2
100 % Salt Substitute 0092 R 03	Mineral substitute	KCl, rice flour, citric acid	Ingredients Inc.	C1, C2, C3, C4, C5
Provesta 029	Yeast product	Yeast autolysate with KCl	Ohly	D1

EVALUATION OF REDUCED SODIUM PROTOTYPES

Details about modifications made to the formulation of the positive control are presented hereafter (Tables 27 and 28). The four salt substitutes were evaluated individually at different doses.

The ingredient based on yeast autolysate and KCl left an after taste and did not satisfactorily improve the intensity of the salt characteristic (formulation D1). KCl-based ingredients were better for adjusting the salt characteristic of the muffin and did not leave an after taste (formulations A2, B2 et C2). The prototypes developed with 100 % Salt Substitute 0092 R 03 stood out slightly (formulation C1 and C2), and an increased dose of this substitute and of the vanilla flavour provided a reduced-sodium muffin with a taste profile in conformity with the positive control (formulations C4 and C5).

TABLE 27 | MODIFICATIONS ALLOWING THE MOST ACCURATE REPRODUCTION OF THE TASTE PROFILE OF THE MUFFIN NOT REDUCED IN SODIUM (POSITIVE CONTROL)

			Positive control	Negative control	Promising formulations	
					C4	C5
Salt (NaCl)		%	0,56	0,09	0,10	0,10
Vanilla flavour		%	0,30	0,30	0,33	0,33
Cannelle		%	0,25	0,25	0,25	0,25
100 % Salt Substitute 0092 R 03		%			0,56	0,63
Sodium per serving of 90 g		mg	419	238	240	240
Potassium per serving of 90 g		mg	149	149	366	391
Evaluation	Intensity of salt characteristic	/5	4,0	2,0	3,3	3,7
	Persistence of salt taste	/5	4,0	3,4	3,8	3,9

TABLE 28 I REDUCED-SALT MUFFIN PROTOTYPES: MODIFICATIONS COMPARED TO POSITIVE CONTROL, SODIUM AND POTASSIUM CONTENT, EVALUATION

			Positive control	Negative control	A1	B1	C1	D1	A2	B2	C2	C3	C4	C5
Salt (NaCl)		%	0,56	0,09	0,09	0,09	0,09	0,10	0,09	0,09	0,09	0,09	0,10	0,10
Vanilla flavour		%	0,30	0,30	0,30	0,30	0,30	0,33	0,30	0,30	0,30	0,33	0,33	0,33
Cinnamon		%	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,27	0,25	0,25
Potassium chloride (KCl)		%			0,30				0,47					
AFS Salt Substitute CL T#1		%				0,30				0,47				
100 % Salt Substitute 0092 R 03		%					0,30		0,01		0,47	0,47	0,56	0,63
Provesta 029		%						0,56						
Sodium per serving of 90 g		mg	419	238	238	238	238	240	238	238	238	238	240	240
Potassium per serving of 90 g		mg	149	149	314	302	269	239	407	387	337	337	366	391
Evaluation	Intensity of salt characteristic	/5	4,0	2,0	2,3	2,9	3,1	2,3	2,6	2,6	3,0	3,0	3,3	3,7
	Persistence of salt taste	/5	4,0	3,4	N.E.	N.E.	N.E.	4,0	N.E.	N.E.	N.E.	N.E.	3,8	3,9

N.E.: Not evaluated

Example 5 | Chocolate chip cookies

Positive control (existing product, not sodium reduced)

170 mg of sodium per serving of 30 g of cookies. Details of this formulation are presented in Table 29.

TABLE 29 | FORMULATION OF POSITIVE CONTROL FOR THE COOKIE AND CONTRIBUTION TO SODIUM AND POTASSIUM CONTENT OF EACH INGREDIENT FOR A SERVING OF 30 g (35 g BEFORE BAKING)

	Formulation %	Per serving of 30 g (35 g before baking)		
		Ingredients g	Sodium mg	Potassium mg
Flour	33,35	11,67	0	12
Brown sugar	12,07	4,22	2	15
White sugar	6,89	2,41	0	0
Shortening	15,51	5,43	0	0
Eggs	7,52	2,63	4	3
Glucose	5,18	1,81	0	0
Water	5,17	1,81	0	0
Vanilla flavour	0,21	0,07	0	0
Glycerine	1,72	0,60	0	0
Chocolate chips	10,14	3,55	2	10
Starch	0,69	0,24	0	0
Xanthane gum	0,05	0,02	0	0
Baking powder	0,15	0,05	3	0
Sodium bicarbonate	0,65	0,23	63	0
Salt (NaCl)	0,70	0,25	95	0
Total	**100**	**35**	**170**	**42**

SODIUM REDUCTION TARGET

The reduction target (Table 30) retained for the cookie is an 18 % reduction in sodium to reach 140 mg per serving of 30 g. This reduction corresponds to Health Check criteria for 2010 and makes it possible to meet Health Canada criteria for "Low sodium content." In addition, several prototypes were developed with a 52 % reduction of sodium, thereby meeting FSA reduction targets (2010 and 2012) as well ad Health Canada criteria for the claim "Reduced sodium content" and "Lightly salted."

TABLE 30 | SODIUM REDUCTION TARGETS FOR THE COOKIE UNDER THE HEALTH CANADA CRITERIA, HEALTH CHECK PROGRAM AND THE UNITED KINGDOM FOOD STANDARDS AGENCY (FSA)

Organization	Health Canada			Health Check	FSA	
Claim, target or criterion to meet	*Low sodium content*	*Lightly salted*	*Reduced sodium content*	Criteria initially set for 2010	Reduction target for 2010	Reduction target for 2012
Sodium quantities to be met	Not more than 140 mg of sodium per reference quantity of 30 g	50 % less sodium than the similar reference food	25 % less sodium than the similar reference food	140 mg or less per serving of 30 g	416 mg of sodium per 100 g	270 mg of sodium per 100 g
Sodium reduction rate to reach	18 % sodium reduction	50 % sodium reduction	25 % sodium reduction	18 % sodium reduction	27 % sodium reduction	52 % sodium reduction

**Studies were conducted using the Health Check program criteria published in September 2008 and were to be applicable as of November 2010. Revised criteria published in March 2009 showed that the cookies had been removed from the Health Check program*

SODIUM SOURCES AND MICROBIOLOGICAL RISK

In the cookie, salt is the highest source of sodium, with a contribution of more than 55 % of total sodium, followed by sodium bicarbonate with a contribution of 37 %. These ingredients were reduced in the reformulation. Salt's major role is to influence taste, whereas the role of sodium bicarbonate is to affect the cookie's texture.

Moreover, considering that the product studied is not micro sensitive, sodium reduction does not represent a significant increase in microbiological health risk

SUBSTITUTION INGREDIENTS

Based on the technical data gathered (table 7), the taste profile of mineral substitutes is appropriate as a salt substitute in applications like chocolate chip cookies. In addition, various functional agents can replace sodium bicarbonate. Table 31 provides details about the ingredients used for the cookie reformulation tests.

TABLE 31 | INGREDIENTS USED TO SUBSTITUTE PART OF THE SALT IN THE COOKIE

(TEST NUMBERS REFER TO PROTOTYPES DETAILED IN TABLES 32 ET 33)

Ingredient	Family	Characteristics	Manufacturer	Tests
Potassium chloride	Mineral substitute	KCl	Different manufacturers	A1, A2
Saltwise 1029	Mineral substitute	-	Cargill	B1, B2
Saltwise 1529	Mineral substitute	-	Cargill	C1, C2
LomaSalt RS 50 Classic	Mineral substitute	Contains 20 % of sodium et 15 % of potassium	Dr Paul Lohmann	D1, D2
LomaSalt RS 100	Mineral substitute	Does not contain sodium	Dr Paul Lohmann	E1, E2
Ammonium hydrogencarbonate	Functional agent	Leavening agent	Kissner	F1
Calcium carbonate	Functional agent	Leavening agent	Rhodia Food	G1
Regent 12XX AJAX	Functional agent	Monocalcium phosphate Leavening agent	Rhodia Food	G1

EVALUATION OF REDUCED SODIUM PROTOTYPES

Details about modifications made to the formulation of the positive control are presented hereafter (Tables 32 & 33).

The first tests consisted in evaluating the mineral substitutes in the prototypes in which sodium was reduced by 18 % by reducing the salt dose. These tests showed that Saltwise 1029, Saltwise 1529 and LomaSalt RS 100 (formulations B1, C1 and E2, respectively) can provide a salt taste with an intensity and persistence similar to that of salt. Potassium chloride (formulation A1) could not provide the same salt taste intensity. In addition, at the doses used, this ingredient appeared to contribute bitterness.

Prototypes were developed by reducing sodium by substituting the sodium bicarbonate. These tests revealed that ammonium hydrogencarbonate (formulation F1) is efficient as a leavening agent in cookies. In fact, the appearance of the prototypes was close to that of the control, even though adjustments to this formulation are in order. Moreover, the combination of calcium carbonate and monocalcium phosphate (formulation g1, in the appendix) does not appear to be appropriate for easily replacing sodium bicarbonate in cookies. These ingredients contributed a tart taste that does not comply with the taste profile of the cookies. Nor did the prototypes present the same surface colouring as the positive control. A more exhaustive reformulation should be considered in order to use these ingredients successfully

TABLE 32 | MODIFICATIONS ALLOWING THE MOST ACCURATE REPRODUCTION OF THE TASTE PROFILE OF THE COOKIE NOT REDUCED IN SODIUM (POSITIVE CONTROL)

			Positive control	Negative control	Promising formulations		
					B1	C1	E2
Sodium bicarbonate		%	0,65	0,65	0,65	0,65	0,65
Salt (NaCl)		%	0,70	0,44	0,40	0,40	0,44
Saltwise 1029		%			1,00		
Saltwise 1529		%				1,00	
LomaSalt RS 100		%					0,70
Sodium per serving of 30 g		mg	170	135	133	135	135
Potassium per serving of 30 g		mg	42	42	N/A	N/A	N/A
Evaluation	Intensity of salt characteristic	/5	4,0	2,9	3,7	3,7	3,9
	Persistence of salt taste	/5	4,0	3,1	3,8	3,7	3,9

TABLE 33 | REDUCED-SALT CHOCOLATE CHIP COOKIE PROTOTYPES: MODIFICATIONS COMPARED TO POSITIVE CONTROL, SODIUM AND POTASSIUM CONTENT, EVALUATION

			Positive control	Negative control	A1	B1	C1	D1	D2	E1	E2	A2	B2	C2	E3	F1	G1
Sodium bicarbonate		%	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.00	0.00
Salt (NaCl)		%	0.70	0.44	0.44	0.40	0.40	0.13	0.00	0.44	0.44	0.00	0.00	0.00	0.00	0.70	0.70
Potassium chloride (KCl)		%			1.00							1.00					
Saltwise 1029		%				1.00							1.50				
Saltwise 1529		%					1.00							1.00			
LomaSalt RS 50 Classic		%						0.57	0.87								
LomaSalt RS 100		%								0.55	0.70				0.70		
Ammonium hydrogencarbonate		%														0.650	
Calcium carbonate		%															0.98
Regent 12XX AJAX		%															0.77
Sodium per serving of 30 g		mg	170	135	135	133	135	135	139	135	135	75	81	81	75	107	107
Potassium per serving of 30 g		mg	42	42	234	N.A.	N.A.	75	92	N.A.	N.A.	234	N.A.	N.A.	N.A.	42	41
Evaluation	Intensity of salt characteristic	/5	4.0	2.9	3.2	3.7	3.7	2.9	3.6	3.5	3.9	3.1	3.1	2.8	2.9	3.2	N.E.
	Persistence of salt taste	/5	4.0	3.1	3.6	3.8	3.7	3.0	3.3	3.8	3.9	3.1	3.0	2.6	2.6	3.2	N.E.

N.A.: Not available (certain data are missing)
N.E.: Not evaluated

Example 6 | Onion soup (dehydrated product)

Positive control (existing product, not sodium reduced)

955 mg of sodium per serving of 250 ml (reconstituted soup). Details of this formulation are presented in Table 34.

TABLE 34 | FORMULATION OF POSITIVE CONTROL FOR THE ONION SOUP AND CONTRIBUTION TO SODIUM AND POTASSIUM CONTENT OF EACH INGREDIENT FOR A SERVING OF 250 mL OF RECONSTITUTED SOUP (14 g IN DEHYDRATED FORM)

	Formulation %	Per serving of 250 ml (reconstituted soup)		
		Ingredients g	Sodium mg	Potassium mg
Dried onions	38,50	5,39	1	87
Salt (NaCl)	12,85	1,80	702	0
Malto dextrin	11,20	1,57	0	0
Onion powder	11,00	1,54	1	15
Corn starch	6,00	0,84	0	0
Hydrolysed vegetable proteins	6,00	0,84	134	12
Yeast extract	4,50	0,63	42	16
Vegetable fat	4,40	0,62	0	0
Monosodium glutamate	3,60	0,50	65	0
Caramel powder	1,50	0,21	9	0
Garlic powder	0,25	0,03	0	0
Pepper	0,25	0,03	0	0
Total	**100**	**14**	**955**	**130**

SODIUM REDUCTION TARGET

The sodium reduction target (Table 35) for muffins is a sodium reduction of 50 %, to reach 480 mg of sodium per serving of 250 g.This reduction corresponds to the Health Check program and Health Canada criteria for the claim "Lightly salted." This target was retained because it is both realistic and more constraining than the Health Canada criteria for the claim "Reduced sodium content" and the target proposed by the Food Standards Agency (FSA) in the United Kingdom for 2010. Health Canada criteria for the claim "low sodium content" were not retained since they would require a major reduction (more than 85 %) of sodium and this exercise was not considered to be relevant for the purposes of this guide.

TABLE 35 | SODIUM REDUCTION TARGETS FOR THE SOUP UNDER THE HEALTH CANADA CRITERIA, HEALTH CHECK PROGRAM AND THE UNITED KINGDOM FOOD STANDARDS AGENCY (FSA)

Organization	Health Canada			Health Check	FSA	
Claim, target or criterion to meet	*Low sodium content*	*Lightly salted*	*Reduced sodium content*	2010 criterion	Reduction target for 2010	Reduction target for 2012
Sodium quantities to be met	Not more than 140 mg of sodium per reference quantity of 250 ml	50 % less sodium than the similar reference food	25 % less sodium than the similar reference food	480 mg or less per serving of 250 ml	250 mg of sodium per 100 g	230 mg of sodium per 100 g
Sodium reduction rate to reach	85 % sodium reduction	50 % sodium reduction	25 % sodium reduction	50 % sodium reduction	33 % sodium reduction	40 % sodium reduction

SODIUM SOURCES AND MICROBIOLOGICAL RISK

In onion soup, salt is by far the highest source of sodium with a contribution of nearly 75 % of total sodium, and thus it was the only ingredient reduced in the formulation. Salt's role is to influence the taste of the soup. Considering that the product studied is in a dehydrated form, sodium reduction does not represent a significant increase in microbiological health risk.

SUBSTITUTION INGREDIENTS

Based on technical data gathered (table 7), the taste profile of each of the three families of salt substitution ingredients is appropriate for applications like soup. Table 36 presents the details of the mineral substitutes, yeast products, and flavours selected for the salt substitution tests in onion soup.

TABLE 36 | INGREDIENTS USED TO SUBSTITUTE PART OF THE SALT IN ONION SOUP

(TEST NUMBERS REFER TO PROTOTYPES DETAILED IN TABLES 37 AND 38)

Ingredient	Family	Characteristics	Manufacturer	Tests
Potassium chloride	Mineral substitute	KCl	Different manufacturers	B1, J1, K1
Saltwise 1029	Mineral substitute	-	Cargill	C1
Saltwise 1529	Mineral substitute	-	Cargill	D1
Bonded KCl Mimic 11004279	Mineral substitute	KCl avec natural flavour	Wixon	E1, F1, g1, H1, H2, I1, I2
Springer 2012/20 mG L	Yeast product	Nucleotide-rich yeast extract (12 %)	BIO SPRINGER	F1
UnSal20 Onion Flavouring Z71aa 1NC1 2	Flavour	Flavours	Ungerer Limited	G1
(Flavouring preparation)	Ungerer Limited	G1	PTX Food Corporation	H1, H2
Intense 2	Flavour	Natural flavour (cultured whey)	PTX Food Corporation	H1, H2
Natural Flavor Modulator (Salt) FMT TM 711047	Flavour	Natural flavour et NaCl (10 à 16 %)	Kerry	I1, I2
Springer 2020/0 mG L	Yeast product	Nucleotide-rich yeast extract (20 %)	BIO SPRINGER	J1, K1, L1
Citric acid	Functional agent	Acidity regulator	Different manufacturers	J1, K1, L1
Super YE	Yeast product	Yeast extract and NaCl (4,5 à 9,5 %)	Ajinomoto	K1
Mycoscent	Flavour	Natural flavour	Marlow Foods	Li

EVALUATION OF REDUCED SODIUM PROTOTYPES

Details about modifications made to the formulation of the positive control are presented hereafter (Tables 37 & 38). Tests consisted in evaluating the salt substitutes individually or in combinations. The most interesting formulations were re-evaluated using modified substitution concentrations.

The increase in certain ingredients already present in the control formulation, such as yeast extracts, hydrolysed vegetable proteins and onion powder, contributed to enhancing the taste profile obtained with salt substitutes. Adding citric acid prolongs and enhances the taste. Yeast extracts contribute to prolonging the effect in the mouth.

Finally, onion soup is an example of a dish in which the salty taste is very present and is the first to be perceived, followed by that of the onion and the beef. In this context, the effect of salt is very difficult to simulate when the sodium reduction target is 50 %.

TABLE 37 I MODIFICATIONS ALLOWING THE MOST ACCURATE REPRODUCTION OF THE TASTE PROFILE OF THE ONION SOUP NOT REDUCED IN SODIUM (POSITIVE CONTROL)

			Positive control	Negative control	Promising formulations			
					B1	C1	J1	K1
Salt (NaCl)		%	12,85	3,90	3,90	3,55	3,45	3,40
Onion powder		%	11,00	11,00	11,00	11,00	15,00	15,00
Hydrolysed vegetable proteins		%	6,00	6,00	6,00	6,00	7,00	7,00
Yeast extract		%	4,50	4,50	4,50	4,50	6,00	6,00
Potassium chloride (KCl)		%			8,60	0,00	5,50	5,50
Saltwise 1029		%				20,45		
Springer 2020/0 mG L		%					4,00	4,00
Citric acid		%					0,18	0,18
Super YE		%						0,50
Sodium content per serving of 250 ml		mg	955	465	465	476	476	480
Potassium content per serving of 250 ml		mg	130	16	791	130	130	565
Evaluation	Intensity of salt characteristic	/5	4,0	1,4	3,1	2,6	2,6	2,6
	Intensity of spicy taste	/5	4,0	1,6	3,1	2,7	2,7	2,6

TABLE 38 | REDUCED-SALT ONION SOUP PROTOTYPES: MODIFICATIONS COMPARED TO POSITIVE CONTROL, SODIUM AND POTASSIUM CONTENT, EVALUATION

			Positive control	Negative control	A1	B1	C1	D1	E1	F1	G1	H1	H2	I1	I2	J1	K1	L1
Salt (NaCl)		%	12,85	3,90	3,50	3,90	3,55	3,30	3,50	2,75	3,45	3,45	3,45	3,25	3,00	3,45	3,40	3,45
Onion powder		%	11,00	11,00	15,00	11,00	11,00	11,00	15,00	15,00	15,00	15,00	15,00	15,00	15,00	15,00	15,00	15,00
Hydrolysed vegetable proteins		%	6,00	6,00	7,00	6,00	6,00	6,00	7,00	7,00	7,00	7,00	7,00	7,00	7,00	7,00	7,00	7,00
Yeast extract		%	4,50	4,50	6,00	4,50	4,50	4,50	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00
Potassium chloride (KCl)		%				8,60										5,50	5,50	
Saltwise 1029		%					20,45											
Saltwise 1529		%						20,70										
Bonded KCl Mimic 11004279		%							2,50	2,50	2,50	2,50	2,50	2,50	2,50			
Springer 2012/20 mG L		%								1,25								
UnSal20 Onion Flavouring Z71aa 1NC1 2		%									2,40							
Intense 2		%										0,50	1,00					
Natural Flavor Modulator (Salt) FMT TM 711047		%												1,40	2,80			
Springer 2020/0 mG L		%														4,00	4,00	4,00
Citric acid		%														0,18	0,18	0,18
Super YE		%															0,50	
Mycoscent		%																0,20
Sodium content per serving of 250 ml		mg	955	465	480	465	476	478	480	454	478	478	478	479	477	476	480	480
Potassium content per serving of 250 ml		mg	130	16	143	791	130	130	333	333	333	333	333	333	333	130	565	143
Evaluation	Intensity of salt characteristic	/5	4,0	1,4	2,2	3,1	2,6	2,2	1,3	1,6	1,3	2,4	2,5	1,8	2,0	2,6	2,6	2,3
	Intensity of spicy taste	/5	4,0	1,6	1,9	3,1	2,7	2,2	2,0	2,3	2,0	3,1	2,8	2,3	3,4	2,7	2,6	2,3

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Reformulation of products to reduce sodium:

Salt Reduction guide for the Food Industry

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