SCIENTIFIC COMMITTÉE
OF THE FEDERAL AGENCY FOR THE
SAFETY OF THE FOOD CHAIN

Joint advisory report
SciCom 05-2012 and SHC 8663

Concerns: Reformulation of foodstuffs – salt reduction (Sci Com 2010/09 – SHC 8663)

Advisory report endorsed by the Scientific Committee of the FASFC on 16 March 2012 and by the Superior Health Council (SHC) Board on 4 April 2012.

Summary

High levels of sodium intake have been associated with a series of health risks, including high blood pressure, with various clinical consequences such as certain cardiovascular diseases. It has also been shown that a lower blood pressure benefits health. Salt (NaCl, "kitchen salt") is the main source of sodium in foodstuffs, and aiming at a salt reduction will therefore translate into a reduction of the sodium (Na^+) intake. In several European countries, but also outside Europe, various salt reduction campaigns have been launched. In Belgium, a campaign was set up within the framework of the National Food and Health Plan for Belgium (NFHP), which focussed on e.g. raising consumer awareness and reaching an agreement with the food industry and distributors to reduce the salt content of foodstuffs. Economical and technological factors, as well as subjective ones (e.g. taste) all play a part in reducing the salt (sodium) content of foodstuffs. This advisory report mainly looks at the most important aspects of salt reduction with respect to food safety and public health.

In Belgium, the average adult salt intake is around 10.5 g per day. The Superior Health Council (SHC) advises to reduce this intake to < 5 g per day, the largest contributors to which are foodstuffs prepared outside the home (bread, cheese, cooked pork meats, ready-made meals, etc) and "ready-to-use" dishes (± 75 %). Salt is not added to foodstuffs for sensory reasons alone, but also for microbiological and technological purposes. It follows that any foodstuff reformulation needs to take into account the different functionalities of salt in food. However, such reformulation cannot signify that the fat or sugar content of these foodstuffs will rise, as this would be counterproductive in striving towards a healthy diet. Moreover, the microbiological and chemical safety of the reformulated product should always be assessed.

The methods that aim at cutting down on the salt content in food include reducing it gradually, using salt substitutes, acting on the perceived taste (e.g. seasoning, flavour enhancers, physical availability of salt, etc.) and replacing other sodium-containing food additives. However, with many food products displaying an excessive salt content and the salt content of food products of the same type showing a significant amount of variation, the most obvious method, at a first stage, appears to be simply reducing the salt content gradually.

This advisory report issues a series of recommendations intended for politics, the sectors concerned, research and the consumers.

Keywords

Salt, salt substitutes, foodstuffs

Mesh terms

Food, Food and Beverages, Sodium Chloride, Sodium, Dietary, Food Industry, Food Technology, Food Safety, Food Preservation, Food Microbiology, Food Habits, Food Preferences, Food labeling, Health Food, Nutrition Policy, Public Health.

Abbreviations

An	Obligatory anaerobic
bw	Body weight
CRIOC:	Centre de Recherche et d'Information des Organisations de Consommateurs
CVA	Cerebrovascular accident, stroke
EDTA	Ethylene diamine tetraacetic acid
EFSA:	European Food Safety Authority
ESAN	European Salt Action Network
FA	Facultatively aerobic
FASFC	Federal Agency for the Safety of the Food Chain
FPS HFCSE	Health, Food Chain Safety and Environment
FSA	Food Standards Agency
GHP	Good Hygiene Practices
HVP	Hydrolysed vegetable protein
ICP-AES	Inductively coupled plasma atomic emission spectroscopy
JND	Just Noticeable Difference
KCl	Potassium chloride
M	Microaerophilic
MSG	Sodium glutamate
NaCl	Sodium chloride
NFHP	National Food and Health Plan
SE	Salt-equivalent
SHC:	Superior Health Council
TOPH	Trial of Hypertension Prevention
WASH	World Action on Salt & Health
WHO	World Health Organization

1. Terms of reference

1.1. Phrasing of the question

This advisory report was drawn up on the initiative of the Scientific Committee of the FASFC and the Superior Health Council (SHC), which co-operated on this project. It is concerned with:

1. providing an account of the issue: salt reduction vs. sodium reduction (**section 2**);
2. looking at the Belgian population's salt intake (**section 3**);
3. examining the public health risks attendant upon an excessive sodium intake (**section 3**);
4. discussing the technological function of salt in foodstuffs and the food safety risks of reducing the salt content (**section 4)**;
5. considering possible approaches to salt reduction and the advantages and disadvantages of these approaches (**sections 5 & 6**).

In this document, the term "salt" is used to refer to sodium chloride or NaCl. The other salts under discussion will be explicitly referred to by their chemical names.

1.2. Legal context

- Council Directive 90/496/EEC of 24 September 1990/ Royal Decree of 8 January 1992 on nutrition labelling for foodstuffs
- Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods
- Regulation (EC) No 1925/2006 of the European Parliament and of the Council of 20 December 2006 on the addition of vitamins and minerals and of certain other substances to foods
- Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives
- Council Directive 89/398/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to foodstuffs intended for particular nutritional uses
- Commission Directive 2008/60/EC of 17 June 2008 laying down specific purity criteria concerning sweeteners for use in foodstuffs
- Commission Directive 2008/84/EC of 27 August 2008 laying down specific purity criteria on food additives other than colours and sweeteners
- Commission Directive 2008/128/EC of 22 December 2008 laying down specific purity criteria concerning colours for use in foodstuffs.

In order to answer the question, an *ad hoc* working group was set up with experts in preventive medicine, public health, epidemiology, chemistry, food technology and engineering, nutrition physiology and physiopathology as well as foodstuff analysis.

Following the discussions of the working group on July 5, 2010, November 29, 2010, January 31, 2011, April 26, 2011, June 28, 2011 (hearing of the organisations concerned), October 24, 2011 and January 12, 2012, as well as those during the plenary session of the Scientific Committee on March 16, 2012 and the SHC Board on April 4, 2012,

The scientific Committee of the FASFC and the Superior Health Council issue the following joint advisory report:

2. Introduction

Excessive salt has adverse health effects. Thus, an excessive salt intake can favour the development of high blood pressure, which is a risk factor for cardiovascular disorders. In addition, too much salt is also a risk factor for stomach cancer and osteoporosis (see section **3.3**). Based on data from the USA, it turns out that a salt reduction of just 1 g/day could have a significant beneficial effect on public health, to the same extent as other intervention campaigns do, such as anti-tobacco campaigns and campaigns targeted at reducing cholesterol levels (Bibbins-Domingo *et al.*, 2010).

The nutrient that influences blood pressure is in fact sodium (Na+), and a "salt reduction" really means a "sodium reduction". Salt (NaCl) is the main source of sodium in foodstuffs, but it is not the only one. Sometimes, other sodium salts are added as preservatives, fermentation products, thickeners, etc. (see **table 4.3.1**). Taking into account the molecular weight of the two ions (Na+ and Cl-), sodium amounts to 39.7% of the molecular weight of NaCl and 1g of salt contains around 17 mmol sodium and 17 mmol chloride. The “salt equivalent” (SE), in other words the amount of “salt” that corresponds to the sodium content, is calculated by multiplying the sodium content by 2.5 (1g of sodium = 2.5 g of salt). In this advisory report, the term "salt” is used to refer to sodium chloride (NaCl), except when mentioned otherwise.
The most commonly used method to analyse NaCl is quantifying the Cl- ions through titration (e.g. Mohr method, Volhardt method). However, given the fact that Na+ is the significant ion in terms of public health and that sources for Na+ other than salt (NaCl) can be found in the diet, it is highly advisable to measure the Na^+ ions, e.g. by means of emission spectrometry or ICP-AES.

It is believed that 75% of the salt intake is provided by processed foods (section **3.2**). That is why the National Food and Health Plan (NFHP) of the FPS Health, Food Chain Safety and Environment (FPS HFCSE) has been co-operating for some time now with the sectors concerned, such as the food industry, the distribution sector, the CHR industry and mass catering, to reduce the salt content in the food offer.[1] Several other countries have launched salt reduction programmes as well (WASH, 2011a; Webster *et al*., 2011; EC, 2009; PHAC, 2009). **Table 2.1** provides an overview of some of these programmes. The long-term objective of these salt reduction programmes is to reduce the salt intake (which averages 9-10 g/day) to 5-6 g/day. The main measures are: (1) reducing the salt content in (processed) foodstuffs (especially in products that contribute most to the salt intake, but across-the-board salt reduction in all products is advisable to grow accustomed to a less salty taste), (2) informing/raising the awareness of the population, (3) developing salt substitutes, (4) imposing requirements on the labelling of these products as well as (5) other regulatory measures. The efficiency of salt reduction programmes can be assessed by monitoring the population salt intake (e.g. by taking urine samples, assessment by means of a food consumption survey) and by taking into account the salt content of foodstuffs (based on the labels on the products concerned and laboratory analyses).

Table 2.1. Salt reduction programmes in several countries
(see also: WASH, 2011a; Webster *et al*., 2011; EC, 2009; PHAC, 2009)

Country	Start	Main measures	Results	Reference
Belgium	‘80	- Royal Decree of 2 September 1985 on bread and other bakery products	Reduction of the salt content in bread	
	2009	- Campaign “Stop le sel !“ (Drop the salt !”): Population information - Agreement with the distribution and processing sector to reduce the salt intake by 10 % by 2012 - Agreement with the bread sector regarding iodised salt	In 2009, the salt intake amounted to 10 g/day (= zero-measurement) – a new measurement is planned for 2012	http://www.monplannutrition.be http://www.stoplesel.be
Finland	1978	- Population information - Spreading of salt substitutes - Heart symbol for a beneficial nutritional profile - Warning on the packaging when the salt content is too high	~20 years: 14 g/day→ 10 g/day	Laatikainen *et al*.(2006)
France	2002	- Population information - Gradual salt reduction in products that contribute most to the salt intake (especially bread)	2001 – 2005: ± 5 % reduction of the salt intake	Anses (Afssa) (2002) Hercberg (2006)
United Kingdom	2003	- Population information - Reduction of the salt content in	- 2001 – 2006: 6 to 7% reduction of the salt intake	FSA (2010a) FSA (2009)

[1] http://www.health.belgium.be/eportal/Myhealth/Healthylife/Food/FoodandHealthPlan2/SALT/Menu/index.htm?fodnlang=fr

		foodstuffs - “Traffic light” labelling	- 24 – 45% salt reduction in the main products	
Ireland	2005	- Reduction of the salt content in foodstuffs - Restrictions on the claims “low sodium/salt”, “very low sodium/salt” and “sodium free/salt free”	2008: Salt reduction in - Bread: -10 % - Sauces: -15 % - Soups: -10 %	FSAI (2005)
Sweden	2008	- Population information - Reduction of the salt content in foodstuffs		FOPH (2009)
Australia	2007	Campaign “Drop the salt!” - Average 25% reduction of the salt content in foodstuffs - Average 25% reduction of the salt content in catering - Population information - Clear labelling		AWASH (2009)
USA	1995	Regulatory measures (health claims, statement, upper contents)		FDA (2011)
Canada	2007	- Population information - Voluntary reduction of the salt content in foodstuffs - (regulatory restrictions)		Health Canada (2010)

In 2007, the “European Salt Action Network” (ESAN)[2] was launched upon the initiative of the World Health Organisation (WHO) Europe based on the recommendations and conclusions of the “Second WHO European Action Plan for Food and Nutrition Policy” (WHO, 2007a), the resolution “Prevention and Control of non-communicable Diseases“ (WHO, 2007b) and the meeting “Reducing Salt Intake in Populations” (WHO, 2006). The ESAN aims at exchanging information on communication, monitoring and technological progress in the framework of the different salt reduction programmes. In the same context, the “EU Framework for National Salt Initiatives” was launched in 2008, which is a framework that is not legally binding (and therefore optional), the objective of which is to achieve a salt intake of 6 g/day or less in the different Member States. For all foodstuffs, a common European minimal criterion is recommended in order to reduce the 2008 baseline salt levels by 16% by 2012 (EC, 2008b). Action is clearly being taken at the international level (international market) to reduce the salt content in foodstuffs, both by policy makers as well as the industry.

In order to improve consumer protection against misleading labelling practices, the nutrition and health claims authorised on the packages have been set at the European level (Regulation (EC) n° 1924/2006). The following nutrition claims made on the salt/sodium content (as well as any other claim that is likely to have the same meaning for the consumer) are authorised:

- “low sodium/salt”: may only be made where the product contains no more than 0.12 g of sodium, or the equivalent value for salt, per 100 g or per 100 ml. For waters, other than natural mineral waters falling within the scope of Directive 80/777/EEC, this value should not exceed 2 mg of sodium per 100 ml.
- “very low sodium/salt” : may only be made where the product contains no more than 0.04 g of sodium, or the equivalent value for salt, per 100 g or per 100 ml. This claim shall not be used for natural mineral waters and other waters.
- “sodium-free or salt-free” : may only be made where the product contains no more than 0.005 g of sodium, or the equivalent value for salt, per 100 g.

[2] 23 countries have joined the network, viz. Belgium, Bulgaria, Croatia, Cyprus, Finland, France, Georgia, Greece, Hungary, Ireland, Israel, Italy, Malta, the Netherlands, Norway, Poland, Portugal, the Russian Federation, Serbia, Slovenia, Spain, Switzerland and the United Kingdom (coordinator). The WHO Europe and the EC act as observers; http://www.euro.who.int/en/what-we-do/health-topics/disease-prevention/nutrition/policy/member-states-action-networks/reducing-salt-intake-in-the-population

- "reduced sodium/salt" : may only be made where the reduction in sodium content, or the equivalent value for salt, is at least 25 % compared to a similar product, except for micronutrients.
- "no added salt/sodium" (currently still a proposal): may only be made where the product does not contain any added sodium/salt nor any other added ingredient containing sodium/salt and the product has a naturally low content of sodium or equivalent value for salt (< 0.12 g Na/100g).

Several factors play a part in reducing the salt (sodium) content of foodstuffs, such as consumer perception (e.g. taste, E numbers on the labels), economical factors (e.g. the cost of the ingredients, the international market) and techniques (e.g. organoleptic properties and food safety issues). This advisory report does not aim to provide a full discussion of this issue, but to debate on the main aspects involved in reducing the salt content of foodstuffs by putting the emphasis on food safety and public health.

3. Nutritional aspects of and justification for reducing the salt content of foodstuffs

3.1. Physiological overview of the sodium balance

Sodium determines the osmolality (i.e. the number of particles) of the extracellular fluids, or, in other words, the water and salt balance (homeostasis) and volemia (i.e. the volume of the extracellular fluids and the blood volume) of the organism. The sodium concentration in plasma remains fairly stable (~140 mmol/l) despite sometimes significant variations in the sodium (salt) intake. A higher sodium intake causes water to be retained in order to maintain osmolality.

In order to play a part in upholding the water-salt balance of the organism, and especially volemia (i.e. the volume of extracellular fluids and the blood volume), the sodium has to be provided as sodium chloride. From a practical point of view, it is therefore of paramount importance to convert the amount of sodium chloride (usually called "salt"). Indeed, the assessment of the urinary sodium excretion (usually expressed in mmoles per 24 hours) is the most objective means of estimating the dietary salt intake, usually expressed in g per 24 hours. The extra-renal sodium losses (sweat- and digestion-induced losses) are very limited under physiological conditions with no significant sweating. These losses usually range between 15 and 20 mmoles per day. Adding them to the amount of sodium eliminated through the kidneys provides a fairly objective and precise assessment of the dietary sodium intake. The often highly variable amounts of sodium provided through food, which can go from 20 up to 450 mmoles (i.e. between 1 and 26 g of salt) per day depending on the food habits, are usually excreted in an almost quantitative manner by the kidneys. This high ability of the kidneys to adjust the urinary sodium excretion to a more or less significant dietary intake results from very complex, but generally highly efficient, neuro-hormonal mechanisms.

3.2. The population salt intake in Belgium

The average salt intake varies in most countries and ranges between 9 and 12 g of NaCl per day for the adult population. It is about 20% higher for men than it is for women (EFSA, 2006; INTERSALT, 1988). This intake is close to 4 to 5 g of salt per day for 4-6 year-olds, and 5 to 6 g per day for 7-12 year-olds (EFSA, 2006).

The recent assessment of the salt intake in Belgium, which was carried out within the framework of the NFHP and was based on the urinary sodium excretion, revealed that the adult salt intake averages 10.5 g/day and is therefore close to that in the other European countries (Vandevijvere *et al*., 2010; INTERSALT, 1988). Most (about 75%) of the dietary sodium intake is due to the consumption of industrially prepared foods, i.e. foods with an increased salt content (**figure 3.2.1).** This especially concerns bread, cooked pork meats (certain kinds of which may contain up to 80 mmol of sodium per

100 g), dairy products such as cheeses with a high salt content, ready-made meals, sauces or soups (Ni Mhurchu *et al.*, 2010; Vandevijvere & Van Oyen, 2008; EFSA, 2006).

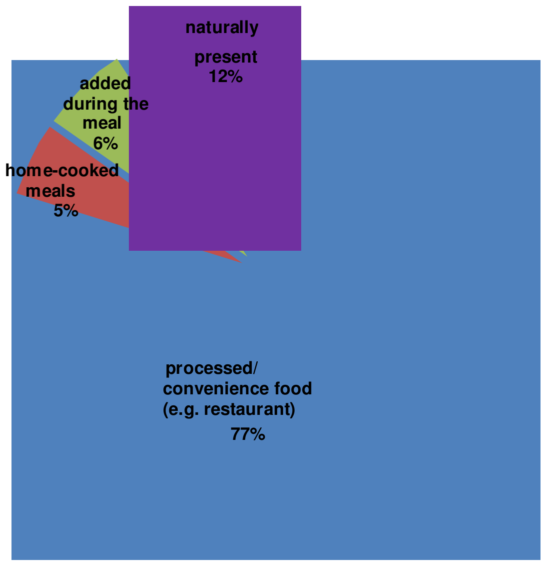


Figure 3.2.1. Contribution of the different salt sources to the overall intake (source: **EC, 2008a)**

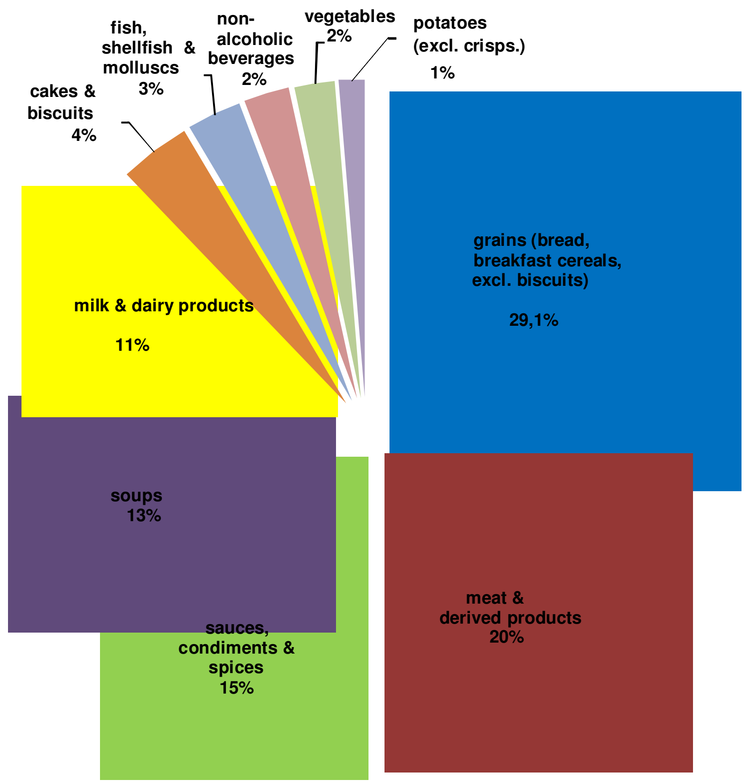


Figure 3.2.2. Groups of foodstuffs that contribute most (> 1%) to the salt intake of the Belgian population (source: Vandevijvere & Van Oyen, 2008)

The often excessive use of salt by the food industry is largely due to the beneficial effect salt has on taste and texture in many foodstuffs. It also aims at enhancing food preservation by reducing the risk of microbial proliferation (EFSA, 2006) (see **section 4**). The sodium content of most natural foodstuffs is very low, ranging between 0.1 mmol per 100 g for fruits and vegetables and 3.0 mmoles per 100 g for certain kinds of fish or meat. The salt intake that results from adding salt during cooking or at meals amounts to between 10 and 15% of the usual overall sodium intake.

Aside from the dietary intake of sodium chloride (and therefore of kitchen salt), sodium is also provided, though to a lesser extent, through food additives (i.e. as sodium nitrate, phosphate or glutamate) or beverages with a high sodium bicarbonate content (EFSA, 2006). It should be noted, however, that it is especially the sodium that is ingested as sodium chloride (and therefore the dietary salt intake) that plays a part in regulating the water and salt balance (homeostasis) and is responsible for the many adverse health effects of an excessive salt intake.

3.3. Salt, blood pressure and cardiovascular diseases

Strokes and heart disease are the main cause of premature death and disability (Lopez *et al.*, 2006). High blood pressure is one of the most important risk factors for these disorders. The higher the blood pressure, the greater the risk (Lewington *et al.*, 2002). Any definition of hypertension is therefore rather arbitrary and rests on clinical applications.

Reducing the population blood pressure levels therefore also lessens the risk of stroke and heart disease. Based on the results of controlled intervention trials, it has been assessed that lowering the systolic blood pressure by 5 mm Hg would also reduce the mortality from stroke and coronary heart disease by 23 and 16%, respectively (He & MacGregor, 2003).

Different areas in scientific research (epidemiology, migration studies, *in vitro* and animal experiments, clinical and pathological research and randomised and controlled clinical trials) have shown the significance of the salt intake on the population distribution of blood pressure and on the incidence of hypertension in adults.

The direct effect of salt on strokes and heart disease has rarely been examined in clinical trials. In the "Trials of Hypertension Prevention" (TOPH I et II), over 3,000 individuals with an average blood pressure of 127/85 mm Hg and a habitual salt intake of 10 g/day were randomly divided into one group with a restricted salt intake and a control group. The salt reduction achieved in the intervention group was about 2 to 2.5 g/day, with a concomitant drop of -1.7/-0.9 mm Hg in the systolic and diastolic blood pressures after 18 months in TOPH I and of -1.2 et -0.7 mm Hg after 36 months in TOPH II. In the intervention group, a 25-30% reduction was observed in the incidence of cardiovascular diseases 10-15 years after the study had been concluded, regardless of age, gender, race and body weight (Cook *et al.*, 2007). Another study was conducted in healthcare facilities in Taiwan. For 2.5 years, the meals in two facilities were prepared with salt of which half had been replaced by KCl, whereas the remaining three facilities used ordinary salt. The mortality from cardiovascular disorders dropped by 41% among the population in the facilities where the NaCl concentration had been reduced by half (Chang *et al.*, 2006). It should, however, be noted that these trials do not provide any solid evidence regarding the direct effect of reducing the salt intake on cardiovascular disorders and that there will probably never be any trials based on a sufficient number of individuals with a restricted salt intake over a lengthy period of time and sufficient clinical criteria in groups that are representative of the general population. Besides, it is difficult to determine the salt intake precisely. In order to typify an individual appropriately, it is necessary to measure the 24-hour urinary sodium excretion repeatedly. The scientific foundation of the strategies aimed at reducing the population salt intake should therefore be expressed in terms of consequences of the salt intake on the blood pressure, which can then in turn be translated into the known consequences of the blood pressure on strokes and heart disease.

The link between the salt intake and the blood pressure was examined in detail in observational and interventional trials. The results of the INTERSALT study support the theory that the greater the population salt consumption, the greater the age-related rise in blood pressure (Intersalt, 1988). The results of intervention trials such as the DASH trial show that a low salt intake, regardless of the effects of other dietary changes, brings about a lower blood pressure (Sacks *et al.*, 2001). By using the results of other intervention trials as well, it has been calculated that a 3 g/day salt reduction leads to a 3.6 to 5.6 mm Hg reduction in the systolic blood pressure and a 1.9 to 3.2 mm Hg reduction in the diastolic blood pressure in individuals with hypertension; this effect was reduced by half in individuals with a normal blood pressure, i.e. a 1.8 to 3.2 mm Hg and 0.8 to 1.8 mm Hg reduction in systolic and diastolic blood pressure, respectively. In these studies, there was a significant dose-response relationship between the salt intake and the blood pressure (He & MacGregor, 2003).

The impact of a high-salt diet on the development of high blood pressure has also been shown in children (He & MacGregor, 2006).
However, the influence of the salt intake on blood pressure varies significantly from one person to another; a distinction needs to be drawn between "salt-sensitive" individuals and others. This greater "salt sensitivity" is largely genetically determined (Miller, 2011), which could account for the higher occurrence of a greater salt sensitivity in certain population groups, such as those of African descent (EFSA, 2006). Salt sensitivity can also be acquired, especially among obese, insulin-resistant and elderly individuals (EFSA, 2006). It can also be induced by a salt overload, following an increased blood pressure response to angiotensin II (Chamarthi et al., 2010). An excessive salt intake can also stimulate the activity of the sympathetic nervous system in salt-sensitive individuals (Stocker et al., 2010).

The results of the intervention trials show that a low-salt and balanced diet has a beneficial effect on blood pressure down to around 5 g/day and that it can be even lower for certain population subgroups. This fits with the aim of reducing the salt intake to 5 g/day, as proposed by various international advisory bodies (Appel *et al.*, 2011; NICE, 2010; WHO, 2010; Mancia *et al.*, 2007; IoM, 2005) and by the SHC in Belgium (SHC, 2009a). The main measure to achieve such a salt reduction is cutting down on the salt content of industrially prepared foods (Bochud *et al.,* 2010; He & MacGregor, 2010; Ni Mhurchu *et al*., 2010; Dötsch *et al*., 2009; Vandevijvere & Van Oyen, 2008).

On the other hand, the outcome of some studies leads their authors to cast doubt on the usefulness and safety of strongly reducing the salt intake for the whole population or to believe that this is only useful for "salt-sensitive" individuals (Graudal *et al*., 2012; O'Donnell *et al*., 2011; Stolarz-Skrzypek *et al*., 2011; Taylor *et al*., 2011; Alderman, 2010; Cohen & Alderman, 2007; Alderman, 2006; EFSA, 2006). The efficiency of strongly reducing the salt intake as a means of preventing cardiovascular disorders is therefore still controversial. According to some authors, a strong salt intake reduction could even worsen morbidity and increase cardiovascular mortality in diabetic patients (Ekinci *et al*., 2011; Thomas *et al*., 2011) or patients suffering from chronic cardiopathy (Paterna *et al*., 2008).

Apart from the importance of reducing the salt intake in preventing cardiovascular disorders, a low-salt diet considerably curbs the evolution and significantly lessens the complications of chronic nephropathy (Krikken *et al*., 2009) and diabetic nephropathy in particular (Suckling *et al*., 2010).

Other adverse effects of a diet with too much salt include the increased loss of calcium through the kidneys, with a greater risk of nephrolithiasis and osteoporosis (Damasio *et al*., 2011; Caudarella *et al*., 2009). Also to be mentioned is the likely impact of a diet with too much salt on certain types of cancer, especially stomach cancer (EFSA, 2006; Tsugane, 2005; Cohen & Roe, 1997). Recent studies have suggested that, though salt is not a carcinogenic substance as such, preserving certain types of food (such as fish eggs) in salt can increase the carcinogenic effect of these foodstuffs. It has also been recently suggested that a diet with too much salt increases the risk of developing stomach cancer even without a *Helicobacter pylori* infection (Peleteiro *et al*., 2011).

Among the undeniable benefits conferred by reducing the salt intake, there is first of all that of preventing and controlling high blood pressure; the latter especially concerns "salt-sensitive" individuals (i.e. obese, diabetic and elderly individuals). This beneficial effect of reducing the sodium intake is enhanced by a concomitant rise in the potassium, magnesium and calcium intake (Karppanen *et al*., 2005; Sacks *et al*., 2001). However, simply providing potassium, calcium or magnesium supplementation to treat hypertension is not efficient if the sodium intake is not also reduced (Beyer *et al*., 2006). Among the beneficial effects of a low-salt diet, there is also that of controlling high blood pressure to prevent strokes and heart disease, as well as an effect on osteoporosis and certain types of cancer. The health risks of a reduced salt intake are very low, especially if the intake amounts to 5 g NaCl per day. However, a strong reduction in the salt intake can result in a significant rise in activity of the renin-angiotensin system and of the sympathetic nervous system, as well as in certain metabolic factors of the cardiovascular risk, such as the blood levels of cholesterol and triglycerides (Graudal *et al*., 2012). A rise in the circulating levels of angiotensin, aldosterone, and noradrenaline following a strong eduction in the sodium intake could account for the fact that the latter does not result in a lower blood pressure in normotensive individuals subjected to a very low salt diet, whereas cardiovascular morbidity could even be on the increase (Graudal *et al*., 2012; Stolarz-Skrzypek *et al*., 2011). Tayie & Jourdan (2010) suggest that a lower salt intake could lead to an iodine deficiency, especially in women, as iodised kitchen salt often represents a crucial iodine source in women. However, a recent analysis of this issue carried out in the Netherlands (Verkaik-Kloosterman *et al*., 2010) indicates that a 50% reduction of the salt content of industrially prepared food would result in an iodine intake that would be just around 10% lower. A higher iodine content in salt (NaCl) combined with a better distribution of iodised salt in households (instead of common kitchen salt) could easily counter such an effect, which in itself is of low importance. In no case should the use of iodised salt lead to a higher salt intake as a means of providing an optimal iodine intake.

Another risk that could theoretically result from the food industry using less salt to preserve food would be that this could lead to greater bacterial proliferation (such as the proliferation of *Listeria monocytogenes* or *Clostridium botulinum)* (Taomina, 2010) (see sections **4.1** and **5**). However, it should be noted that the sodium salts used to this end are often sodium lactate or diacetate. Yet these types of sodium salts haven't been shown to have the same impact on health as sodium chloride.

4. The technological function of salt in food

Depending on the type of food, salt (NaCl) is added for hygienic (microbiological stability), organoleptic and/or technological purposes. It follows that the margins for salt reduction are different for each type of product (large margin for bakery products, narrower margin for cooked pork meats and cheese, variable for different ready-to-eat foodstuffs such as soups, sauces, ready-made meals).

4.1. <u>Microbiological safety</u>

Salt has been used for centuries to increase the shelf life of foodstuffs, especially that of meat and fish products. Salt can not only prevent the food from spoiling, but can also inhibit the growth of pathogenic micro-organisms (Stringer & Pin, 2005). As new preservation techniques and types of packaging have become available (e.g. refrigeration, preservation in a protective atmosphere), salt has grown less important as a preservation technique. At the moment, there are but few foodstuffs that are preserved with salt only, with several different hurdles (hurdle technology) usually being resorted to in order to control microbial growth. Regardless of whether or not they are combined with salt, production and preservation techniques at high or low temperatures are applied, the pH level or redox potential is adjusted and other ingredients or additives are added to create a stable product with a longer shelf life (**table 4.1.1**). However, salt remains a frequently used component to create an unfavourable environment for food spoilage micro-organisms and pathogens in foodstuffs. In addition, the use of salt allows for a lower preservative content (e.g. sulphur dioxide, benzoic acid), a lower degree of acidity or a milder treatment (e.g. heating), which may have a positive impact on the nutritional or organoleptic quality of the product.

Table 4.1.1. A few methods to prevent microbial growth with a reduced salt content

Chemical	Physical	Biological
Preservatives (e.g. ingredients with inherent antimicrobial properties, nisin, etc.)	• Heat treatment • Preservation at low temperatures (e.g. refrigeration, freezing) • Drying • Irradiation • High-pressure treatment • Preservation or packaging in a protective atmosphere	Ferments

The efficiency of salt in inhibiting microbial growth or destroying micro-organisms depends on many intrinsic and extrinsic properties of the food matrix. **Table 4.1.2** presents a series of growth-inhibiting conditions for a few food pathogens.

Table 4.1.2 Growth-inhibiting conditions for a few food pathogens (source : Stringer & Pin, 2005).

Organism	Minimum growth temperature	Maximum, inhibitory water activity (salt-adjusted)	Equivalent salt concentration (% w/w)	pH	Oxygen relations
Aeromonas hydrophila	0	0.97	5	4.5	FA
Bacillus cereus	4.10*	0.93	11	5.0	FA
Campylobacter jejuni	32	0.98	3	4.9	M
Clostridium botulinum, proteolytic	10	0.94	10	4.6	An
Clostridium botulinum, non-proteolytic	3	0.97	5	5.0	An
Clostridium perfringens	12	0.95	7	5.0	An
Escherichia coli (VTEC)	7	0.95	8	4.0	FA
Listeria monocytogenes	0	0.92	12	4.3	FA
Salmonella spp.	5	0.93	11	3.8	FA
Staphylococcus aureus	7	0.86	19	4.0	FA
Vibrio parahaemolyticus	10	0.95	9	4.8	FA
Yersinia enterocolitica	-2	0.95	7	4.2	FA

FA= Facultatively aerobic, An= Obligatory anaerobic, M= Microaerophilic
*= psychrotrophic and mesophilic strains

The main mechanism through which salt preserves food is that of lowering the water activity or a_w[3]. Salt probably reduces the a_w value by adding Na^+ and Cl^- ions to the water molecules (Henney *et al.*, 2010). Depending on the initial a_w value of the food, and at a given pH level, modifying the salt content (and therefore the a_w value) may inhibit the growth of micro-organisms in foodstuffs (a_w < a_w minimal growth) or can make it possible for certain micro-organisms to multiply in foodstuffs (a_w > a_w minimal growth). Besides adding salt (curing), drying or adding sugar are techniques that allow for the multiplication of micro-organisms to be slowed down by lowering the a_w value. Apart from lowering the a_w value, salt dehydrates bacterial cells, changes their osmotic pressure and slows down their growth. It has also been suggested that for certain micro-organisms, salt decreases oxygen solubility, interferes with cellular enzymes or forces cells to consume energy to evacuate the Na^+ ions from the cell, all of which curbs microbial growth (Henney *et al.*, 2010; Taormina, 2010; Stringer & Pin, 2005).

Salt not only affects pathogen growth, but can also influence their heat resistance. The effect depends on the species, but the thermal inactivation of micro-organisms is usually more significant with higher a_w values, which makes it rather unlikely that reducing the salt content will increase heat resistance. On the other hand, cells or spores may sustain sublethal damage through thermal treatment, which makes them less able to survive in unfavourable conditions created by e.g. the presence of salt. Thus, adding salt has been found to increase heat resistance in *Escherichia coli*, *Staphylococcus aureus*, *Listeria monocytogenes* and the heat-sensitive strains of *Salmonella,* and to

[3] The water activity or a_w is the amount of free, unbound water, or the total quantity of water that is available for biological reactions.

reduce it in *Pseudomonas fluorescens,* the heat-resistant strains of *Salmonella* and non-proteolytic *Clostridium botulinum* (Taormina, 2010; Stringer & Pin, 2005).

Various terms have been used to describe different levels of microbial tolerance or resistance to NaCl, including “obligate halophile", "salt-tolerant", "salt-resistant" and "facultative halophile". The term “halotolerant” can be considered synonymous with “salt-tolerant”, and both terms are interchangeable with “facultative halophile”. Salt-tolerant and halophilic micro-organisms are sometimes also referred to as xerotolerant or xerophilic, but these terms usually denote low a_w conditions created by high levels of sugar. Micro-organisms that become reversibly adapted to NaCl are classified as salt-resistant (Taormina, 2010).

Examples of food-borne pathogens that are salt-tolerant, salt-resistant and halophilic are *L. monocytogenes, Staphylococcus aureus* and *Vibrio parahaemolyticus*, respectively (Taormina, 2010). Fungi are more apt than bacteria to thrive and survive in low a_w foods. Most fungi (including those that produce mycotoxins) can multiply in the presence of oxygen on the surface of foodstuffs, even in very low a_w foodstuffs or in foodstuffs with a high salt content, provided that the relative air humidity suffices. Examples of salt-tolerant fungi include *Torula, Hemispora, Oospora,* and *Sporendonema*. Salt-tolerant yeasts such as *Debaryomyces hansenii, Hansenula anomala,* and *Candida pseudotropicalis* may grow at NaCl concentrations up to 11% (a_w = 0.93). Viruses that may inadvertently contaminate foodstuffs are not usually impacted by the levels of NaCl seen in foodstuffs (Taormina, 2010).

A series of sodium-containing molecules used in food preservation can be found **in table 4.3.1.** Though NaCl usually contributes most to the Na content of foodstuffs, it is also necessary to take into account the sodium intake linked to other molecules that are often used for preservation purposes.

For several foodstuffs, such as frozen products, products that have undergone enough thermal treatment to eliminate all pathogens (e.g. canned food), acidic products (pH<3.8), and foodstuffs with a low a_w in spite of a reduced salt content (e.g. due to a high sugar content), reducing salt will not immediately cause the product to spoil nor will it jeopardise its microbiological safety (Stringer & Pin, 2005). However, the impact of reducing the salt content on microbiological safety should always be verified when reformulating a product for salt reduction purposes. The English Advisory Committee on the Microbiological Safety of Food has, amongst other things, pointed to efforts made towards reducing the salt levels as one of the possible factors in the increased incidence of listeriosis in the United Kingdom (ACMSF - Advisory Committee on the Microbiological Safety of Food, 2009). Apart from *Listeria monocytogenes,* other pathogens can also develop more rapidly in foodstuffs with a reduced salt content and other sodium-containing preservatives, viz. *Clostridium botulinum*, *Clostridium perfringens*, *Bacillus cereus*, *Staphylococcus aureus*, *Yersinia enterolitica*, *Aeromonas hydrophila*, *Clostridium perfringens* and *Arcobacter* (Henney *et al.*, 2010; Stringer & Pin, 2005).

In the literature, several mathematical equations have been proposed to calculate the a_w for a given foodstuff depending on the salt concentration (as well as other variables), as well as the growth of micro-organisms (Anses, 2010; Samapundo *et al.*, 2010b; Taormina, 2010; Stringer & Pin, 2005; Hutton, 2002). However, predictive models need to be interpreted with the necessary caution. Whilst the industry may initially use existing models, it should also test the impact on safety in actual practice (cf. challenge tests, especially for *Listeria monocytogenes).*

In this context, it should be pointed out that neglecting to abide by good hygiene practices (GHP) is an important factor that contributes towards the appearance of food-borne toxi-infections and that, in many cases, excessive temperatures can result in pathogen growth and outbursts.

4.2. <u>Organoleptic properties</u>

Flavour molecules can be assessed on the basis of their intensity and their persistence. Thus, beyond a given salt content, the salty taste will not be perceived as being more intense. In the case of salt, the intensity of the flavour will increase for a few hundred milliseconds, before fading rapidly (Henney *et al.*, 2010). A critical property of a salty taste is its hedonic or "pleasant" nature. For many foodstuffs, adding salt improves the flavour up to a certain point beyond which adding more salt will tend to result in aversion (inverted-U function). However, the optimal or saturation point differs significantly from one person to another and does not correspond to a given concentration, but rather to a fairly broad spectrum of concentrations considered to be "delicious" by the consumer (Henney *et al.*, 2010).

The intensity of the flavour is not only influenced by the quantity of the salt that is added to a food product, but also by the manner in or the moment at which this is done. Thus, NaCl will produce a more concentrated flavour if it is sprinkled over the meat after rather than during cooking, and the same salty taste could therefore be obtained by adding only half the amount of salt if this is done after cooking (Ruusunen & Puolanne, 2005) (see also section **5.4**).

In addition, other ingredients also play a part in the perceived intensity of the salty flavour. Thus, a more intense salty taste will e.g. be perceived in sausage if its protein content is reduced whilst its fat content is increased, or, in other terms, the perceived saltiness will be greater in products with a higher fat content (Desmond, 2006; Ruusunen & Puolanne, 2005). Yet reformulations that strive towards reducing the salt content should not result in an increased fat content, as this would be counter-productive in promoting a healthy diet.

Salt not only provides a salty taste, but may also influence other organoleptic properties of foodstuffs (Henney *et al.*, 2010; Hutton, 2002). For several foodstuffs (soups, rice, eggs and crisps), it has been shown that salt improves the perception of product thickness/consistency, enhances sweetness, hides any metallic or chemical aftertaste and allows the overall flavour to fully develop by improving its intensity. Salt can improve or enhance taste by reducing bitterness or lowering the a_w value. A low a_w leads to a higher concentration of flavours and a greater volatility of the flavour components, resulting in an improved aroma (Henney *et al.*, 2010; Hutton, 2002).

Salt therefore plays a more significant part in the organoleptic profile of a given product than simply providing the desired salty taste. It follows that reducing the salt content of foodstuffs may also require to identify the manners in which the perceptual properties of salt or its effects on the overall taste may be replaced.

Finally, we point out in this context that high-salt foodstuffs increase the thirst sensation.

4.3. Functional properties

Apart from enhancing preservation and taste, salt is added to foodstuffs for the following technological purposes (Henney *et al.*, 2010; Hutton, 2002):

1. to **improve texture**: For example, salt strengthens gluten in bread dough by giving the dough a uniform texture and strength. With salt present, gluten holds more water and carbon dioxide, allowing the dough to rise without tearing. Salt improves the tenderness in cured meats such as ham by promoting the binding of water by protein. It also gives a smooth, firm texture to processed meats. Salt contributes to the development of the typical rind hardness on cheese and helps produce the desirable, even consistency in cheese and other foods such as sauerkraut;
2. as a **binding agent**: Salt helps to extract the proteins in processed and "formed" meat products by providing binding strength between meat particles. By adding salt to increase the water binding properties, cooking losses are reduced. Salt increases the solubility of muscle proteins in water. In sausage making, stable emulsions are formed when the salt-soluble protein solutions coat the finely-formed globules of fat, providing a binding gel consisting of meat, fat and moisture.
3. **fermentation Control:** In bakery products (e.g. bread), salt controls fermentation by slowing down and controlling the rate of fermentation, which is important in making a uniform product. Gherkins, sauerkraut, cheese and fermented sausages owe many of their characteristics to the activity of lactic bacteria. Salt favours the growth of these more salt-tolerant starter cultures by inhibiting the growth of spoilage organisms and undesirable fungi, which are naturally present in these foodstuffs.
4. **to develop colour:** Salt promotes the development of colour in ham, bacon, hotdogs and sauerkraut. Used with sugar and nitrate or nitrite, salt produces a colour in cooked pork meats which consumers find appealing. Salt enhances the golden colour in bread crust by reducing sugar destruction in the dough and promoting the Maillard reaction.

5. as a **carrier:** Additives authorised as dry powder are highly concentrated and need to be thinned down to obtain the right dosage. Salt can be used as a solid carrier to obtain the right dosage or to achieve an even distribution of the additives or other ingredients in the product. For example, the nitrite curing salt used to prepare meat products to e.g. preserve a natural colour in the meat. Another example is salt enriched with the micronutrient iodine, i.e. iodised salt, which is added to bread in order to optimise the population iodine intake (SHC, 2009b).
6. **taste:** As mentioned under section **4.2**, in most cases, salt is added to enhance taste. However, salt is generally added in excessive amounts. Certain products do indeed have a salty taste (e.g. bacon, salt crisps), but others seem much less salty, despite the fact that they display a high salt content, i.e. "hidden salt" (e.g. seasoning mixes, pesto, ready-made meals, meat salads, pizza, biscuits, etc.).

Salt (NaCl) can have other functions depending on the type of food: an overview is provided for several types of foodstuffs in **table 4.3.2.** However, apart from salt, other sodium-containing substances are sometimes used to obtain the desired physical properties for the product. **Table 4.3.1** mentions several sodium-containing additives as well as their potential function in foodstuffs. It provides an individual description of each additive as well as a series of purity criteria. Other additives than those mentioned in **table 4.3.1**, as well as sweeteners and colours can contain sodium (directive 2008/84/EC, Directive 2008/60/EC, Directive 2008/128/EC). In addition, certain additives can be placed on the market as different salts (e.g. sodium, calcium, potassium salt). The conditions of use of the additives approved in different food categories are mentioned in Regulation (EC) n° 1333/2008. Information on the various additives approved for use in food can also be found via the European additive database (https://webgate.ec.europa.eu/sanco_foods/main/?event=display).

Table 4.3.1. A few sodium-containing additives and their potential function in foodstuffs

Preservatives [1]	
Sodium benzoate	E211
Sodium ethyl para-hydroxybenzoate, sodium salt	E215
Sodium methyl para-hydroxybenzoate, sodium salt	E219
Sodium sulfite	E221
Sodium hydrogen sulfite	E222
Sodium metabisulfite	E223
Sodium nitrite	E250
Sodium nitrate	E251
Sodium acetate	E262
Sodium propionate	E281
Sodium tetraborate (borax)	E285

Antioxidants[1]	
Sodium ascorbate	E301
Sodium erythorbate	E316
Sodium lactate	E325
Sodium citrates	E331
Sodium tartrates	E335
Potassium sodium tartrate	E337
Sodium phosphates	E339
Sodium malates	E350
Sodium adipate	E356
Calcium disodium ethylenediaminetetraacetate(Disodium EDTA)	E385

Emulsifiers, thickeners, gelling agents, stabilisers[1]	
Sodium alginate	E401
Sodium, potassium and calcium salts of fatty acids	E470a
Sodium Stearoyl-2 lactylate	E481

Additives with other properties [1]	
Acidity regulators, anti-caking agents, raising agents	
Sodium carbonates	E500
Sodium sulfates	E514
Sodium Hydroxide	E524
Sodium ferrocyanide	E535
Sodium gluconate	E576
Flavour enhancers	
Monosodium glutamate	E621
Disodium guanylate	E627
Disodium inosinate	E631
Disodium 5'-ribonucleotide	E635
Glycine and its sodium salt	E640

(1) definitions: Regulation (EC) n° 1333/2008.

Table 4.3.2 Functions of salt in a series of foodstuff types (sources: Amongst others: Johnson, 2011; Henney *et al.*, 2010; Anses, 2002; Hutton, 2002)
Note: It is not always possible to draw a clear distinction between the microbial, technological and organoleptic functions and a certain amount of overlap is therefore possible.

Product type	Indicative concentration/typical salt concentration	Microbial function	Technical function	Organoleptic	Examples for other potential salt sources [1]	Note
MEAT AND DERIVED PRODUCTS						
Cooked ham	2010: 2.2 g SE/100g → 2012: 2.1 g SE/100g [a]	bacteriostatic (sometimes in combination with fermentation, drying, smoking, nitrite)	pH Improved water retention capacity (more tender meat) binding, emulsifying and gelling properties (through improved solubility of muscle proteins)	Flavour enhancers and flavour	Group 1 additives [2] are approved for use in processed meat Sodium nitrate/nitrite (E250/E251) Sodium phosphates (E339) Sodium lactate (E325) Sodium acetates (E262), Sodium ascorbate (E301) and sodium citrates (E331) in minced meat preparations Spices/ seasoning mixes (e.g. sodium glutamate – E321) Intrinsically present	RD 08/06/83 [b]: If the salt content in cooked processed meat and heated meat preparations >2%, expressed in NaCl, this shall be mentioned in the list of ingredients. A 0.2% deviation is tolerated.
Salami	2010: 4.2 g SE/100g → 2012: 4.0 g SE/100g [a]					
Cured products	2010: 5.2 g SE/100g → 2012: 5.0 g SE/100g [a]					
Cooked products	2010: 1.9 g SE/100g → 2012: 1.8 g SE/100g [a]					
SAUCES						
Meal sauces (hot sauces/dehydrated sauces)	650 mg/50g [a]				E.g. Group 1 additives [2] and sodium benzoate (E211) are approved for use in certain sauces, sodium sulfites (E221/E222/E223) are approved for use in mustard.	
Cold sauces	Typical values are: - tomato ketchup: 2.3 % - mayonnaise: 1.5 % 195 mg Na/15g [a]	Many formulations are based on a combination of salt, sugar, acetic acid for preservation at room temperature				
Soy sauce				High salt content (17-18 %) to produce the volatile components that are typical of soy sauce		
BREAD AND RELATED PRODUCTS						
Bread	RD 02/09/85 [c]: Kitchen salt content expressed in NaCl, calculated on the dry matter, shall not exceed 2.0 % (i.e.	Bacteriostatic (yeast, fungi) (the a_w value is mainly verified using the sugar	- Reduced elasticity and more stable gluten : improves dough malleability (less sticky – may,	Improved taste and volume of the bread + finer and more golden crust	- raising agents (e.g. sodium bicarbonate – E500, sodium acid pyrophosphate – E450)	- The emulsifier sodium stearoyl lactate (E481) is sometimes added to improve the volume of the

	~1.2-1.3 g/100g bread)	content, not the salt content)	however, increase the mixing time) - Slower fermentation (delayed gas production) - Stabiliser during rising - Can increase the shelf life (dry atmosphere) or shorten it (moist atmosphere)		- Preservatives (e.g. sodium propionate – E281) - Emulsifiers (e.g. sodium Stearoyl-2 lactylate – E481) - Group 1 additives [(2)] are approved for use in certain bread rolls and fine bakery products	bread or to guarantee the texture of frozen bread. - Dough conditioners (e.g. sodium caseinate) - Iodised salt substituted for NaCl.
Fine bakery products				Flavour enhancer for sweet flavour		
Industrial cakes	0.4-0.6 % finished product	Low contents used (0.3-0.5 %) to prevent the formation of fungi and to increase the shelf life at room temperature				"Quick" bread rolls, cakes, biscuits make use of chemical fermentation agents rather than yeast to obtain airy textures, including sodium bicarbonate (E500)
Toasts/rusks	Standard : 2% on dough basis (~1.5 % finished product)		See bread	See bread		Also found on the market : Toasts with no added salt, with reduced Na content and diet toasts
BREAKFAST CEREALS						
	2% would typically be added to the initial mixture for the extrusion of products with wheat, maize, rice flakes and grilled products		Reduces the available water quantity for starch gelatinisation and increases gelatinisation duration and temperature	Improves aroma and texture (especially if reduced sugar content)	- Aroma and flavour enhancers (e.g. sodium glutamate – E621) - Group 1 additives [(2)] are approved for use	Flavour carriers (e.g. sodium caseinate)
FISH AND DERIVED PRODUCTS						
		- Microbial inhibition and partial destruction of fish parasites (e.g. herring worm *Anisakis simplex*) - Curing to clean the fish prior to canning - Important for the preservation of smoked fish	Enzyme inhibition and dehydration of the fish tissue – reduces the "cook-out" (i.e. loss of moisture during cooking)		Group 1 additives [(2)] are approved for use, but also e.g. sodium benzoate (E211), sodium sulfites (E221/E222/E223), sodium nitrate (E 251).	
EGG PRODUCTS						
			Stabilisation of frozen commercial egg yolk		Group 1 additives [(2)] are approved for use, as well as sodium benzoate (E211),	

					sodium phosphates (E339)	
CHEESE						
	Typical weight % in the finished product: - Cheddar : 1.6-1.8 % - Emmenthal: 0.8 % - Parmesan: 2.1 % - Edam: 1.3 % - Gouda: 1,3 % - Brie: 1.5-1.8 % - Camembert: 1.6-1.8 % - Feta: 3 % - Cottage cheese: 0.8-1.0 % - Swiss cheese: 0.8-1.2 %, but 0.5 % is possible for rindless cheese	- Regulates the starter culture activity - Slows down the growth of most micro-organisms	The amount of salt added, the method used to do so and the stage at which this is done depend on the type of cheese - Regulates the starter culture and enzymatic activity (pepsin, chymosin, plasmin) - Ensures the transition from pressing to ripening - Additional effect during pressing (expressing the whey from the curd) - Contributes to the build up of a rind - Controls the pH (e.g Cheddar, Stilton)	Enhances the organoleptic potential of the cheese (e.g. reduces the water content, enzymatic activity, malleability)	- Preservatives (e.g. sodium nitrate – E251); - Emulsifiers (e.g. sodium diphosphate, sodium hexametaphosphate – E339) (e.g. sodium-containing emulsifying salts are used in processed cheese); - acidity regulators (e.g. sodium carbonates - E500); - Aroma and flavour enhancers (e.g. enzyme modified dairy ingredients) - Intrinsically present (milk); - Group 1 additives [(2)] are approved for use in non-ripened cheeses, processed cheese).	
FATS AND OILS						
Butter				Mainly added for organoleptic purposes	Sodium carbonates (E500) in acid cream butter	
Stocks			Technical function for stock cubes	Organoleptic properties	Flavour enhancer monosodium glutamate (E621)	
SNACKS						
Salted snacks (peanuts, crisps, etc)			Is also used as a carrier for micro-ingredients (aromas, antioxidants, etc.)	One of the main characteristics of these products is their salty taste	Group 1 additives [(2)] are approved for use in snacks made from potatoes, grains, flour, starch or potato flour, processed nuts	Chocolate products and other sweets can also include sodium-containing additives (e.g. sodium carbonates - E 500 and group 1 [(2)] additives)
READY-MADE MEALS/ CONVENIENCE FOOD						
	Max. sodium content of 370mg /100g [(a)]	Products containing meat or cheese	Sometimes for technical purposes : e.g. - Quenelles: supports the efficiency of the emulsion - Sauerkraut: Fermentation process	Salt from ingredients and added for organoleptic purposes	Group 1 additives [(2)] are approved for use in certain deserts	

FRUITS & VEGETABLES						
Fermented vegetables (sauerkraut, gherkins)		- Controls microbial flora - Regulates the starter culture activity	- Controls the microbial flora to achieve appropriate fermentation conditions - Influences changes in texture - Chemical effects (gherkins)		- Preservatives (e.g. sodium benzoate -E211 in olives, sodium sulfites - E221/E222/E223) - Colour maintenance (e.g. sodium bisulfate – E514) - Sodium citrates – E331 (e.g. in jam and jelly) - Group 1 [(2)] additives are approved for use in dried vegetables and fruits, fruits and vegetables preserved in vinegar, oil or brine, fruit and vegetable preparations - Intrinsically present (e.g. celery)	
onions			- Prevents the vinegar from becoming cloudy, probably through protein "fixation". - Prevents pink colouring (also true for cauliflower in vinegar) -Prevents the formation of quercetin deposits (i.e. glycoside) (yellow spots – also true for gherkins)			
Canned vegetables and fruit	Max. 250mg Na/100g [(a)]			aroma		
Products derived from potatoes						
E.g. croquettes, duchess potatoes, mashed potatoes	Max. 0.76 g salt/100g [(a)]				May contain sodium ascorbate (E301), sodium lactate (E325), sodium sulfates (E514), etc.	
SOUPS						
	850 mg Na/250 ml [(a)]			Mainly added for organoleptic purposes, flavour enhancer	Group 1 additives [(2)] are approved for use, as well as sodium benzoate (E211), sodium erythorbate (E316), sodium phosphates (E339)	A distinction should be made between warm and cold soups (i.e. carton/ canned soup and powder soup)
BEVERAGES						
Isotonic sports drinks			Osmoregulator: - The beverages are designed to have the same osmotic composition as blood. Sweating requires the intake of water, but over-dilution of the blood may result in a low plasma sodium content + role of sodium in the absorption of glucose and water		E.g. group 1 additives [(2)] are approved for use in vegetable juice and flavoured beverages)	
BATTER AND COATINGS						

			- Prevents the batter from freezing - Improved adhesion when applied on frozen products (e.g. crumbs on fish)		Group 1 additives [2] are approved for use in batter, as well as sodium phosphates (E339)	

[1] by means of illustration and not exhaustive: for additional information (e.g. maximum amounts, restrictions/exceptions, other additives approved for use), see Regulation EC n°1333/2002; [2] sodium-containing Group 1 additives are: sodium acetates (E262), ascorbate (E301), lactate (E325), citrates (E331), tartrates (E335/E337), malates (E350), alginate (E401), carbonates (E500), sulfates (E514), hydroxide (E524), gluconate (E576), guanylate (E621), glycinate (E640), salts of fatty acids (E470a), monosodium glutamate (E621), disodium inosinate (E631) and disodium 5'-ribonucleotide (E635).
(a) sectoral agreement ; [b] Royal Decree of 8 June 1983 regarding the production and placing on the market of processed meat and meat preparations ; (c) Royal Decree of 2 September 1985 on bread and other bakery products.

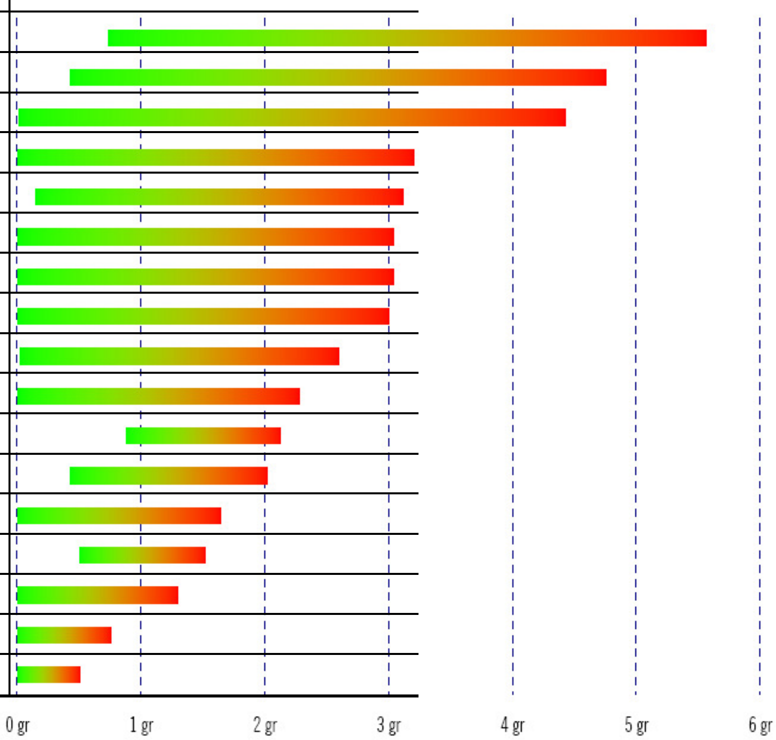
5. Potential (technological) methods to reduce the salt content

The consumer has grown used to the salty taste in processed foodstuffs, which makes it more difficult from an organoleptic point of view to reduce the salt content in certain types of foodstuffs. The cost involved is another impediment to replacing the salt in food, as this is one of the least expensive food ingredients. Moreover, consumers prefer "natural" products over products with chemical names or E-numbers[4] on the label (tendency towards "clean label" products, i.e. clear and understandable labelling of foodstuffs, which rules out technical names as well as certain artificial ingredients).

Apart from a gradual reduction of the salt content, a process during which the consumers' "taste" grows used to the adaptation through a succession of small steps (5.1), there are also a series of other potential avenues for reducing the salt or sodium content in foodstuffs. The simplest and most obvious way to remove the sodium would simply be to use less salt without affecting taste, texture and preservation. Recent measuring results (Nubel, 2011; nVWA, 2011; WASH, 2011b; CRIOC, 2009) indicate that this is a feasible option for many producers. **Table 5.1** gives a general overview of the average salt content of certain product categories available on the Belgian market, calculated on the basis of the labels only (CRIOC, 2009).

Table 5.1. Salt content in different product categories (g/100 g), calculated on the basis of the labels (source: CRIOC, 2009)

	Average [salt] (g/100g)	**Standard deviation**	**[Salt] distribution per product category (g/100g)**
Meat and derived products	2.666	0.450	
Sauces	1.866	0.450	
Meat substitutes	1.424	0.906	
Fast-food	0.941	0.421	
Bread and derived products	1.030	0.387	
Fish and derived products	1.495	0.246	
Dairy products	0.672	0.103	
Fats and oils	0.661	0.376	
Snacks	1.280	0.288	
Breakfast cereals	0.761	0.208	
Salads	1.722	0.135	
Ready-made meals	1.146	0.318	
Vegetables and fruit	0.407	0.140	
Soups	0.965	0.228	
Potato products	0.520	0.222	
Beverages	0.111	0.020	
Products derived from grains	0.108	0.039	



[4] An E number implies that an additive has received EU approval. Before being given an E number, the additive is subjected to a thorough safety assessment by the Scientific Committee for Food or the EFSA.

Even though the same category contains a broad variety of product types (e.g. the category "meat and derived products" includes both raw ham and turkey fillet with an average salt content of 5.01 and 1.78 g/100g, respectively; the category "dairy products" includes both processed cheese and yoghurt, with an average salt content of 2.27 and 0.15 g/100g, respectively, this table illustrates the fact that certain product categories contain a great deal more salt than others. Additional information regarding the distribution of the salt content per product type can be found in the CRIOC study concerned (CRIOC, 2009). The Belgian food composition table (NUBEL, 2011) also mentions the salt content of different foodstuffs, based on both the labelling of these products as well as on analyses. These data show that there is a significant amount of variation in the salt content of similar types of products. A WASH ('World Action on Salt & Health') survey has even revealed that products of the same brand, including fast-food chains in different countries, display different sodium contents (WASH, 2011). Given the variability of the salt content within different product categories and types, eliminating some of the sodium without replacing it is indeed possible for quite a few products as a first step towards reducing the salt intake. In this respect, it should, however, be pointed out that the lower values are not indicative. In other words, though these products belong to the same category, they may involve different modes of preparation.

One of the most frequently applied methods is the use of salt substitutes, especially potassium chloride (KCl) (**5.2**). Another method is the use of flavour enhancers that do not have a salty flavour themselves, but enhance the perceived saltiness of the NaCl ("salt boosters") (**5.3**). The physical form of salt can also be optimised in such a way that most of the salty taste is released, or the salt can be added to the product in such a way as to increase the perceived saltiness (physical "boosters", distribution of the salt in the product, **5.4**). Another means of reducing the salt - and therefore the sodium - content is to replace other sodium-containing substances (**5.5**). As mentioned above (**3.2**), it is especially the sodium that is ingested in the form of NaCl that is responsible for many of the adverse health effects of an excessive salt intake. Moreover, there is also a series of other possible avenues that mainly influence the perceived taste (timing for adding salt, use of other condiments, etc.) (**5.6**).

Before lowering the salt content of foodstuffs (and ultimately replacing it), the potential technological impact of this measure should always be examined (regardless of whether or not alternative means are used as well) by taking into account possible effects on the main microbial flora. An anarchic reduction of the NaCl content in processed food may not only cause certain foodstuffs to spoil more quickly (with adverse financial consequences for the producers, distributors, retailers and consumers), but may also result in increased pathogen growth and survival (see **4.1**).

5.1. <u>Gradual reduction</u>

The preference for a salty taste is believed to be flexible. Though limited in number, experiments have shown that, after an initially strongly negative reaction, people following a low-salt diet eventually accept low salt contents and consider foodstuffs with the initial salt content as too salty. These shifts in preferences also occur the other way around. They are thought to result from the actual sensory perception of salt rather than from some sort of physiological regulatory process (Henney *et al.*, 2010; Dötsch *et al.*, 2009; Leshem, 2009).

It therefore seems possible to reduce the salt concentration progressively whilst maintaining the same organoleptic perception in the consumer. Tests on perceived taste have shown that people are usually unable to perceive differences in taste in between two concentrations if the difference is below approximately 10% ("Just Noticeable Difference" or JND). This estimation is based on sensory tests with pure aromatic solutions, not on actual foodstuffs. The latter are chemically more complex, which makes it more difficult to pin-point any changes in the concentrations of individual substances. This in turn means that the JND may be higher or lower than 10% depending on the foodstuff concerned (Henney *et al.*, 2010).

This approach, which is sometimes referred to as the “salami effect”, has already been used successfully by a number of British producers to cut down on the salt content. Thus, a 33% reduction was reached in the grain sector between 1998 and 2005, a 25% reduction has been achieved in bread since the late 1980s and a 33% reduction in cheese products, etc. (Kilcast, 2008). In Belgium too, the salt content in bread was gradually reduced in the past (from 2.8% DM, with an intermediate value of 2.2% DM) in accordance with the Royal Decree of 2 September 1985, which holds that the salt content in bread shall not exceed 2% in dry matter. This has gone unnoticed by the consumers.

For such a strategy to be successful, a certain amount of co-ordination is required both within and between sectors. Yet it may take some time to reduce the salt content gradually. However, the impact and implementation of such a measure can be speeded up through appropriate labelling on the packaging. For example, one of the measures of the Finnish salt reduction programme has been to provide the packaging with either a heart symbol or a warning aimed at drawing the consumers’ attention to the beneficial nutritional profile (and therefore positive salt content) or too high salt content of the product, respectively (Laatikainen *et al*., 2006). In the United Kingdom, the Food Standards Agency (FSA) has promoted the placing of labels with nutritional information on the packaging of foodstuffs, including the "traffic light" labels, which show at a glance whether or not a given product has a high (red), medium (orange) or low (green) salt, sugar and saturated fat content (FSA, 2010b).

In this context, it should be pointed out that it is important to accustom children to a less salty taste from the earliest age. It is therefore advisable to add less salt to home-cooked meals, in collective kitchens (e.g. in schools) and in the CHR industry. In addition, the consumers should be made aware of the fact that, when they prepare meals at home, they should take into account the fact that certain ingredients or components of the meal are already rich in hidden salts (e.g. stock, seasoning mixes, added cheese, etc.).

5.2. Salt substitutes

Ingredient technology makes it possible to add alternatives to salt to the food that compensate for the functional properties of salt.

For example, in structured and emulsified products (e.g. sausages, cooked pork meats), functional proteins (e.g. soy or milk), hydrocolloids (e.g. gum or alginates) and starch can partly replace the functionality of the salt-soluble proteins that form a gel network and "glue together" pieces of meat in more salted products (Desmond, 2006). Similarly, phosphates are believed to constitute useful salt substitutes in meat products (Desmond, 2006). Phosphates improve the water-binding properties of fresh and dry meat products by increasing the ionic strength, which causes negatively charged points of the meat proteins to be released, thereby allowing the proteins to bind more water[5]. The functionality of phosphate is strongly influenced by the presence of salt and the two ingredients work synergistically. However, for the purposes of sodium reduction, some phosphates are sodium salts, but are used to a much lesser extent than NaCl. For example, sodium polyphosphate (E452) contains around 31% of Na, whereas NaCl contains 39%, but is usually only added at the rate of 0.5%, as opposed to 2 to 4% for salt.

There are several salt substitutes available on the market. These salt substitutes, presented as ready-to use blends or blending salts, may in some cases still contain NaCl or sodium.

[5] We would like to draw attention to the legislation on producing and marketing processed meat and meat preparations (Royal Decree of 8 June 1983) and to the more specific legislation (e.g. Royal Decree of 4 February 1974 on Ardennes ham), which fix upper levels for the phosphate content and the water/protein ratio in meat products.

Many studies have already been conducted on the effects of partially replacing NaCl by potassium chloride (KCl), and some of these blends are available on the market (Desmond, 2006). Replacing NaCl by KCl leads to a similar effect on the a_w. Several publications have shown that KCl is as potent an inhibitor as NaCl for pathogen micro-organisms such as *Listeria monocytogenes*, *Cronobacter* and *Aeromonas hydrophila* (Anses, 2010). NaCl conveys an almost pure salty flavour, whereas KCl has a flavour that is both salty and bitter. This bitterness increases significantly in KCl/NaCl blends over 50:50 (Henney *et al.*, 2010; Kilcast, 2008; Desmond, 2006). Apart from KCl, other potassium salts can be used as salt substitutes.

For instance, potassium phosphates (E340) are also available on the market and are just as efficient as sodium salts with respect to water-binding, gel formation or ionic strength (Desmond, 2006). Further examples for potassium salts approved for use are potassium citrate (E332) and potassium bicarbonate (E501). Several facts still plead against across-the-board replacement of NaCl by potassium salts (not only the bitter flavour, but especially the health risks, see **section 6**).

Other examples for alternatives to NaCl are calcium chloride (E509) and different magnesium salts (e.g. magnesium sulfate, magnesium chloride – E511). However, their use is limited by their potentially bitter flavour. Magnesium sulfate is not said to provide high levels of "saltiness", and has been perceived as very bitter in high concentration solutions. Adding magnesium sulfate to KCl and NaCl solutions has resulted in less salty and more bitter flavours, even though such combinations are found in certain commercially available sea salts (Kilcast, 2008). Moreover, magnesium salts are said to have a laxative effect, which rules out any intensive use.

In a recent placebo-controlled double-blind randomised trial, replacing NaCl by a blending salt (50 % NaCl, 25 % KCl and 25 % of the "triple salt" magnesium, ammonium and potassium hydrochloride or $Mg_4K(NH_4)_3CL_{12}.24H_2O$) (Sarkkinen et al., 2011) was found to reduce systolic blood pressure. This study involved a limited number of subjects (45 individuals) and extended over a short experimental period (8 weeks). A larger-scale study is required to confirm this positive effect of replacing sodium salt by a mineral blend of potassium and magnesium salts.

A considerable disadvantage of many substitution salts is their bitter (metallic) flavour. Yet there are means to cover it, e.g. by adding the amino acid L-lysine or the non-reducing sugar trehalose. Trehalose, apart from being used as a sweetener, can also be used as a stabiliser and flavour enhancer.

Studies on salt substitutes usually focus on their functional and sensorial consequences, and much less on microbiological stability. Thus, a study on the effects of the salt substitutes $MgCl_2$, $MgSO_4$, KCl and $CaCl_2$ on the bread fungi *Penicillium roqueforti* and *Aspergillus niger* have shown that NaCl and $MgCl_2$ were most effective in inhibiting the growth of *A. niger* and *P. roqueforti*, respectively (at equivalent concentrations in the aqueous phase), which implies that the use of substitution salts may result in lower microbial stability (Samapundo *et al.*, 2010b).

Increasing the a_w (by reducing the salt concentration) can be compensated by lowering the pH, e.g. by means of organic acids. In the food industry, many organic acids are used as preservatives, such as acetic acid (E260), lactic acid (E270), sorbic acid (E200), citric acid (E330) (Brul & Coote, 1999). Organic acids are found in either a dissociated or non-dissociated state. The balance between these two states depends on the pH of the food. Both forms of the acid are found whenever the pH-value equals the pKa of the acid. The dissociated form predominates in case of an acid pH, and is the most effective to inhibit the growth of micro-organisms.

5.3. Salt/ flavour enhancers

The literature discusses a series of compounds that can be used as salt or flavour enhancers, including amino acids, lactates, ribonucleotides (adenosine monophosphate), trehalose, yeast extracts, protein hydrolysates ("hydrolysed vegetable protein" or HVP) and other mycoprotein derivatives (Dötsch et al., 2009; Kilcast, 2008; Desmond, 2006). Some of them are commercially available. The working mechanism of flavour enhancers is based on stimulating the gustatory receptors in the mouth and throat. The latter keep the salt channel open for a longer period of time, so to speak, which increases the perceived saltiness, but the real mechanism underlying flavour enhancement is not yet clear, and the observations made tend to be the result of "trial and error" (Dötsch et al., 2009).

Roughly speaking, a distinction needs to be drawn between flavour enhancers with glutamate as the main active component, such as monosodium glutamate (MSG, E621) and those without, such as guanylic acid, sodium guanylate, calcium inosinate (E626 to E637). In addition, there are flavour enhancers such as natural yeast extracts and protein hydrolysates. These products do contain glutamate, but this is not the most significant salt replacing component.

The following components are all glutamates: glutamic acid (E620), sodium glutamate (MSG, E621), potassium glutamate (E622), calcium glutamate (E623), ammonium glutamate (E624) and magnesium glutamate (E625). MSG may be the best known flavour enhancer on the market and has a "umami taste". Yet its use has a rather poor reputation (cf. the "Chinese restaurant syndrome"[6]).

Among other things, yeast extracts contain glutamic acid, peptides, nucleotides, glutathione, vitamin B, minerals and other flavouring agents. The taste of the yeast extracts varies according to the amounts to which these components are used. Yeast extracts can enhance the flavour, but can also cover the bitterness of the KCl.

Among the amino acids, arginine is the most widely mentioned as a salt enhancer. Certain studies attribute a very strong effect to arginine (e.g. more than double the salt flavour of 4.5 g/l NaCl), whereas others find it to have only a minimal effect and a marked bitterness. A high intake of arginine can increase the urinary sodium excretion. Combinations of arginine and aspartate are said to be more effective salt enhancers. In some cases, lysine also turns out to be a useful salt enhancer with no aftertaste. Besides, the salt enhancing effect of protein hydrolysates has also been attributed to the base amino acids present. Protein hydrolysates may sometimes contain the carcinogen 3-MCPD (3-chloro-1,3-propanediol) (Sci Com, 2010).

Lactate, which is usually added as potassium salt (E326), is said to significantly increase the perceived saltiness. It has also been shown that dibasic acids like succinic acid, malic acid, tartaric acid and adipinic acid increase the perceived saltiness at relatively low doses. The multimodal flavour enhancers discussed in the literature include alapyridaine, a compound isolated from beef stock and formed during a Maillard reaction between glucose and alanine, as well as the alkyl dienamides.

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[6] Refers to links to disorders such as headaches, dizziness, palpitations, mainly after eating at a Chinese restaurant, where MSG is sometimes added as a flavour enhancer. There is a scientific consensus on the fact that MSG has no adverse health effects to the amounts used in the industry (Beyreuther *et al*., 2006).

5.4. <u>Physical « boosters » of perceived saltiness</u>

The gustatory receptors can be stimulated chemically as well as physically. Thus, the perceived saltiness is influenced by the salt crystals' shape and size. For certain superficial applications of salts (e.g. crisps), increasing the solubility of the salt particles by reducing their size can improve the salty taste perceived whilst reducing the salt content. These different dissolution rates could be an important factor for the unique properties of certain sea salts (Kilcast, 2008). As regards the crystal shape, it has been shown in emulsion system models that flake salt displays a better functionality in terms of increased fixation, pH, protein solubility than grain salt. It is believed to dissolve better and more quickly than grain salt, which could be important when no water is added to the preparation, as is the case in e.g dry meat products (Desmond, 2006).

A similar taste or perceived saltiness can be obtained by working with "salt pulses" (i.e. an unequal distribution of the salt in the product) (Henney *et al.*, 2010; Busch *et al.*, 2009; Dötsch *et al.*, 2009). This can be done by e.g. putting the salt in several small layers in the product (e.g. bread, sausage), by putting it on one of the ingredients of a liquid product instead of dissolving it (e.g. on croutons or small pieces of chicken in soup) or by adding a "pseudo" salt to the product (starch particles with a small salt crust).

5.5. <u>Non sodium-containing additives</u>

Of all the sodium-containing molecules used in foodstuffs, NaCl is about the most effective in preserving the food against pathogens and spoilage micro-organisms. As a result, NaCl has the most significant impact on the microbiological safety of the foodstuffs (Taormina, 2010). In order to reduce the sodium content whilst ensuring the highest possible level of safety and quality of the food, it can therefore be worthwhile to consider alternatives for sodium-containing additives, other than salt.

5.6. <u>Other methods</u>

Cutting down on the salt intake could also easily be achieved by reducing the salt content in foodstuffs and by allowing the consumers to add the amount of salt they wish for themselves (*ad libitum*). Studies have indeed revealed that when consumers are allowed to make up for the lack of salt in a meal themselves by using the salt shaker, the final amount of salt is lower than when they eat a product that was salted from the beginning. In other words, it could be counter-productive to advise against using the salt shaker as a first step towards reducing the salt intake, especially since the contribution of salt from the salt shaker to the overall intake is relatively low (Henney *et al.*, 2010). However, such a measure is difficult to implement (requires a correlation production environment – family circle) and to communicate to the consumers.

Adding certain ingredients with a strong effect on taste can contribute towards adding less salt during the cooking or preparation process (Henney *et al.*, 2010; Kilcast, 2008). Adding e.g. seasoning and fresh spices, lemon, mustard or vinegar, which have typical flavours, can sometimes be resorted to instead of or in combination with salt. However, such a strategy can be difficult to apply in the production environment, but is entirely feasible in e.g. collective kitchens and the CHR industry.

As mentioned under section **4.2** above, the timing for adding the salt can also influence the intensity of the flavour (e.g. after cooking the meat) and may provide another avenue for salt reduction.

6. Advantages/risks of dietary potassium supplementation

With potassium chloride or KCl one of the most obvious and commonly used salt substitutes, the advantages and risks of potassium supplementation are discussed in greater detail below.

6.1. Physiological overview of the potassium balance

Potassium is a mainly intracellular cation and altered plasma levels do not always reflect the overall potassium levels in the organism. Though the potassium levels in the extracellular fluids are low and fairly stable, ranging between 3.5 and 5.0 mmol/l, the intracellular levels vary between 120 and 150 mmol/l, depending on the potassium balance and acid-base balance. Several factors maintain and influence the extracellular potassium homeostasis, viz. hormonal (insulin, corticoadrenal steroids, catecholamines), humoral, neural or metabolic factors. The fact that kalaemia (i.e. the extracellular potassium levels) is little influenced by the dietary potassium intake is accounted for by the increased postprandial insulin secretion, which boosts a speedy uptake of the potassium by the muscle cells. The kidneys adapt more slowly to the potassium intake (i.e. the urinary potassium excretion rises more slowly), but do so very efficiently, with the kidneys eliminating 90 to 95% of the dietary potassium intake. In healthy subjects, whose renal function is therefore normal, the kidneys' great ability to adapt allows to maintain the potassium balance, even in the event of oral overload several times above the normal dietary potassium intake. However, this ability of the kidneys to eliminate excess dietary potassium decreases with age. The dietary potassium requirements in adults range between 3.1 and 3.5 g per day (i.e. between 78 and 88 mmoles) (EFSA, 2006).

6.2. Dietary potassium intake

The dietary potassium intake in adults usually ranges between 2 and 4 g per day (50 to 100 mmoles), but high intakes of 5 to 6 g of potassium (125 to 150 mmoles) per day are usually well tolerated in healthy adults (EFSA, 2006). Such potassium intakes may, however, increase the kalaemia (i.e. the plasma potassium levels) in insulin-resistant subjects (with a metabolic syndrome complicated or not by type-2 diabetes) and elderly subjects. The hyperkalaemia (plasma potassium levels over 5.5 mmol/l) this can result in increases neuronal, cardiac and muscular excitability. Conversely, severe hypokalaemia can cause muscle paralysis, cardiac arrhythmia and metabolic alkalosis. However, potassium depletion is only observed in pathological situations or as a result of certain pharmacological treatments such as laxative or diuretic abuse. Dietary potassium deficiency is rare, since it is found in most foodstuffs. The recommended dietary intake of potassium, viz. 3.0 to 4.0 g per day (SHC, 2009a) is reached by consuming enough fruits and vegetables, especially raw vegetables.

6.3. Dietary potassium intake and regulation of the blood pressure

Several studies have shown that the impact of an excessive salt (and therefore sodium) intake on the blood pressure is intensified by an insufficient dietary intake of potassium (EFSA, 2006; Morris *et al.*, 2006; Geleijnse, *et al.*, 2003). On the other hand, the beneficial effect of reducing the sodium intake on the blood pressure is enhanced by increasing the potassium intake at the same time (He *et al.*, 2010; Braschi & Naismith, 2008; Geleijnse *et al.*, 2003; Naismith & Braschi, 2003; He & MacGregor, 2001). However, simply increasing the dietary potassium intake without abiding by a low sodium diet does not allow to reduce the blood pressure values in individuals with high blood pressure (Dickinson *et al.*, 2006).

Replacing one third of the sodium chloride content in bread by potassium salts, which would lead to 22 mmoles additional potassium per day, seems palatable (Braschi *et al.*, 2008). Potassium supplementation can be achieved by means of potassium chloride, but also potassium citrate or bicarbonate. The latter two types of potassium salts seem to have a lesser impact on the taste of the food and also have a positive effect on bone turnover by reducing the urinary calcium excretion (He *et al.*, 2010; Braschi & Naismith, 2008; Sellmeyer *et al.*, 2002).

Potassium supplements under 50 mmoles (viz. 2 g of potassium) per day are usually accepted given their low impact on the taste of the food (He *et al.*, 2010; Braschi, *et al.*, 2008). However, larger amounts of 100 mmoles (4 g of potassium) per day can result in taste aversion (Zoccali *et al.,* 1985; Jeffrey *et al.*, 1984), which is responsible for the frequent abandonment of this nutritional substitute, even by those with potassium depletion (Hueston, 1990). In actual practice, replacing sodium by potassium in food therefore turns out to be complicated by the latter's poor palatability. Moreover, the effect of replacing sodium chloride by potassium salts, which suggests a lowering of the blood pressure, has not been confirmed by certain studies (Dickinson *et al.*, 2006; Zoccali *et al.*, 1985).

6.4. <u>The risk of toxicity attendant on the dietary supplementation of potassium salts</u>

Dietary potassium supplementation can turn out to be toxic at doses as low as 1 to 5 g per day (Saxena, 1989), even though it only involves up to twice the recommended potassium intake in adults (SHC, 2009a). This risk is particularly high in elderly individuals, those with insulin resistance or certain renal disorders or who receive treatment for high blood pressure with renin-angiotensin system inhibitors (John *et al.*, 2010). Apart from hyperkalaemia and the cardiac risks it entails, the toxicity of potassium leads to nausea, neurological complications, and, in rare cases, stomach and intestinal ulcers (EFSA, 2006; Saxena, 1989). Even in healthy subjects, an acute oral load of 5 to 7 g of potassium increases the kalaemia and is liable to induce alterations of the heart function or neurological complications (EFSA, 2006). In subjects with an impaired renal function, hyperkalaemia and disorders of the heart function can occur when administering dietary supplements of even low amounts of potassium, such as e.g. 1 g of potassium per day. Very severe cardiac complications, such as cardiac arrest, are very rare, but they have been reported in relatively young individuals whose diet was enriched in potassium salts (John *et al.*, 2010 Saxena, 1989; Schim van der Loef *et al.*, 1988).

6.5. <u>Conclusion</u>

Several elements therefore plead against across-the-board replacement of NaCl by potassium salts in foodstuffs. Indeed, apart from the rather limited impact of potassium supplementation on the blood pressure, the poor palatability of these potassium salts considerably limits the indication for dietary supplementation. Yet above all, it is the risk of toxicity linked to hyperkalaemia (which is responsible for cardiac and neurological complications and is higher in many individuals, viz. the elderly, insulin-dependent individuals or those undergoing certain pharmacological treatments for hypertension) that pleads against resorting to across-the-board dietary potassium supplementation in the dietary prevention of cardiovascular disorders in addition to reducing the dietary sodium intake.

7. Conclusions

A high salt intake can result in a higher blood pressure, which is a significant risk factor for cardiovascular disorders. Too much salt in our diet also entails a risk of renal disorders, osteoporosis and stomach cancer. Several studies have shown that reducing the salt intake has a beneficial effect on the blood pressure; this effect is stronger in individuals with high blood pressure and those who are "salt-sensitive" (diabetics, elderly and overweight people).

At the population level, a lower salt intake is not expected to lead to any adverse effects.

When reformulating foodstuffs in order to reduce their salt content, the priority must go to the (microbiological and chemical) safety of the food. Salt is a highly effective preservative, but other ingredients - regardless of whether or not they are combined with targeted transformation and preservation techniques – can also constitute as good an alternative to guarantee the microbial stability of the food product.

Given the fact that salt can also play an important organoleptic and functional role, all aspects of reformulation need to be taken into account when reducing and/or substituting the salt.

As there is no miracle product that would allow for the salt to be replaced by a single ingredient (cf. the disadvantages of potassium salts as salt substitutes), it is necessary to develop and optimise a combination of substances to add to the food.

However, most foodstuffs contain an excessive amount of salt (based on the salt content in similar products alone), which means that simply gradually reducing the salt content is the most logical first step in a programme that strives to reduce the population's salt intake.

Reformulating a product to reduce its salt content needs to be done judiciously and should be considered within a full reformulation strategy, i.e. in combination with, among other things, lowering the fat and sugar contents. The Scientific Committee and the Superior Health Council wish to draw attention to the fact that reducing the salt content of foodstuffs should by no means lead to an increase in their fat or sugar content.

8. Recommendations

- ***For politics***

- The Scientific Committee and the Superior Health Council commend the initiatives taken by the National Food and Health Plan and the FPS Health, Food Chain Safety and Environment to raise the consumers' awareness of the adverse health effects of salt and to engage in dialogue with the sectors concerned to reduce the salt content in the food offer.
- It is worth pointing out that an Australian study has shown that though voluntary salt reduction by the industry is cost-effective, the public health benefits would be significantly greater if the salt content in foodstuffs were limited by law (Cobiac *et al.,* 2010). Apart from bread, Belgium has, until now, opted for self-regulation.
- In an initial stage, it is advisable to reduce the salt content gradually, rather than to encourage the use of salt substitutes.
- Monitoring the salt content in foodstuffs is of paramount importance to verify whether the product does indeed follow a falling trend. By regularly analysing the sodium content in different types of foodstuffs on the basis of a food basket, it is possible to establish whether the industry honours its commitments. In this respect, we refer to a study carried out by the CRIOC with the support of the FPS Public Health, which assesses the sodium content in various product categories based on the labelling (CRIOC, 2009). Nubel (Belgian table of foodstuffs, database for brand names) and the FASFC (monitoring programme) also take initiatives to analyse and monitor the sodium content in various foodstuffs.
- Analysing the "salt content" should be done on the basis of the sodium content. It is also desirable to monitor other salts (potassium, calcium, etc.) in order to supervise their potential substitution.
- Monitoring the salt intake is of key importance to measure the impact of the salt reduction programme (e.g. by measuring the urinary sodium excretion, conducting a food consumption survey).

- ***For the sectors concerned***

- Given the significant amount of variation between foodstuffs of the same type or within a same product category, it should be possible to simply reduce the salt content in a series of products without replacing it or resorting to a radical reformulation of the product.
- The objectives regarding the salt content of the products and meals should be formulated and implemented at the sector level and within an international framework (many producers of branded food products operate at an international level and can take part in sodium reduction programmes in other countries).
- The objectives fixed cannot lead to a higher content of other components that are also liable to have adverse health effects (e.g. a higher sugar or fat content).
- Reformulation requires devoting the necessary attention to the microbiological and chemical safety of the products.
- The restriction on the salt content should be taken into account as early as the design stage for new products.
- The salt content of food products should be monitored (e.g. databases, analysis, self-reporting, market studies).
- The labelling should be based on the sodium content and be as clear as possible to the consumer (salt content based on the salt-equivalent, which amounts to sodium x 2.5).
- Operator awareness should be raised (e.g. via training in the CHR industry, catering schools, etc.) as well as that of the consumer (e.g. via labelling, guarantees of quality, information available on the menu).
- We would like to draw attention to the (potential) role played by collective kitchens, caterers, the CHR industry, cooks (in culinary TV shows), cookbooks, etc. in this issue and to the contribution of “convenience food” (prepared meals, seasoning mixes) to the salt intake.
- Particular attention should be devoted to developing low-salt products for children.

- ***For research***

- The salt intake of the Belgian population (adults and children) should be assessed at regular intervals via, e.g. "health examination surveys “ with 24-hour urine collections.
- Regular surveys regarding the food consumption patterns could identify any changes in the food habits.
- Studies should be conducted regarding the reformulation of food products and its potential interference with strategies aimed at reducing the sugar and fat content, new preservation techniques, etc.
- A study on the intake of salt substitutes could be relevant in the event of these substitutes being commonly used as a means to reduce the salt content.

- ***For the consumer***

- Eat a varied and balanced diet according to the principles of the food guide pyramid.
- Limit the consumption of high-salt foodstuffs and choose alternatives with less salt (e.g. alternative brand, alternative type of food product of the same category, etc.).
- Prepare your own meals as often as you can (rather than resorting to "convenience food").
- Limit the amount of salt added to the preparations. The flavour can be enhanced by adding e.g. other condiments with a strong aroma. However, commercially available spice blends may also contain salt.
- Children should be accustomed from the earliest age to less salt in their food.

For the Scientific Committee The Chairman,	For the Superior Health Council The Chairman,
Prof. Dr. Ir. André Huyghebaert	Prof. Jean Nève
Brussels,	Brussels,

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10. Composition of the working group

The following experts took part in the joint Sci Com – SHC working group to draw up this advisory report :

De Backer Guy (SHC)	Preventive medicine, public health, epidemiology	UGent
Dewettinck Koen (Sci Com)	Food technology and engineering	UGent
Huyghebaert Andre (Sci Com)	Chemistry, foodstuff technology	UGent
Kolanowski Jaroslaw (SHC)	Physiology and pathophysiology related to food : pathophysiology of obesity, metabolic syndrome and type-2 diabetes	UCLouvain
Maghuin-Rogister Guy (Sci Com, SHC)	Foodstuff analysis	ULg

The Administration was represented by:

De Boosere Isabelle	FPS Health, Food Chain Safety and Environment, DG 4
Laquière Isabelle	FPS Health, Food Chain Safety and Environment, DG 4

Different organisations were invited to a hearing during which they described their vision on salt reduction and shared information that supports this vision. This hearing was held on 28 June 2011. The following individuals were heard:

De Meerleer M.	Vakgroep Levensmiddelen- en Agrotechnologie, HoGent
Denoncin A.	Fédération Francophone des Boulangeries
Heroufosse F.	Wagralim
Marquenie D.	Fevia
Léonard H.	Fédération Francophone des Boulangeries
Vandamme A.	Flanders'Food
Van Damme E.	Fédération Flamande des Boulangeries VeBic
Van Laere D.	Vakgroep Levensmiddelen- en Agrotechnologie, HoGent
Wagemans K.	Fédération des Grandes Boulangeries FGGB

A reaction was sent in writing by Fenavian and the Belgian consumers' association Test-Achats.

This working group was chaired by Koen Dewettinck and Guy Maghuin-Rogister, the scientific secretaries were Wendie Claeys (Sci Com) and Michèle Ulens (SHC).

Endorsement/Validation:

The advisory report was endorsed by the Scientific Committee of the FASFC during its meeting on 16 March 2012 and by the standing working group "Nutrition and Health, including Food Safety" (NHFS) of the Superior Health Council during its meeting of 29 February 2012. It was validated by the SHC Board during its meeting on 04 April 2012.

The Scientific Committee (FASFC) consisted of the following members :
D. Berkvens, C. Bragard, E. Daeseleire, L. De Zutter, P. Delahaut, K. Dewettinck, J. Dewulf, K. Dierick, L. Herman, A. Huyghebaert, H. Imberechts, G. Maghuin-Rogister, L. Pussemier, K. Raes*, C. Saegerman, M.-L. Scippo*, B. Schiffers, W. Stevens*, E. Thiry, M. Uyttendaele, T. van den Berg, C. Van Peteghem. * = invited experts

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Disclaimer

The Scientific Committee of the FASFC and the SHC Board reserve the right to change this advisory report at any time by mutual agreement if any new information and data should become available to them after the publication of this version.

11. Legal framework of this advisory report

For the Sci Com:

Loi du 4 février 2000 relative à la création de l'Agence fédérale pour la Sécurité de la Chaîne alimentaire, notamment l'article 8 ;

Arrêté royal du 19 mai 2000 relatif à la composition et au fonctionnement du Comité scientifique institué auprès de l'Agence fédérale pour la Sécurité de la Chaîne alimentaire ;

Règlement d'ordre intérieur visé à l'article 3 de l'arrêté royal du 19 mai 2000 relatif à la composition et au fonctionnement du Comité scientifique institué auprès de l'Agence fédérale pour la Sécurité de la Chaîne alimentaire, approuvé par le Ministre le 9 juin 2011.

About the Superior Health Council (SHC):

The Superior Health Council is a federal body that is part of the Federal Public Service Health, Food Chain Safety and Environment. It was founded in 1849 and provides advisory reports on public health issues to the Ministers of Public Health and the Environment, their administration, and a few agencies. These advisory reports are drawn up on request or on the SHC's own initiative. The SHC takes no decisions on the policies to follow, nor does it implement them. It does, however, aim at giving guidance to political decision-makers on public health matters. It does so on the basis of the most recent scientific knowledge.

Apart from its 25-member internal secretariat, the Council draws upon a vast network of over 500 experts (university professors, members of scientific institutions), 200 of whom are appointed experts of the Council. These experts meet in multidisciplinary working groups in order to write the advisory reports.

As an official body, the Superior Health Council takes the view that it is of key importance to guarantee that the scientific advisory reports it issues are neutral and impartial. In order to do so, it has provided itself with a structure, rules and procedures with which these requirements can be met efficiently at each stage of the coming into being of the advisory reports. The key stages in the latter process are: 1) the preliminary analysis of the request, 2) the appointing of the experts within the working groups, 3) the implementation of the procedures for managing potential conflicts of interest (based on the declaration of interest, the analysis of possible conflicts of interest, a referring committee) and 4) the final endorsement of the advisory reports by the Board (ultimate decision-making body). This coherent set of procedures aims at allowing the SHC to issue advisory reports based on the highest level of scientific expertise available whilst maintaining all possible impartiality.

These advisory reports are submitted to the Board. Once they have been endorsed, they are sent to those who requested them as well as to the Minister of Public Health and are subsequently published on the SHC website (www.css-hgr.be), except as regards confidential advisory reports. Some of them are also communicated to the press and to target groups among healthcare professionals.

The SHC is also an active partner in developing the EuSANH network (*European Science Advisory Network for Health*), which aims at drawing up advisory reports at the European level.

In order to receive notification about the activities and publications of the SHC, you can subscribe to the mailing-list and/or an RSS-feed via the following link:
http://www.css-hgr.be/rss.