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"Reaching its limits": Industry perspectives on salt reduction.

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"Reaching its limits": Industry perspectives on salt reduction

Abstract

Purpose: This study explores the barriers to, and implications of, salt reduction initiatives within the UK food manufacturing industry.

Methodology: Thirteen technical and new product development managers were purposefully sampled from businesses supplying foods within the chilled convenience food sector. Data were generated using semi-structured interviews incorporating the critical incident technique. Thematic and comparative analyses identified similarities and differences in the challenges facing different product categories within the sector.

Findings: Barriers to further salt reduction included: manufacturing limitations; new product development constraints; food safety, quality and shelf-life trade-offs; and organoleptic acceptance. No single barrier dominated industry concerns and many barriers were interlinked. Overarching issues of competitive inequality between signatories and non-participants to voluntary salt reduction agreements, and the experience of product reformulation having reached its limits were prevalent.

Originality: This research provides a food industry perspective on the ~~identifies~~ barriers faced by UK food processors and manufacturers in advancing salt reduction within the chilled convenience sector.~~the necessity for successful salt alternatives and technological solutions to support further reduced-salt product reformulation. As salt reduction is a social good, there is justification for Government investment to fund 'pre-competitive' research and development in this area.~~

1. Introduction

The UK Salt Reduction Policy Context

Sodium requirements are met solely through the diet (Durack *et al,* 2008), with salt being the major contributor (Jebb, 2005). Its presence in the body is essential in maintaining osmotic pressure in the blood and tissue (Lean, 2006). An intake of 2.6g/day of sodium, equivalent to 6g/day of salt is the reference nutrient intake (RNI) for the UK (SACN, 2003). However, this RNI is exceeded across all ages and genders, with average adult intakes currently at 8.1g/ day (Sadler *et al*, 2011). High salt intakes are associated with elevated blood pressure which is a risk factor in stroke and cardiovascular disease (Doyle & Glass, 2010) and other conditions, such as kidney disease, osteoporosis and stomach cancer (NHS, 2012; 2011, Durack *et al,* 2008). A decreased salt intake is therefore considered a key preventative measure against coronary heart disease and strokes (WASH, 2012). The social benefits of reducing average salt intakes by 1g per person per day include the prevention of 4147 premature deaths per year and UK National Health Service (NHS) savings of £288 million (Department of Health, 2014a). Further reducing salt intakes to the 6g/day target could prevent an estimated 17,500 premature deaths and a £4 billion saving for the economy, £1.6 million of which would be direct savings to the NHS (WASH, 2012). Given these health and economic impacts reducing salt intake is considered a policy priority to support the prevention of non-communicable diseases (Asaria *et al*, 2007).

Although foods contain salt at low levels in their natural state, approximately 60-90% is added to many foods during manufacture (i.e. non-discretionary salt) (WASH, 2012; NICE, 2010), with the remaining discretionary amounts being added to food whilst cooking or at the table (Lean, 2006). Given the critical role of the food industry in reducing the public's salt

intake, Government policies have focussed on developing voluntary industry salt reduction targets.

The first salt reduction targets were set by the Food Standards Agency (FSA) in 2005 (FSA, 2008) and covered 85 product categories, with further targets (following stakeholder consultation in 2008) set in 2010. The transfer of nutrition policy from the FSA to the Department of Health (DH) in October 2010, led to the 'Public Health Responsibility Deal', a voluntary agreement between the industry and the DH to improve public health and tackle health inequalities through product reformulation and efficient labelling (Wyness *et al*, 2012). As part of this Deal, pledging companies were asked to commit to the collective delivery of a further 15% reduction on 2010 targets (Department of Health, 2012). The anticipated benefits of this target were estimated as reducing 1g/of salt per person per day, or the removal of approximately 19 million kg of salt from foods sold within retail establishments, or 30% of salt that needs removing from the UK population's diet to achieve the 6g/day target (Department of Health, 2012). However, many of the 77 partners who signed up to the pledge (DH), 2012) voiced their concerns about the targets, in terms of safety, quality and sensory acceptance of products such as meat, cheese, pizza, canned fish, cakes, pesto and pies (Consensus Action on Salt & Health (CASH), 2012). Notwithstanding the DH's recognition of the need for investments into technical solutions for salt replacement, a revised set of targets were launched in March 2014 to be achieved by December 2017 across 76 product categories (Department of Health, 2014a).

This research therefore aimed to: 1) explore the barriers to further salt reduction; 2) identify new technologies, production techniques and products that industry are exploring to support further salt reduction; and 3) discuss the implications of increased salt reduction for the UK food industry.

In particular, the research aimed to explore two specific issues from a commercial perspective. First, the assumption that incremental salt reductions over a prolonged time will lead to a 'palate adjustment' as consumers' become more tolerant of and begin to prefer lower salt foods (Bertino *et al.*, 1982; Mitchell *et al.*, 2011), thereby suggesting no commercial benefit to companies continuing to supply foods with high salt contents as consumers would experience them as 'too salty' (Wyness *et al.*, 2012). Second, the potential technical barriers to salt-reducing reformulations which are linked to the preservation and antimicrobial qualities of salt. These properties are a consequence of salt's ability to lower water activity in foods, thus ensuring the optimum developmental requirements of many bacteria are not met (Albarracín *et al.*, 2011).

2. Methods

To explore a range of salt reduction barriers both experienced and perceived by food industry actors, a qualitative research approach typified by open questioning techniques was adopted (Denzin & Lincoln, 2005). Interviews were identified as the most appropriate data generation technique with alternative approaches such as focus groups discounted due to concerns that interviewees may not speak candidly to protect company confidentiality and/or to preserve potential competitive rivalries, and the impracticalities of assembling geographically dispersed interviewees. Early in the development of the research design, the principle researcher (the first author) assumed the role of 'qualified naïvité (Kvale, 2007), in which she sought to learn from the interviewees' knowledge and experiences to understand the practicalities of salt reformulation. This approach required the researcher to be informed of potential barriers and facilitators to food reformulation issues, to enable probing on the subject, whilst also being open to unexpected and new information. Entrée into the domain of salt reduction policy and food industry concerns about product reformulation to lower salt

content included both a literature review for the former, and an analysis of responses to the FSA's 2008 salt reduction consultation for the latter. In this consultation (FSA, 2008), 60 self-selecting participants predominantly industry based (n=42) responded to questions relating to product specific feedback, proposed new targets and general comments. Representations were from manufacturing (n=18), retailing (n=4), trade associations (n=20) as well as various consumer and health related organisations (FSA, 2009). Using a thematic analysis, key barriers facing specific product areas were identified (Table 1). These barriers were then compared across the cohort to identify category specific and generalised concerns.

INSERT TABLE 1 HERE

The analysis of 2008 consultation responses also informed the sampling selection of food manufacturing experts and retailer stakeholders in four ways. First, to capture the two functional areas most affected by salt reduction and product reformulation initiatives, interviewees were required to be employed within the food industry either in technical or new product development roles. Second, the interviewees were required to work within at least one of following three food categories that are associated with significant barriers to further salt reduction initiatives: 1) cooked and sliced meats; 2) ready meals (inclusive of pizza, pies, soups, sauces and quiches); and 3) sandwiches and salads. Specifically, these 'chilled, convenience foods' require manufacturing in high-risk or high-care facilities, denoting strict and high levels of hygiene, working practices, fabrication, facility design and equipment needed to produce food-safe products. Third, expert informants should represent a range of both branded and own-label chilled, convenience foods. Fourth, experts should be drawn from both small to medium sized enterprises with < 250 employees, and large enterprises ≥ 250 employees. These selection criteria required a purposeful sampling technique and this was achieved through use of a gatekeeper, the technical manager of a multiple retailer, who used knowledge of their supply base to identify potential interviewees

and a route for introductions. Potential interviewees were provided with information about the research and a list of the 5 open-ended questions that would form the basis of the interview. Thirteen experts participated in the study, ten food manufacturers and three employees of a multiple retailer. The sample description is provided in Table 2.

INSERT TABLE 2 HERE

Participants were asked questions relating to: 1) their role and product category responsibilities; 2) the main impacts of salt reduction on their business; 3) what, if any, barriers they were facing whilst reducing salt in their product categories; 4) activities the company were undertaking to overcome these; and 5) novel technologies or products they had explored to facilitate salt reduction. The critical incident technique (CIT) was used throughout the interviews to attain context-rich, first hand perspectives on salt reduction initiatives and the associated challenges (Flanagan, 1954). Analytically, CIT supports the identification of differences and similarities that are attached to specific events or 'critical incidents' such as salt reduction experiences, whilst also identifying emerging trends. The interviews, which were conducted by telephone, lasted approximately 30 minutes and were digitally recorded and transcribed *verbatim*. The fieldwork was conducted during January and February 2013.

The data analysis utilised a thematic approach (Braun &Clarke, 2006). Each interview transcript was manually open-coded. These codes were then sorted and compiled into topical categories that explained them (Charmaz, 2006), which were then compared and contrasted (see Table 3).

INSERT TABLE 3 HERE

3. Results

Product reformulation to reduce salt content had been trialled by all the experts' companies with varying degrees of success. Generalised and product specific barriers to salt reduction, and the tensions and trade-offs relating to strategies to address these barriers were identified and are now discussed.

Salt reduction in simple foods:

Food safety* versus *shelf-life

The pivotal role of salt in contributing to the production of safe food, by hindering the growth of potentially harmful microorganisms, was implicitly acknowledged by all the interviewees, irrespective of company size. Some food safety concerns were product specific. For example, cooked meat manufacturers were concerned about the mis-curing of cooked meats in brine (a salt based solution), and there were specific concerns about *Clostridium botulinum* and *Listeria monocytogenes* control. Manufacturer response to addressing such food safety concerns is to shorten use-by dates with concomitant impacts on manufacturer's planning, ordering and logistical systems:

> *"My biggest concern is that such a significant salt reduction will undoubtedly have a marked effect on the shelf-life of all cooked meat products. Most concerning of all this may result in a higher proportion of mis-cures which could present a food safety risk"* (Participant A).

> *"During trialling of reduced salt products it has become apparent that there is an increased risk of Listeria monocytogenes associated with the incremental reductions in salt content. This has been overcome through the reduction of internal shelf life of*

high risk ingredients by one day and also the incorporation of more checks and testing procedures throughout manufacture" (Participant I).

Functionality and manufacturing process efficiency

The functionality of salt in relation to manufacturing process efficiency was also identified as a challenge by some food manufacturers. For example, within dough-based product categories, salt reduction had a negative impact on yeast function, and for comminuted meat products (e.g. burgers and sausages produced by processes including the crushing and grinding of meat muscle and fat) impaired slicing:

"Too little salt can result in some particularly active doughs to become too elastic as there is no inhibitive effect on the yeast. On a sheet and cut line this can cause major issues with weight control and transfer through the process" (Participant B).

"When producing comminuted meats the reduction in sodium content will affect the binding of proteins, resulting in increased muscle separation and hence reduced slicing yields and creating poor quality slice." (Participant A).

Salt reduction in complex compound foods:

Salt reduction in some complex compound foods was accommodated by process modifications, including the manufacturing point at which salt was added as a seasoning, which was typically moved to the end of the manufacturing process:

"We have also reviewed our process, especially with cooked products such as soups and sauces, we now add seasoning at the end of the process to give maximum flavour impact with the minimum level of addition" (Participant F).

"We haven't had to develop new processes to overcome salt reduction as of yet however there has been a need to modify existing processes such as vacuum tumbling to offset any yield and textural implications from salt reduction" (Participant H).

However, there were significant barriers to salt reduction associated with altering the salt profile of ingredients or reducing the quantity of highly salted ingredients which caused problems in recipe authenticity and new product development (NPD).

Authenticity

Restrictions to NPD arising from the salt reduction agenda were noted by more than half of the interviewees as being a major concern, particularly in multi-component food categories. Within the NPD discussions, salt reduction requirements were causing industry problems associated with the ability to produce foods using authentic recipes, which for example may require specific textures and/or flavour profiles associated with particular cuisines. Moreover, using authentic ingredients also limited the scope for reformulation when the ingredients are made to specific recipes with protected geographical indications (PDI) or designations of origin (PDO) such as *Prosciutto di Parma*:

:

"One of the biggest challenges faced is the development and reformulation of meal centres – especially Chinese/Thai/Indian. It is impossible to truly replicate the authentic flavours associated with these cuisines due to the naturally high sodium contents of these foods and the restrictions imposed on the use of authentic ingredients such as soy sauce" (Participant D).

"Reformulation in some cases has been deemed impossible for some products due to their authentic nature and processes of manufacture. A good proportion of international cooked meats are produced to specific, protected recipes resulting in no leeway being available for reformulation" (Participant L).

Strategies to address such NPD barriers generally required a trade-off between authentic ingredients and food quality (as perceived by consumers). For example, reducing the quantity of high salt containing ingredients, particularly cured meats, would reduce salt content. However, the quantity of meat (or protein content) in compound foods is often a factor in consumers' purchasing decisions and a potential unique selling proposition (USP) for specific brands. Therefore reducing meat or fish content in a compound food could lead to a reduction in customers' perceived quality and associated loss in competitiveness:

"Development of products to meet the salt reduction targets can be difficult with products containing ham, bacon, cheese, smoked salmon or prawns – all of which are consumer favourites for sandwich fillings. All of these ingredients are high in salt but are also high in the customer purchasing decision. Reduction or replacement of these ingredients would result in a significant decrease in customer satisfaction" (Participant I).

"Many cooked meat products … contain Wiltshire cured trim, which is the main source of salt within the recipe. We will struggle to meet the target without reducing the meat content or significantly changing the recipes, and this would affect the flavour, character and USP of these lines" (Participant A).

Organoleptic Acceptability

Irrespective of the complexity of a food, the organoleptic factors of taste/flavour and texture were identified as barriers to continued salt reduction by most of the interviewees. Concerns about organoleptic factors were not product or company specific. Flavour-compromise barriers were a concern to a high proportion of the interviewees, with a number of manufacturers reporting an increase in consumer complaints about product flavour following salt reformulation.

> *"In order to balance out the use of ingredients that require salt as part of their food safety controls/ functionality, and that are pivotal to the product, many of the other ingredients i.e. tomato sauce are developed with considerably reduced salt level. For efficiency reasons these sauces are used on many pizzas within the range. This can and historically has had a damaging effect on complaint levels with customers stating that the products (not containing the high salt ingredients) are bland and tasteless" (Participant B).*

> *"The addition of salt to the sauce helps bring out the overall tomato and herb notes. The reduction of salt in this component would be possible; however if you were to remove all of the salt, the sauce would become less flavoursome and would have detrimental effects on the overall product" (Participant E).*

Texture-compromise barriers arising from salt reduction were also significant for dough-rheology and protein based ingredients. Other texture (and perceived quality) changes resulting from salt reduction included product degradation over the shelf-life. Ready meals, quiche and dips suppliers referred to salt reduction causing free water leeching, and sauce separation over shelf-life, leading to customer dissatisfaction:

> *"The biggest challenge we have faced so far has been organoleptically in terms of flavour and texture. We have had to be very aware regarding texture of delicate protein – i.e. prawns. If the salt level is reduced too much then the texture can become*

too firm once cooked, perhaps even tough at further reduction levels. This means it is in our best interest to keep salt at an optimum level which we are nearing the lower end of now so texture isn't compromised" (Participant H).

"Reduction in salt from the quiche pastry case has led to an increased water activity within the product hence resulting in water migration from filling to pastry. This leads to soggy pastry towards the end of shelf-life and increased customer dissatisfaction and complaint" (Participant J).

Novel Technological Investment

Salt alternatives had not been commonly and successfully used by industry to date and the main salt alternatives being explored by companies are noted in Table 4.

INSERT TABLE 4 HERE

A consistent view expressed amongst interviewees was that some product and process modifications had been pushed to their salt reduction limits, requiring significant investments in manufacturing plant and equipment to permit further salt reduction. Interviewees believed that these cost implications would most likely be borne by businesses, irrespective of company size. Furthermore, novel technological development was identified as a necessity to facilitate further salt reduction through reformulation.

"When looking for example, at cooked meats there is a need to significantly change production facilities/factories to meet current and any future targets. These changes would have huge costs to the business and as a result further investment incentives are needed if salt reduction is to be pushed further" (Participant K)

"There are quite a lot of salt replacers on the market however they are very expensive when compared to salt. Salt currently costs approximately 20p/kg and many salt replacers cost £2-3/kg which is a huge on cost for the manufacture" (Participant J).

"In upcoming years there is going to be a need for significant changes to production facilities and factories to allow the food industry to meet any further targets the Department of Health sets. Salt reduction is reaching its limits at the moment and without new emerging technologies or restructuring of manufacturing plants, any further advance will come at great expense to the food industry" (Participant K)

Competitive parity

A consistent tension underpinning the above discussion was competitive parity. Interviewees noted that, although all retailers had signed up to the voluntary salt reduction targets within their own-label products, branded manufacturers and the takeaway market were slower signatories. This had led to significant underperformance of own-label foods when benchmarked against branded foods.

"There is a struggle to meet targets when products are benchmarked against branded products. Brands haven't moved as quickly as retailers to meet targets so their products tend to contain high levels of salt and are favoured by consumers due to their higher levels of perceived flavour" (Participant K).

"Meat feast pizzas and products that are benchmarked against takeaway offerings such as […] etc. will never truly be able to be developed as a match due to the salt guideline restrictions placed on the supermarkets that are not currently imposed on the takeaway market" (Participant B).

Moreover, most salt reduction signatories are UK based, compounding the industry perception of an uneven competitive environment. One strategic option for manufacturers

with overseas production sites was to move production outside the UK to meet consumer perceptions of quality and authenticity:

> *"There are worries within the UK food industry that UK manufacturing will get undermined and production will get moved overseas in upcoming years if salt reduction through reformulation continues. Overseas suppliers do not have to comply with the salt reduction initiatives, especially if the products are branded. On the other hand the sourcing of low salt raw materials may end up being restricted to UK suppliers if other countries do not follow suit soon" (Participant M).*

4. Discussion

For most countries, implementing a national salt reduction programme is likely to be one of the simplest and most cost-effective ways of improving public health (Webster *et al*, 2012). This requires consumers to reduce their salt consumption; either through the development of consumer education programmes to reduce discretionary intake (see *inter alia,* He &McGregor, 2008; WHO, 2012); and/or the selection of low salt processed foods (indicating the need for the development of an effective salt labelling policy); and/or reducing the salt content of foods available to the consumer (WHO, 2010). Although examination of consumer education and taxation policies are beyond the scope of the current analysis (but see, *inter alia*, Grimes *et al*, 2009; Mytton, *et al*, 2012; Letegic & Campbell, 2011 for further discussion of this issue), it should be noted that consumers concerned about the potential risks of salt consumption may drive demand for processed foods with a reduced salt content, at least for a proportion of the market (Mohan, Campbell & Willis, 2009). Industry responses to such demand may conceivably result in reformulated foods being promoted with a reduced salt unique selling proposition in parallel with 'conventional' foods. However, the intended "stealth reduction" (Wilson *et al.*, 2012) of the present salt reduction policy assumes that

gradual reductions will not be identified by consumers (Doyle & Glass, 2010) and that consumers' palates will change to prefer less salty foods (Bertino *et al.*, 1982; Mitchell *et al.*, 2011). While it is possible that healthier consumer choices may be facilitated by "nudging" sensory preferences for salt content downwards through reducing the salt content of processed foods (e.g. He &McGregor, 2008; Dötsch *et al*, 2009), this requires widespread adoption of initiatives such as the UK DH Responsibility Deal. However, as fewer branded manufacturers than retailer own-label produces (Department of Health, 2012) and restaurants and takeaway establishments have signed up to the salt reduction pledge, (Department of Health, 2014b), the palate adjustment theory is less likely to be realised. Additionally, the reduced sensory acceptability of reformulated foods compared to non-modified foods in benchmarking tests represents a competitive barrier to continued salt reduction. Other competitive barriers are now discussed.

Potential unintended consequences of salt reduction include increased production costs and food waste. Although the due diligence defence in food law (Food Safety Act 1990, as amended) has made food safety a non-competitive issue in the UK, the heightened risk of microbial growth for some food categories caused by salt reduction, may require increased microbial testing, with adherent costs borne by the food manufacturing and distributive industries and/or consumers. The additional commercial strategic option of reducing the shelf-life of reformulated foods may also conflict with sustainability goals to reduce food waste. Exploiting technological innovation to extend shelf life (for example through investment in food research), may be one mechanism to address this barrier, although the application of some (novel) food technologies may not be accepted by all consumers. Such tensions associated with harmonising health and sustainability policies suggest~~s~~ the need to ensure maximum public good results from policies. In the case of the latter, due consideration needs to be given to socio-economic and ethical impacts, as well as those

associated with health and the environment (see König *et al*, 2010, for a similar example relating to food risk analysis).

Although the majority of organoleptic barriers identified within this study related to the known palatability of foods through salt's own textural and taste properties (Liem *et al.*, 2011) and influence on the flavours of other foods (Desmond, 2006), consumers' preferences for authentic ingredients and flavours from different cultural cuisines present a significant barrier when they are naturally high in salt e.g. soy sauce or cured meats. This is compounded when raw materials may be subject to PDO or PDI status, which precludes change to a historically or geographically authentic recipe with protected intellectual property rights. Although reducing the quantity of authentic ingredients is a strategic option, this risks rejection by consumers when evaluated against competing food products. Competitive implications of this unequal playing field including companies considering moving manufacturing to plants outside the UK, requires Governmental policy consideration. Mandatory rather than compulsory salt reduction is one such option, but on the grounds of commercial interference and choice, may be opposed by both industry and consumers respectively. A more realistic policy goal is the inclusion of mandatory "warning" salt labelling for ALL products within the EU where salt levels are very high to support consumer informed choice, although this would require further investigation. Investments into the development of technological solutions to support further salt reduction could also be considered. Here, the industry could input into the future research funding landscape via organisations such as the Knowledge Transfer Networks, which connect businesses, academics and funders to develop new products, processes and services (https://connect.innovateuk.org/knowledge-transfer-networks).

To date, much salt reduction has focussed on the removal of free salt within products. Salt substitutes can be used in combination with additives to suppress the notable absence of salt, as well as flavour intensifiers to enhance the perceived salinity of the product (Doko Jelinić *et al.*, 2010). Although this research has highlighted that salt alternatives are not currently commonly used, there is potential for future facilitation of further salt reduction (Wilson *et al.*, 2012). For example, technologies to redistribute salt crystals to the product's exterior opposed to its interior promises a rapid salt sensation, initiating a heightened salt perception by the consumer, with the added bonus of reducing the overall content of salt. Another approach is exploring the engineering of salt with lower solubility, allowing the crystals to travel through the gastrointestinal tract without entirely dissolving. This allows for a sufficient salty taste to be experienced on the tongue, whilst limiting the overall ingestion of salt. These novel technologies are all still at concept or trial stage and so may take years to come to market. As salt reduction has 'reached its limits' investment in technological solutions is vital for future salt reduction. As such technologies are 'pre-competitive', are likely to contribute to public health and may assuage competitive barriers to present salt reduction, public funding of technological interventions to support further salt reduction is an obvious policy route which may support food industry resilience.

Conclusions

This study has shown that salt reduction (to meet salt targets) solely through reformulation has reached its limit in a number of products, and is approaching its limitation in others. Industry experts expressed grave concern regarding the setting of additional, more stringent, salt targets, following the challenging 2012 targets set by the DH. A number of barriers to further salt reduction were identified, some of which were apparent during the 2008 FSA salt

406 reduction consultation process and remain unresolved, whilst others have emerged since. It is
407 apparent that there is not one single barrier preventing further salt reduction, but a number of
408 barriers encompassing different parts of the manufacturing process. These barriers, including
409 food safety, manufacturing, development, organoleptic and quality concerns, all have a
410 potentially negative impact on consumer acceptance of reduced salt products. If the UK
411 wishes to achieve its target salt intake of 6g/day, notice and action needs to be taken in light
412 of these concerns. These include investment into pre-competitive R&D to support the
413 development of novel ingredients and technologies that could facilitate further salt reduction,
414 policies to support an equitable competitive environment to maintain the resilience of the UK
415 food industry to prevent it leaving the UK, and continued salt reduction public health
416 campaigns. Thus collaboration between Government, industry and the public is required to
417 share in the challenge to significantly lower the UK populations' salt intake and in turn
418 improve the health of the nation.

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571 **Table 1: Concerns arising from 2008 FSA Salt Reduction Consultation**

Product	Consultation Concerns
Meat products	Increased customer complaints received over taste/texture – increased costs involved with additional flavourings; Shelf life reduction – poses operational difficulties in supply chain; Food safety risks - *Listeria monocytogenes, Clostrisium botulinum,* Authentic nature of some meats poses problems, Increased food borne illness & bacterial growth; Major impact on NPD – inclusion of other ingredients i.e. in sausages and burgers reduced and restricted.
Bread	Flavour affected – risk all bread tasting the same; Reduced shelf life due to increased mould growth; Inferior loaves and more variability due to yeast functionality being affected; Poor crust colour; Main raising agent (sodium bicarbonate) contains sodium – no alternatives.
Cheese	Moisture levels affected; Emulsifying salts necessary for manufacture – high sodium content; Reduced shelf-life – spoilage and off notes present; *Clostridium butyricum* prevention reduced – blowing; Increased mould and bacterial growth.
Butter	Increased bacterial growth; Difficulties achieving uniform distribution of salt; Increased *Listeria monocytogene*; Reduced shelf-life – 14 day reduction already observed.
Ready meals & meal centres	Reduced shelf-life; Increased addition of sugar to enhance flavour; Increased customer complaints over flavour; NPD restriction.
Pizza	Bland; Reduced shelf-life; Increased food safety risk.
Buns, cakes, pastries & fruit pies	Increased use of additives; Main raising agent (sodium bicarbonate) contains sodium – no alternatives; Reduced shelf-life; Denser texture due to loss of aeration.
Sandwiches	NPD restriction; Increased customer complaints about blandness; Reduced shelf-life; Food safety concerns.
Pasta sauces, thick sauces & pastes	Authentic recipes often high in salt; Flavour impacted; Sauce stability reduced; May lead to increased use of additives and artificial preservatives.
Biscuits	Organoleptic limitations; Household favourites – reduced customer satisfaction; Increased customer complaints.
Quiches	Depreciation of texture over shelf-life; Increased customer complaints about blandness; Reduced shelf-life; NPD restriction.

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575 **Table 2: Sample Description**

	Products category	**Contact**	**Company information**
A	Cooked and sliced meats	Group Technical Manager	Manufacturer, large company
B	Chilled ready meals: pizza	Technical Manager	Manufacturer, large company
C	Chilled ready meals	Technical Manager	Manufacturer, large company
D	Chilled ready meals	New Product Development Manager	Multiple retailer
E	Chilled ready meals: pizza	New Product Development Manager	Manufacturer, large company
F	Dips, sandwiches, soups and sauces	New Product Development Manager	Manufacturer, large company
G	Chilled ready meals	Technical Manager	Manufacturer, large company
H	Chilled ready meals	Technical and NPD Managers	Manufacturer, SME company
I	Sandwiches and salads	Technical and NPD Managers	Manufacturer, large company
J	Chilled ready meals: pies, quiche and savouries	New Product Development Manager	Manufacturer, large company
K	Chilled ready meals; cooked and sliced meats; and sandwiches and salads	Trading Law and Technical Manager	Multiple retailer
L	Cooked and sliced meat	Technical Manager	Manufacturer, large company
M	Chilled ready meals; cooked and sliced meats; and sandwiches and salads	Category Technical Manager	Multiple retailer

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577 **Table 3: Barriers to further salt reduction specified by industry experts**

Participant → Salt Reduction Concern ↓	A	B	C	D	E	F	G	H	I	J	K	L	M
Manufacturing													
New technology required	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓
Reduced Consistency	✓	✓			✓					✓	✓	✓	✓
UK vs. Overseas manufacture		✓			✓			✓			✓		✓
Reduction of shelf life of raw materials internally		✓	✓		✓	✓	✓		✓				✓
Production of raw materials affected	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Functional properties of ingredients affected	✓	✓	✓		✓	✓	✓	✓		✓		✓	
Organoleptic													
Flavour compromise	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Texture compromise		✓	✓		✓			✓	✓	✓			✓
Enhance flavour of other ingredients					✓	✓		✓					✓
Food Safety													
Higher proportion of mis-cures	✓											✓	✓
Increased risk of *Listeria. monocytogenes*	✓	✓			✓		✓		✓	✓	✓	✓	✓
Increased risk of *Clostridium. botulinum*	✓										✓	✓	
Increased risk of spoilage micro-organisms	✓	✓			✓	✓			✓	✓	✓	✓	✓
Reduced shelf-life	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓
Development													
Made to specific, protected recipe	✓		✓	✓			✓					✓	✓
Restriction		✓	✓	✓	✓			✓	✓	✓	✓		✓
Use of authentic ingredients		✓		✓	✓			✓			✓		✓
Quality													
Meat content reduction	✓	✓	✓		✓		✓		✓	✓	✓	✓	✓
Aesthetic properties affected	✓	✓			✓			✓		✓	✓	✓	✓
Balance – compromise salt in one component to allow use of another			✓							✓			✓
Sauce splitting over shelf life			✓			✓	✓		✓				✓
Water migration over shelf life	✓		✓			✓	✓			✓		✓	
Consumer													
Characteristic features affected	✓							✓				✓	✓
Customer acceptance/expectations		✓	✓				✓	✓		✓	✓		✓
Business related													
Waste increases	✓							✓		✓		✓	✓
Underperformance vs. benchmark		✓					✓	✓		✓	✓		✓
Own brand vs. branded products											✓		✓
Salt alternatives													
Difficult to find acceptable flavoured alternatives	✓		✓				✓		✓	✓	✓	✓	✓
Difficult to source clean declaration alternatives	✓		✓						✓	✓	✓	✓	✓

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579 **Table 4: Salt alternatives explored by interviewees**

Salt Alternative	Description
Nu-Tek Potassium Chloride	Single embedded micro-crystal KCl that significantly reduces any bitter/metallic note associated with straight KCl.
Mycoscent®	A natural flavouring derived from mycoprotein. Has the ability to impart a salty taste without the addition of sodium. Mycoscent has a synergistic effect and characteristics such as sweetness and spice are lifted with its use.
SODA-LO® (Salt Microspheres)	Salt encapsulated within a dextrin shell resulting in free flowing crystalline microspheres that deliver a salty taste through the maximisation of surface area relative to volume.
Seagreens®	Human food quality, nutritious, brown wrack seaweed.
Sub4Salt®	Consists of NaCl, KCl & sodium gluconate. Can replace salt without sacrificing taste. 1:1 substitute with much lower sodium content than natural salt, does not give rise to side effects such as off/bitter/metallic tastes.

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