The Challenges and Benefits of Replacing Salt with Yeast Extract in a Selected Butter and Bread Based Product

A Thesis Presented for the Award of Master of Science by

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For research Carried Out Under the Guidance of

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Declaration

"I hereby verify that the information, which I now present for assessment on the program of study leading to the award of Master's Degree, is wholly my own work and has not been extracted from the work of others expect to the degree that such work has been cited and acknowledged within the transcript of my own work. No section of the work comprised in this thesis has been presented in support of an application for another degree or qualification to this or any other institution."

Signed:  Date: May 2023

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Sincerely thank you all!

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Abstract

As living standards in countries have improved, there is a higher demand for healthy, nutritious food. Health and well-being are the concerns in today's world, health issues that the world is facing are making us concerned about what we eat. Salt is a cheap way of adding flavour to food and making it taste better. The recommended daily intake of salt should be around a teaspoon full but the reality is that the average person is consuming up to double that figure. The main concern in the world today is that excessive consumption of salt can lead to health issues such as an increase in blood pressure and a higher risk of developing cardiovascular diseases. Food manufacturers are looking for new alternatives to reduce or replace salt in products. Those alternatives will be challenging for food businesses as salt enhances the quality and taste of their product and in most cases, it is a cheaper additive than using another alternative. Food manufacturers also face complications, as the consumer will expect product with reduced salt or with a salt alternative to have the same appearance and flavour as the original version of the product but be healthier because of the reduced salt or salt replacement. One of the alternatives for salt is yeast extract. Yeast extract is a natural product that can be easily produced and could be used as an alternative to salt. It has a taste similar to salt, but it is a healthier alternative. This study shows how salt is being replaced by yeast extract and the product keeps the same characteristics. Yeast extract gives food the same properties as salt and keeps the same shelf life to the product.

List of Abbreviations

%	Percentage
<	Less than
>	More than
ACC	Aerobic Colony Count 30°c 48hrs
AMU	Atomic Mass Unit
BC	Before Christ
CFU	Colony Forming Unit
EC	Council Regulation
EC	European Commission
FOP	Front of Package
FSAI	Food Safety Authority Ireland
FSDA	Food and Drugs Administration
g	Gram
GDA	Guidelines Daily Amount
GRAS	Generally Recognised as Safe
GRAS	Generally Recognized as Safe
GRN	Goods Receive Note
HFSS	High in Saturated Fat, Salt, and Sugar
KCL	Potassium Chloride
NaCl	Salt – Sodium chloride
NDNS	National Diet and Nutrition Survey

PHE	Public Health Ireland
RI	Reference Intake
SSP	Sequence Specific Primer
UK	United Kingdom
US	United States
VACCP	Vulnerability Assessment Critical Control Points
WHC	Water Holding Capacity
WHO	World Health Organization
YE	Yeast Extract

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Chapter 1

Introduction

Health and food go hand in hand, we are what we eat (Ludwig Feuerbach *et al*, 1848). Working in the food industry and learning in relation to food and health concerns made me choose this topic for research. The focus of this study is “The Challenge and the Benefits of Replacing Salt with Yeast Extract”, this was a research study completed on two different established products “samples” 1) Sage and Onion Stuffing and 2) Parsley Butter produced by an Irish food manufacturer. The replacement of salt with yeast extract was completed to assess the effect of yeast extract on taste, functionality, and shelf life of the product and the challenges that this replacement will bring for the consumers and the manufacturers. Salt plays an important role in a humans’ diet; today's research shows that the level of salt taken in our daily intake affects our health and well-being. Salt reduction is prominent in the top ten emerging trends in healthy foods, to reduce salt in food is an initiative globally. Salt in diet reduction for disease prevention but the effects of removing salt from food that may decrease shelf-life and give an un-appealing product. Food manufacturers are encouraged to lower the sodium content of processed foods, which are high in salt. The reduction of salt without compromising the taste is a challenge (WHO *et al*, 2020). This will be a challenge for the food businesses to deal with in the future. This study will include an investigation into aspects of manufacturing and economics of potential salt replacements. Salt plays an important role in our diet; it was used as a food preservative in ancient times and continues to be used nowadays. Sodium is one of the main minerals in our bodies and plays a leading role in many physiological processes (Albertino Bigjani *et al*, 2022). Food companies must take steps to reduce salt intake in food and to help consumers reduce their daily salt intake. This will be a challenge to achieve for 2023 in relation to the reformulation of existing products, investigation is required into how this will impact shelf life, taste, and the expectations of consumers. This new challenge will not be just applicable to food retailers/manufacturers but also to food service and restaurants. This research could potentially offer insight into trending methods to reduce salt in food products and do people notice the difference or have a preference.

Objectives of this research are:

- Review the health benefits of salt
- Investigate the functions of salt in products: shelf life and organoleptic (appearance, aroma, taste, texture).
- Will the shelf life and organoleptic testing be impacted by replacing salt with yeast extract?
- Will yeast extract give the same shelf life to the product?

- How will yeast extract affect the product and the cost?

The main objective of this study is to reduce the salt concentration in Sage and Onion Stuffing and Parsley Butter and replace the reduced amount with yeast extract YE. I utilized my workplace to complete this research, their facilities, the NPD kitchen, and my work colleagues to complete organoleptic testing. All samples were prepared following the existing recipe and reformulated the new recipe by replacing salt with yeast extract, under the same processing conditions. The sensory evaluation trials determined the acceptable level at which yeast extract YE can replace salt. This research is to establish how food production companies can reduce recipe salt and what the implications are for product quality, food safety, and sensory acceptance.

1.1 The Story of Salt?

The medicinal antiquity of salt arises from in prehistoric records and is densely recounted to numerous segments of social history. Salt can be separated from oceanic water, mineral sediments, surface deposits, saltwater lakes, and saline springs (S. Karger AG, Basel *et al*,1994). The process of salting includes a sequence of actions with the objective to conserve fishery products with the use of salt (U. Nwaigwe *et al*, 2017). Throughout history, the accessibility of salt has been vital to society. With Solnitsata, in Bulgaria, thought to be the initial city in Europe which was a salt mine, supplying the region now known as the Balkans since 5400 BC. Remnants of Solnitsata have been carbon-dated to approximately 4,700 to 4,200 B.C., but salt manufacture at this location commenced as premature as 5400 B.C., conferring to archaeologist Vasil Nikolov of Bulgaria's National Institute of Archaeology (Thomas H and Maugh *et al*, 2012)**.** Salt with the chemical formula NaCl, 1: 1 ratio of sodium and chloride ions, more commonly known as table salt, plays a significant function in our diet. In prehistoric eras, salt was commonly utilized and used as a functional ingredient to preserve foods i.e., fish, meat, etc. due to its effects as a food flavour enhancer, reduction of water activity of food, and as such extend the shelf life in food. Table salt has been found to be amongst the most frequently appearing compounds in the world. Sea salt is generated from the vaporisation of oceanic waters. As a result of its foundation, this variety of salt is classified by its natural contents of iodine and amongst other significant minerals (lithium, magnesium, zinc, and selenium). Sea salt has a predominantly distinguishing taste in comparison to table salt, therefore reduced quantities sea salt may be employed, additionally adding to its comparatively low sodium essence, it has been found to be the healthiest category of salt (Millena Ruszkowska *et al*, 2022). The compound sodium chloride consists of Na^+ and Cl^- ions bound together by electrostatic forces of attraction in a substantially sized network known as a crystal. The hypothetical sequence of the one Na+ and one Cl^- ion suggested is a formula unit. It is the minimum compilation of ions from which we can determine the formulation NaCl photo 1.1 (Yallascience *et al*, 2017).

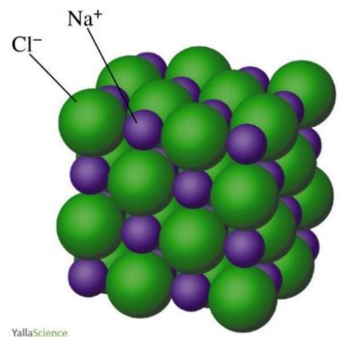


Image 1.1.1 Formula unit of NaCl, taken from (Yallascience *et al*, 2017).

1.1.2 Salt Storage Stability

It can be found that the most universal categories of salts consist of table salt and iodised salt. Both of these categories of salt generally comprise of approximately 97% to 99% sodium chloride containing various anti-caking compounds. Iodised salt contains iodine as well as anti-caking compounds. Iodine can be found to be an important nutrient which may prove problematic to replace outside of a varied diet. Progressively, the iodine may transform the salt to a yellowish colour. This will nevertheless continue to be safe to consume, although it could possible manage to ensure that the salt has a reduced value capacity as a trading piece. Consumers who may be anxious with regards to obtaining sufficient iodine ought to contemplate hoarding seaweed or an additional type of supplement. Salt must be stored in a concealed dry area, by doing so it will effectively stop the salt from soaking up vapour from within the air. Salt should be shielded away from additional powerful-scented objects, so it doesn't not develop any unwanted aromas. When one is opting to store iodized salt, you must ensure that the salt is segregated from hot temperatures as this will cause the heat to decrease the level of iodine within the salt. (*DianeVuković et al, 2023).* A study conducted on salt storage in relation to the effects of salt quality within the boundaries of sea salt which was investigated within the Polish salt market, the aim of this research was to evaluate the consequences of storing salt within the quality limitations equally for the crystalline (commercial) sea salt and respectively milled beneath laboratory environments. This research study consisted of six sea salts acquired in several locations in Poland and overseas. There was storage and guidance information provided on the packets and the manufacturers' websites. They displayed the microscopic images of the examined salts table1.1 (MŚmiechowska and Millena Ruszkowska *et al*, 2022).

Salt code Kod soli	Country of origin Kraj pochodzenia	Granularity Granulacja	Price/kg Cena/kg [PLN]	Composition Skład
I	Croatia Chorwacja		6.92	Sodium chloride (> 98 %), calcium (< 0.20 %), magnesium (0.19 %), sodium iodide (< 5 mg/kg), naturally occurring iodide, E536 (anti-caking agent) Chlorek sodu (> 98 %), wapń (< 0,20 %), magnez (0,19 %), jodek sodu (< 5 mg/kg), jodek naturalnie występujący, E536 (środek przeciwzbrylający)
II	Greece Grecja		3.87	Sodium chloride (99.5 %), 3.9 ± 1.3 mg/kg potassium iodate (enriching agent), E536 (anti-caking agent), iodine (23100 µg/kg) / Chlorek sodu (99,5 %), 3.9 ± 1.3 mg/kg jodanu potasu (substancja wzbogacająca), E536 (środek przeciwzbrylający), jod (23100 µg/kg)
III	Greece / Grecja (Mediterranean Sea) (Morze Śródziemne)		8.57	Unrefined, 100 % of coarse-grained sea salt, no anti-caking agents contained therein / Nierafinowana, 100 % soli morskiej grubo mielonej, nie zawiera substancji przeciwzbrylających
IV	Canary Islands Wyspy Kanaryjskie (Fuertaventura)		21	Natural, no additives Naturalna, bez dodatków
V	Origin unknown Pochodzenie niez-nane		7.90	Iodized, potassium iodate Jodowana, jodan potasu (26.0 ÷ 33.7 mg/kg salt / soli)
VI	Denmark Dania		172.52	Sodium chloride (95 %), other minerals (5 %), naturally occurring iodine Chlorek sodu (95 %), inne związki mineralne (5 %), naturalnie występujący jod

Table 1.1.2.1 Microscopic images of the tested salt, taken from (Effect of storage on the quality parameters of sea salt *et al*, 2023).

In the research study, segments of crystalline sea salt were extracted from within their containers, the salt was then exposed to milling, and then the salt was stored in its original containers for a interval of 12 months. Salt samples were then stored within a room which standard environmental specifications existed, for example, within the room, the temperature was 20 ± 2 ºC with the humidity 60 ± 5 %. Conclusions: Centered upon an analysis of water content and activity, it was established that the storage procedure caused the calculated parameters of the sea salts I - III and VI to decrease. Respectively, with regards to the sea salts codes IV and V, it could be found that there was a rise in the water contents and activity after a 12-month storage period. Based upon the valuation of the L* brightness parameter, it was found that there were no statistical variations discovered amongst the un stored and stored crystalline salts. Based upon the Hausner ratio value, it has been discovered that the crystalline samples extracted from the packing and stored were depicted by low uniformity. Respectively, based upon the grinding procedure of the sea salts I - VI reviewed, it was then feasible to grade them as substances categorized by a medium viscidity. The grinding activity increased the rate of the static and kinetic perspective of repose and grounded upon the attained ideals of those constraints, all of the assessed sea salts were then categorized as these samples as poor (MŚmiechowska, Millena Ruszkowska *et al*, 2023).

1.1.3 Salting Process

The salting process is known to be one of the initially recognised as food conservation. Salting technique preservation is a simple process that reduces the water level so that bacteria can't grow and proliferate. The salting procedure is separated into a wet-dry and wet-dry amalgamation (JSTR *et al*, 2021). Salt has been found to be one of the primary components within additives within food industries globally as a result of its reduced pricing and diverse properties (International Journal of Food Science and Technology *et al*, 2011). The most common type of salt used globally is table salt (NaCl), which can be found it both crystal or solution form. The aim of the salting process is not only to preserve the product but additionally to achieve the wanted sensory alterations such as consistency, colour, and distinguishing smell and taste. Salt has been proven to contain antibacterial properties, so it may selectively deter certain damaging microorganisms (J. Bacteriol *et al*, 1937).

1.1.4 The Role of Salt in Food Preservation

Research has shown that societies have employed canning and artificial refrigeration to conserve food for consumption for hundreds of years, salting has been found to be the most effective type of food preservation in prior centuries, salting was predominantly used in meat products throughout the ages, (Barber *et al*, 1999)**.** Salt is known to be one of the original ingredients in the world used for food preservation. Salt has been found to have a multitude of usages with the food preservation and manufacturing industries globally (Elias *et al*, 2019). Salt reduces the water activity (Aw) which results in decreases in the growth of microbes. Salt assists with the development of particular flavours and aromas (M. E. Doyle and K. A. Glass *et al*, 2010). Salting procedures are commonly used in a variety of vegetable and animal consumption products. Salt is primarily used within the methods of food preservative, whilst also commonly used as a softening agent for vegetables (J.E Henney, C.L. Taylor, and C.S. Boon *et al*, 2010). There are several side effects to the salting process such as increasing taste, increasing saturation capacity, protein characteristics, and lipid oxidation (Albarracin *et al*, 2010). The anion element within salt is accountable for the changes and developments in taste. This is due to the fact that salt may restrict taste receptor stimulus. NaCl salts commonly do not attribute to these foods' taste but may impact customers' taste perceptions due to Cl^- anion (E.Caballero *et al*, 2003). The prevalence of salt accumulations was exceptionally significant in early Rome, Egyptian and also within Middle Eastern towns and settlements due to its food conservation elements (Netolitzky e*t al*, 1913; Forbes *et al*, 1965). Salt has the capability to reduce water action through the capability of sodium and chloride ions to combine with water molecules (Fennema *et al*, 1996). Salt is known for its help in reducing the impact of microbial activities of Clostridium perfringens and clostridium botulinum that use available water as a nutrient, the addition of salt to food products could possibly also cause microbial cells to experience osmotic shock, which results in the loss of water from within the cell by which causes the cell to die or inflicts retarded development (Davidson *et at*, 2001).The procedures encompassing the salting process is primarily utilized with the meat and fish industries for preservation purposes. Food stabilization through salt dissemination decreases water activity values and enables the enhancement of an evident flavor throughout the drying period, and within some situations, maturation. The traditional salting procedure was established by casing or rubbing together the raw material with a solid salt, which is moderately liquefied and drained throughout the procedure by fluid waste which originates from the food produce due to the osmotic and diffusional mechanisms (International Journal of Food Science and Technology *et al*, 2011). Salt can assist with the extension of shelf life with regards to cured meat produce, for example dried ham, and also bacon (Fermented Meat and Poultry *et al*, 2015), also canned fish, such as, pilchards, tuna or anchovies, amongst others (A Complete Course in Canning and Related Processes *et al*, 2015).

1.1.5 Solubility and Osmosis System of Salt in Food

Salt, which may be seen as a necessity for food preparation, influences taste of primed plates but as well as the consistency of food by means of dehydration (Bull. Soc. Sea Water Sci. Jpn *et al*, 2011). The discrepancies in element dimension and/or integrity of salt have been found to impact food properties due to salt containing bigger grains can be challenging to dissolve. It pass through slower into food than typical miniature particles of salts (Nippon Shokuhin Kagaku Kogaku Kaishi *et al*, 2007).

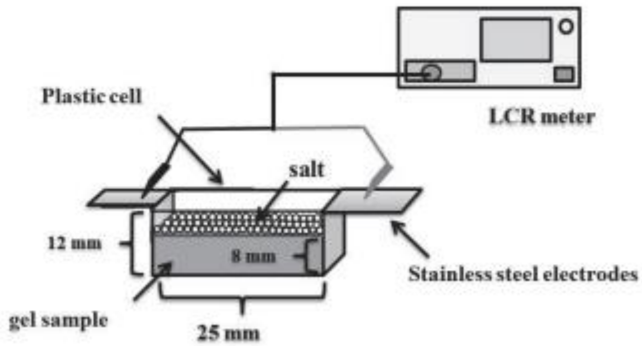


Figure 1.1.5.1 Illustration of LCR meter, taken from (Measurement System for Solubility and Osmosis of Salt in Food *et al*, 2014). Salt dropped on the surface of food is dissolved in water, which reduces its electrical resistance (Int. J. Soc. Mater. Eng. Resour *et al*, 2014).

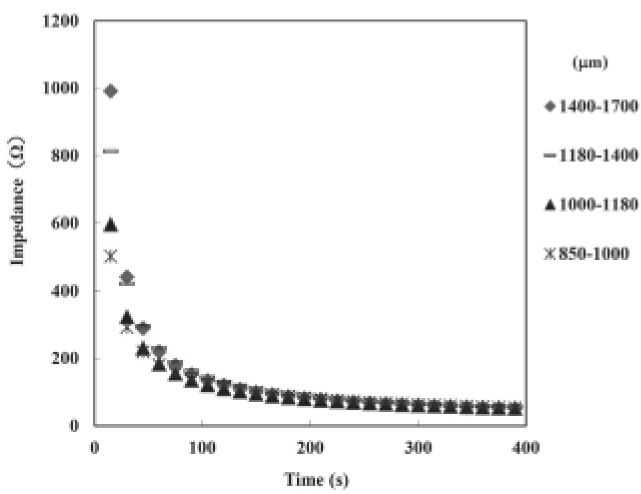


Figure 1.1.5.2 Impedance principles of big particles of salts on 0.8% gel A, taken from (Salt in Food *et al*, 2014).

Figure 1.5.2 Displays deviations in the resistance value with the dropping of the salt, of 10 classes of salts holding separate particle sizes on 0.8% gel A. The reduction of the resistance degree of salt containing big particles appeared slower: whilst bigger particles undertook additional time to dissolve when compared to smaller in size particles (Figure 1.1.5.2).

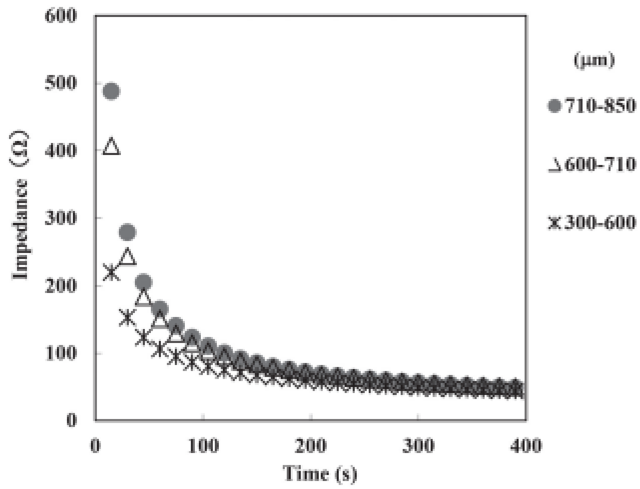


Figure 1.1.5.3 Schematic values of middle particle of salts, taken from (Salt in Food *et al*, 2014).

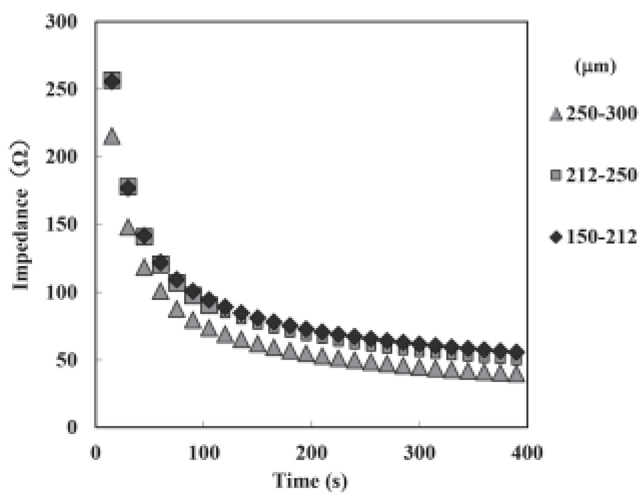


Figure 1.1.5.4 Schematic values of small particle salts, taken from (MeaSalt in Food *et al,* 2014). With regards to minute salt particles, the reduction of impedance value appeared quicker, therefore the findings show that the salt particle size effects its solubility on the surface of foods (Int. J. Soc. Mater. Eng. Resour *et al,* 2014).

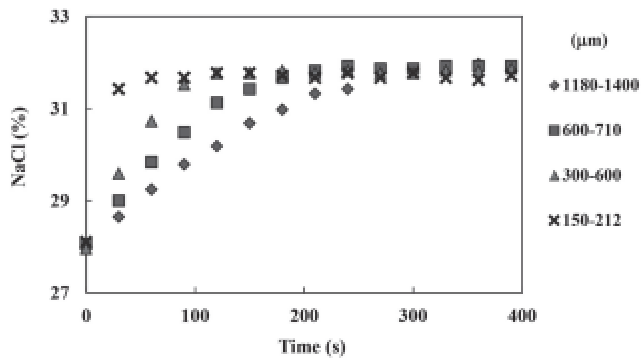


Figure 1.1.5.5 Solubility of salts with different particle diameters, taken from (Measurement System for Solubility and Osmosis of Salt in Food *et al,* 2014).

The solubility levels contained within four salt groupings within the diameters 1180- 1400, 600-710, 300-600, and 150-212 µm in NaCl mixture was estimated (Figure 1.1.5.4). The proportion of salt dissolution reduced as well as the size of the particle. It was found that there was a correspondences amongst solubility and impedance value whilst employing salt of 600-710 µm diameter (Int. J. Soc. Mater. Eng. Resour *et al,* 2014).

1.1.6 The technological role of salt in food production

The operational elements contained within salt in food manufacturing and food production extend beyond the borders of taste. It is clear that salt has a distinctive technological role within food production. Additionally to flavour, it also plays a valuable role in the safety and textural properties. It can additionally plays a part within the development of bacteria within the fermentation processes (International Journal of Food Science and Technology *et al,*2011). Dietary survey data has shown that cereals and cereal produce such as white bread, and pasta impact over 30% of the total salt in our diets, closely followed by meat-based products. Other major sources of salt in our diets include sauces, gravies, and potato products. (NDNS 2019). Salt in meat and meat produce enhances the water-holding competence, tenderizes uncooked meat, and enhances the combining of batters in treated meats. Salt helps in bread fermentation which makes gluten more stable and less extensible and sticky. In cheese salt helps the microbiota, regulate the activity of starters and modifying enzyme activities, and helps connect the cheese's body/texture by adjusting protein structure. Not only does salt give food its "salty" flavour, but it may also develop additional flavours, such as scented fragrances. It contains a stabilized sweetness and assists with the suppression of flavours, primarily bitterness. Salt, also known as sodium chloride, may additionally be found to be a nutrient resource for sodium, a fundamental nutrient necessary for the human body in reduced amounts (The Role of Salt on Food and Human Health *et al*, 2019). In a study done on Olive Oils (Molecules *et al,* 2022), A study conducted in the storage of unprocessed olives immersed in salt and water is regarded as possibly the most credible authentic means due to the large accessibility of seawater in traditional regions where olive trees are cultivated. The application of a substance known as diluted alkaline solution for debittering became more widely used in the XIX era with the advancements within the chemical industry as an self-governing division, and it symbolizes one of the primary applications of lye to cure food (J. Food Qual *et al*, 2018).

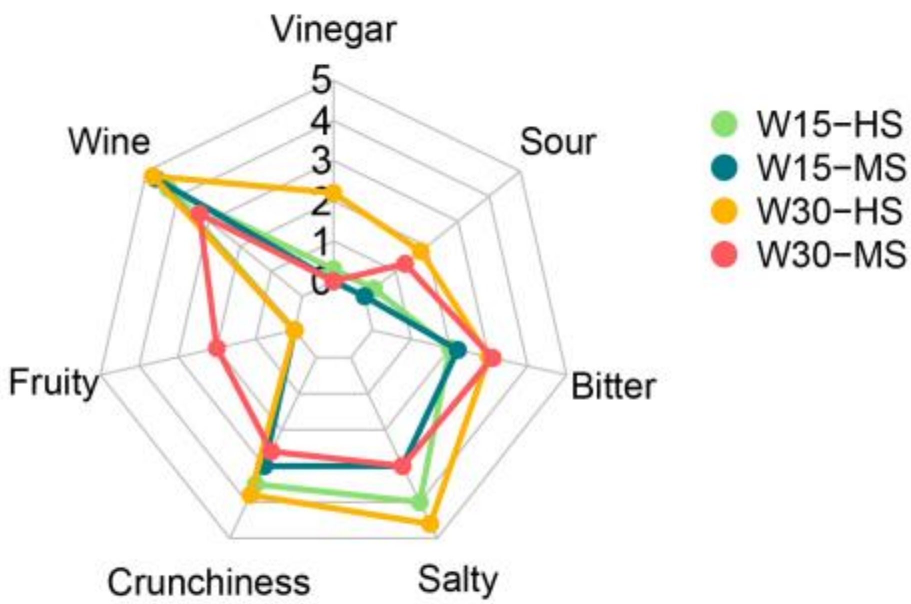


Figure 1.1.6.1 Sensory profile of table olives taken from (Italy) et al, 2018.

The graphs illustrate the processes during each treatment. This starts in a scale from 0 to 10 with 8% NaC1 brine (pea), 15 days in water solution and salting with 6% NaCl brine (teal) for 30 days in water, salting with 8% NaCl brine (orange) for 30 days and in the end salting with 6% NaCl brine (crimson) (J. Food Qual *et al*, 2018). Panelists in this study noticed differenced of high and the lower level of salt concentration within olives. This shows that salt application on olives controls microbiological as well as acidification and debittering (Food Microbial *et al,* 2002).

1.1.7 Salt contents in food

The primary food categories accountable for the highest salt consumption within the European Union can be identified as bakery products as well as bread, cereal produce, as well as meat products in addition to cheese and dairy products. Additional significant groupings are previously made meals and soup products (EC 2012b). Salt that is being used as a component in food, whichever precisely sold to customers or used in food production, should not be lower than 97% of sodium chloride (FAO/WH e*t al*, 2006). There is a food labelling system Guideline Daily Amount (GDA) substituted with Reference Intake (RI) which establishes the labelling system in the Europe Union and United Kingdom according to Regulation (EU) 1169/2011. (Foods and Drinks Federate *et al*, 2014) table 1.1.7.1

Energy or nutrient ▲	Reference Intake ⬍
Carbohydrates	260 g
Energy	8400 kJ / 2000 kcal
Protein	50 g
Salt	6 g
Saturates	20 g
Sugars	90 g
Total fat	70 g

Table 1.1.7.1 Reference Salt Intake, taken from (Foods and Drinks Federate *et al*, 2014).

Reference intake can be combined with the traffic lights labelling to make the information easy for the consumers, The traffic light classification scheme informs the consumer if the food comprises a high, medium, or low level amount of fat, saturated fat, sugars, and salt. It will also inform the consumer of the number of calories and kilojoules in that product figure 1.1.7.1 (J Sainsbury plc *et al*, 2014).

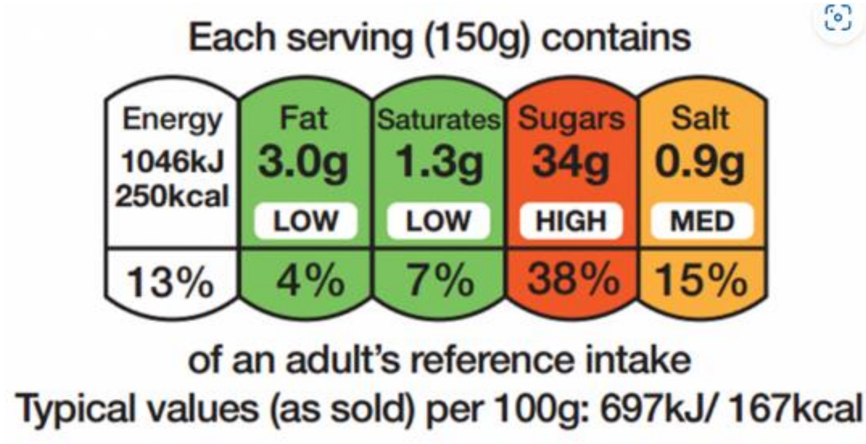


Figure 1.1.7.1 Traffic Light Labelling taken from (Food Standards Agency *et al*,2020).

The traffic light label is color coded and establishes that green is low in a specific nutrient, amber indicates medium and red signifies high nutrient levels. The GDA labels contain the ratio of daily value per serving size and the total measure per ration of these groupings. The front-of-packages (FOP) of the product must list the calorie count, but the back-of-package (BOP) must contain, a minimum, these five key nutrients: Energy, Fat, Saturates, Sugar and Salt (Guideline Daily Amounts" *et al, 2016).*

1.1.8 Salt in meat and meat products

The method of salting, with the use of dry salt or brine, was the primary technique of preserving meat products until the middle of the 20th century, reducing in popularity after the advancements of refrigeration throughout the world. It was commonly coined as "junk" (Clarkson, Janet *et al, 2009).* Also included in sausage batter is primarily as a result of its action in the reduction of water activity (aW), operating as bacteriostatic, and influencing the development of salt within the Earth for pathogenic microorganisms (Meat Science *et al*, 2005). Water-holding capability is identified as the capability of a food template to avoid the release of water from the three-dimensional configuration (Chantrapornchai & McClements *et al*, 2002). The growth in the water-binding function of meat proteins with the adding of salt could be accredited to favoured anion binding (Cl), by protein molecules (Figure 1.1.8.1) (W. Albarracı´n *et al*, 2011).

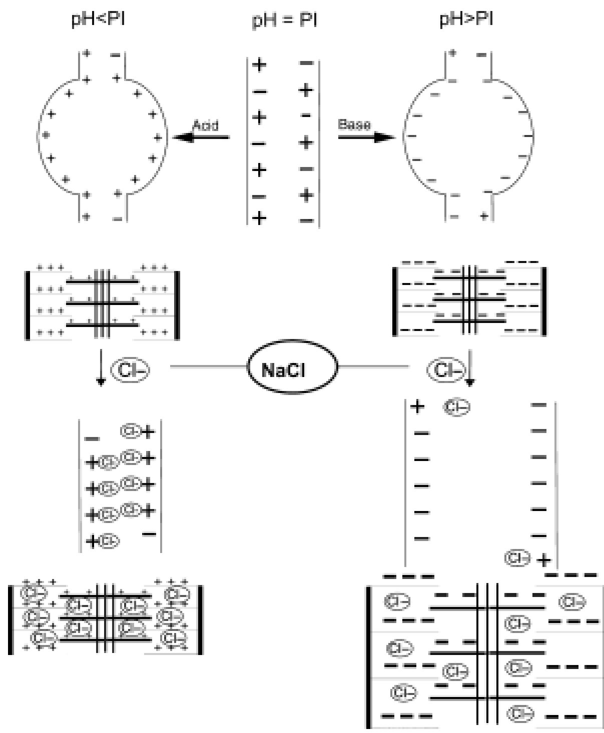


Figure 1.1.8.1 Chloride interaction in protein structure, taken from (W Albarracı´n *et al*, 2011). Protein dehydration occurs at high salt applications (0.6 m) due to the rivalry amongst solutes and proteins for the existing water (Chou & Morr *et al*, 1979 Wismer *et al*, 1994). A study on Calcium ascorbate as a possible substitute for NaCl in dry sausage which has displayed a sensory reduction in sausages with 1% NaCl, 0.55% KCl, 0.23% MgCl2, and 0.46% CaCl2, in comparison to sausages with 2.6% NaCl (Meat Science *et al*, 2001), illustrates a substantial reduction in the sodium content of Spanish sausages was attained by the part replacement of NaCl by a changed proportion of calcium ascorbate (Food Microbiology *et al*, 2009). These sausages displayed poorer findings regarding color and texture when evaluated with control sausages. Observing microbiological limitations, no unnecessary variations were detected with the replacement of NaCl by other salts (Salt in Earth *et al*, 2019).

Microbiological groups (cfu/g)	Salt content (% NaCl)	
	2%	3%
Total mesophiles	7.44	7.93
Total psychrotrophic microorganisms	7.25	7.85
Yeasts	2.6	4.28
Moulds	n.d	n.d
Gram-positive, catalase-positive cocci (GCC+)	6.59	5.38
Lactic acid bacteria (LAB)	8.46	8.41
Enterobacteria	3.21	2.9
Enterococci	5.86	5.66
Spores of aerobic bacteria*	3.11	3.98

Table 1.1.8.2 Microbiological analyses of traditional Portuguese dry-fermented sausages (Painho de Portalegre) with low-salt content, taken from (The role of salt on food and human health *et al*, 2019).

The amount of mesophiles did not differ substantially, sausages with high salt content have high counts of micro. This indicates that the natural microbiota within these sausages is typically halotolerant (Salt in Earth *et al*, 2019).

1.1.9 Iodine

Iodine has been established to be a mineral which body needs to make thyroid hormones, which regulate your metabolism, growth, and development. Iodine is considered to be a trace element containing an atomic mass of 126.9 atomic mass units (amu), contained in the exterior tier of the earth's surface. Insufficient iodine in our diet makes the level of iodine substance fall in the thyroid less than 20ug of salt iodization required for the control of iodine in the body. To equilibrate losses and keep the amalgamation of thyroid hormone, iodine salt is a good replacer in our daily diet (Stability of Iodine in Differently iodized Salts *et al*, 2022). A study demonstrated the iodine content of different types of salt showed that the iodine in the powder salt was high. During the storage period, the iodine content decreased, here affects different factors i.e., types of packaging, storage conditions, etc (Siddiq K *et al*, 2022).

1.2 The use of iodized salt, Iodo-casein, amiton to replace salt in bakery.

A study conducted by D V Vinogradov *et al,* 2022, The usage of iodine-comprising additives contained within the bakery manufacturing technology displayed that the insertion of iodine-containing additives initiated an enhancement with regards to the level of yield of bread. To determine the concerns for avoiding iodine deficiency within the population, it is vital to present new supplementary names of iodine-containing products onto the list for daily intake. Bread has been found to be the most effective agent and there are numerous technologies which can iodize it (Tyurina *et al,* 2009). The objective of the investigation was to examine the impact of iodine-comprising additives (iodized salt, iodo-casein, amiton) on the nutritionary and biological significance of bread, whilst also on its overall quality. The sample was a "Carved" loaf. The application of salt in bakery organizations was conducted by the replacement of eatable salt contained within recipes of selected products with iodized food salt. "sliced" loaf was baked containing quality wheat flour. The mass of the produce was 0.4 kg table 1.6.1 (D V Vinogradov *et al*, 2022).

Raw materials, modes and indicators of the process	Parameter
Baking wheat flour, premium, kg	100
Pressed bakery yeast, kg	3.0
Salt, kg	1.5
Sugar, kg	4
Vegetable oil, kg	2.1
Initial temperature of the semi-finished product, °C	26(±1)
Moisture of semi-finished product, %	42.5
Duration of fermentation, hour	2.5
Final acidity of the semi-finished product, deg.	2.5-3
Dough piece weight, kg	0.46
Proofing time, min.	50
Duration of baking, min	21
Baking temperature, °C	260

Table 1.2.1 Steps of production of a loaf, taken from (The use of iodine-containing additives in bakery production technology *et al*, 2022).

The type of flour was employed to bake foods with numerous iodine-containing additives rendering to the variations of the research: Control used did not use iodine-containing additives, with iodized salt, with Iodo-casein, and with amiton. Iodized salt combines well with elements integrated in the manufacturing recipe, whilst not applying an adverse effect on organoleptic and physical-chemical indicators with regards to the overall quality conditions of final. As well as, edible salt, being enhanced by potassium iodate, which is seen as a strong oxidizing agent, enhances the sum of indicators within bread quality: specific volume, shape stability, and porosity.

Quality indicator	Control	with iodized salt	with iodo-casein	with amiton
Crunch colour	Light-brown	Light-brown	Light-yellow	Light-yellow
Grain	Developed, without voids and seals, thin-walled	Fine, uniform, thin-walled	Medium, uniform, thin-walled	Medium, uniform, thin-walled

Table 1.2.2 Organoleptic index of the quality, taken from (The use of iodine-containing additives in bakery production technology *et al*, 2022).

The use of iodo-casein for additives within bakery produce will not have an effect regarding the technology of production of the final products, and also will not involve the cost of reforming production as a result of the scanty amount of planning required (D V Vinogradov *et al*, 2022).

Quality indicator	Control	with iodized salt	with iodo-casein	with amiton
Weight, g	140.6	141.3	143.8	141.3
Volume yield, cm^3/100 g	295.0	332.3	347.0	331.8
Form stability, h/d	0.33	0.35	0.34	0.33
Moisture, %	42.0	42.0	41.0	42.1
Acidity, °H	2.5	2.5	2.5	2.5

Table1.2.3 Physical-chemical quality indicators, taken from (The use of iodine-containing additives in bakery production technology *et al*, 2022).

Once the iodine comprising additive is added,this will raise the volume yield contained in bread by 12.6%, with the addition of iodo-casein by 17.6% and by adding amiton by 12.5% with regards to the control. It was found that by adding iodine containing additives, there were no effects seen on the organoleptic characteristics of the final product (D V Vinogradov *et al*, 2022).

1.3 Salt reduction targets 2017

These salt reduction targets were initially circulated in 2014 as part of the Public Health Accountability Deal by the British Government. This came about from the growing concern of the high levels of salt consumed by the general public. Salt targets were further set out in 2017 they included 28 categories of food: quiche, meat products, table sauces, processed potatoes, pizzas, sandwiches, cereals, butter, cheese, canned fish, drinks, puddings, baked beans, scotched eggs, Information on the categories of food and beverages contained in product groupings and sub-categories, as well as the aims established were broadly accessible. A study was completed which compared the level salt levels in foods throughout 2018 respective of the 2017 salt decreasing objectives (set in 2014), for 28 classes, covering 76 sub-groupings of food and beverages throughout many sectors within the food industry. Moreover, the salt contents of food and drinks offered in the dining out segment was evaluated along with specific eating out of home aims for 11 categories, encompassing 24 sub-groupings (Publik Health England Salt Targets 2017 *et al* 2020).

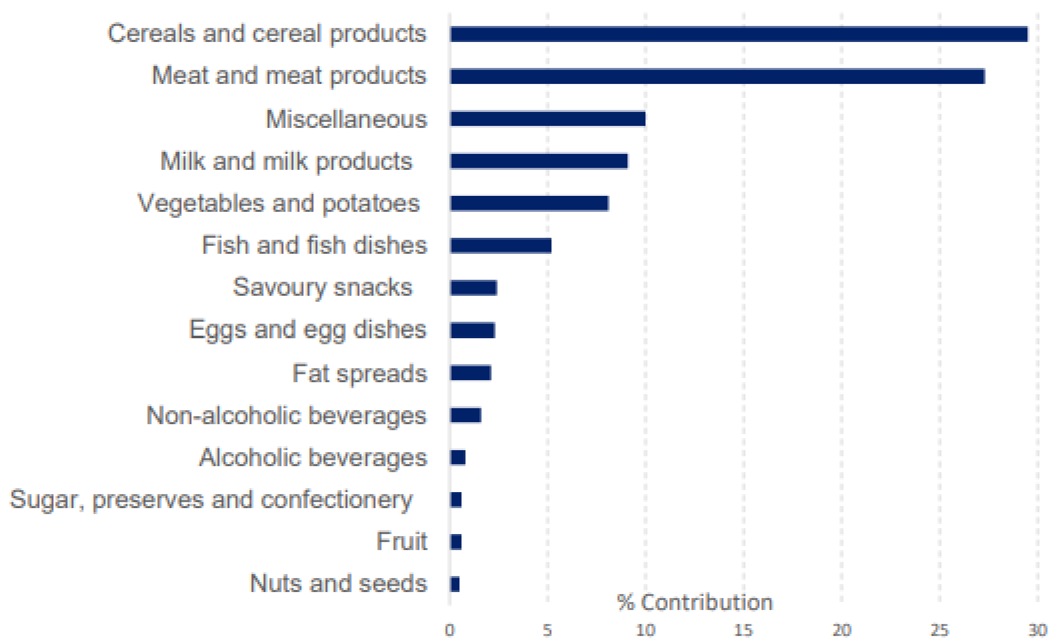


Figure 1.3.1 Percentage daily salt intake for adults aged 19 to 64 years (NDNS years 7 and 8) (Publik Health England Salt Targets 2017 *et al*, 2020).

Utilizes information from the National Diet and Nutrition Survey (NDNS) to emphasize how alternative food groupings impact on an adult's median daily salt consumption. (Publik Health England Salt Targets 2017 *et al*, 2020).

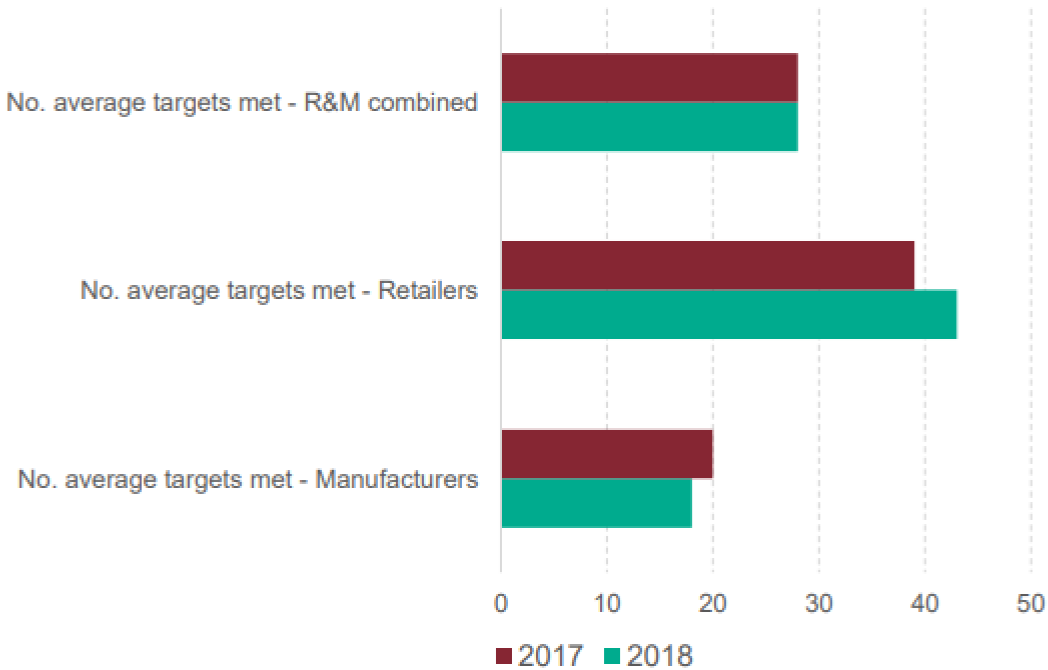


Figure 1.3.2 Summary of average salt targets achievements, taken from (Publik Health England Salt Targets 2017 *et al*, 2020).

Salts targets achievements Illustrates the number of median targets met, by manufacturers and retailers. The number of median targets met in each group is stated for both 2017 and 2018. The findings were displayed independently for retailers, manufacturers, and for retailers and manufacturers combined (Publik Health England Salt Targets 2017 *et al*, 2020).

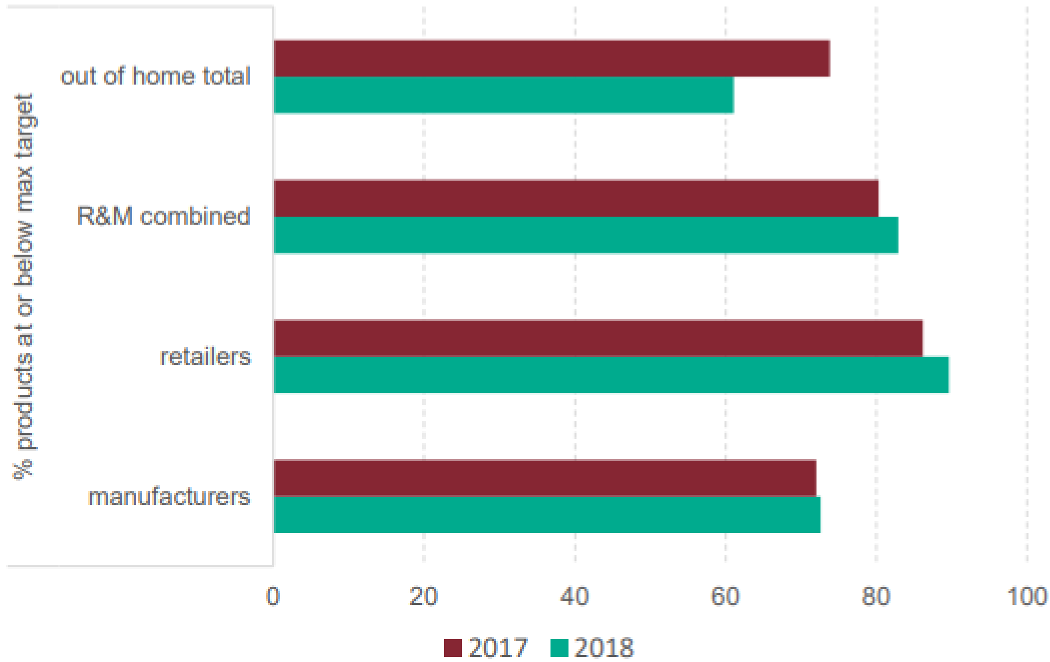


Figure 1.3.3 Proportion of products at or below maximum targets set for all sectors, taken from (Publik Health England Salt Targets 2017 *et al,* 2020). Those targets were set up for out of home sector in comparison to that of manufacturers and retailers independently and collective in 2017 and 2018 (Publik Health England Salt Targets 2017 *et al*, 2020).
Conclusions are illustrated for both homebased segments and dining out segments (Publik Health England Salt Targets 2017 *et al*, 2020).

Conclusions: Findings shows that 74% of products generally were at or beneath limit per portion objectives set explicitly for this segment (in comparison to 70% in 2017). With regards to 2017, where contrasts among regions is possible, it is evident that the eating out sector needs evolving progress. At the retailer end, whilst performance alongside median and maximum objectives is correspondingly mixed, it can be seen that there is an indication of suitable levels of conformity with maximum objectives, specifically among retailers. This is the initial evaluation of development made with respect to meeting the 2017 salt consumption goals at an organisational level, thus assumptions may not be taken to the magnitude in which this echoes current or historical developments on salt lessening. A distinctive directive of expectancy that corporations should be persistent with regards to reduction of salt contained within their produce and to develop on the progress attained since salt aims were first standardised in 2006. With the median salt intake for adults in 2018/19 at 8.4g per day, in comparison to the suggested 6g per day, it is evident that additional work is required to decrease the global populations salt consumption (Publik Health England Salt Targets 2017 *et al*, 2020). The modified objectives are established and hoped to be reached by 2024 (UK Guidelines *et al*, 2020). For foods bought for ingesting at home, it can be seen that over just half of the average salt decrease objectives have been reached which signifies no changes 2017 and 2018 in compared, even though retailers reached more goals in 2018 in comparison to that of 2017 (UK Guidelines *et al*, 2020).

1.4 Salt reduction target for retailers 2024

Salt reduction without compromising the taste is a challenge World Health Organization (WHO e*t al*, 2020). The level of the salt target set by retailers will depend on the individual business, as the salt target is individually set by product category additionally there may be production difficulties to meet the new target, i.e., shelf life can be reduced, taste and the expectations of consumers (UK guidelines *et al*,2024*).*

Butter and Margarine			
Sub-categories	**Description**	**Salt target for 2017 g-salt or mg-sodium per 100g**	**Salt target for 2024 g-salt or mg-sodium per 100g**
Salted butters and buttery spreads	Butter-milk- salted butter and enriched. Spreads Also includes flavoured butter and buttery spreads e.g., garlic butter.	1.48g salt or 590mg sodium (average r) 1.68g salt or 670mg sodium (maximum)	1.33g salt or 530mg sodium (average r) 1.60g salt or 640mg sodium (maximum)
Lightlysalted butter	Lightly salted butters	1.13g salt or 450mg sodium (average p)	1.06g salt or 425mg sodium (average p)
Margarine	Margarines, spreads	1.06g salt or 425mg sodium (average r)	0.95g salt or 380mg sodium (average r)

Table 1.4.1 Outline the difference on salt level for butter and margarine 2017-2019 (Adapted from UK 2024 guidelines).

All food businesses should meet the requirement to decrease the level salt used in their existing products, and any new products launched on the market ought to meet this objective. With the new reformulations of recipes to reduce salt intake, consumers should be ready to adapt to this emerging trend (UK guidelines *et al,2020).*

1.4.2 Salt reduction target for eating out, takeaway and delivery 2024.

The purpose of this target is to help the consumers that eat outside the home to lower their intake salt by lowering the salt intake in dishes (UK guidelines *et al,2020).*

Potato and Burger			
Dish target	**Description**	**Salt target for 2017 g-salt or mg-sodium per 100g**	**Salt target for 2024 g-salt or mg-sodium per 100g**
Potato products	Includes chips with an 8mm or bigger width that have been pre-seasoned before serving.	1.5g salt or 600mg sodium	1.35g salt or 540mg sodium
Burgers in Bun	Small burgers includes single beef / pork patty burgers and chicken burgers.	2.4g salt or 960mg sodium	2.15g salt or 860mg sodium
All other burgers	Includes single patties with cheese, multiple patties with or without cheese and vegetarian / bean or fish alternatives.	3.5g salt or 1400mg sodium	3.33g salt or 1330mg sodium

1.4.2.1 Outline the difference in salt target 2017-2019 (adapted from UK 2024 guidelines)
Reducing salt intake on a daily basis depends on many factors, i.e., population-based, religious, multisectoral, and cultural (UK guidelines *et al,2020).*

1.4.3 Percentages increase in price by category.

Added salt in food doesn't cost just health issues but and pocket of consumers**.** In table 1.5.3.1 we can see what the % of salt tax in a range of foods and drinks is indoors and outdoors (Rachel Griffith Victoria Jenneson Joseph James Anna Taylor *et al*, 2021).

Food at home	Salt tax
Fruit	0.07
Vegetables	0.26
Grains	0.37
Bread	2.48
Breakfast cereals	0.81
Dairy and eggs	0.99
Yogurt	0.37
Cheese fats	1.54
Red meat	1.33
Poultry and fish	0.59
Condiments and deli	3.29
Savoury snacks	1.31
Ready meals	1.07
Fruit juice	0.11
Milk drinks	0.67
Soft drinks	0.15
Sweet spreads	0.39
Biscuits	1.04
Confectionery	0.21
Desserts	0.44
Total	**0.88**

Table 1.4.3.1 Salt in foods without reformulation, adapted from (The impact of tax on added sugar and salt *et al*,2021).

1.4.3 Salt tax for food eaten outside of home.

According to WHO, at minimum one in four adults recounted consuming fast food on a regular basis. The diets of both female and male who ingested take away food which was high in energy, and energy density. Fast food contained over one-third of the day's energy, total fat, and saturated fat, and was high in energy density (World Organisation *et al*, 2020).

Food out of home/100g	Salt tax
Soft drink	0.02
Hot beverages	0.01
Sugar confectionery	0.11
Chocolate confectionery	0.22
Cake and desert	0.41
Savoury snacks	0.48
Sandwiches	0.62
Fruits and nuts	0.04
Vegetables	0.02
Meals	0.28
Other	0.4
Total	0.24

Table 1.4.3.1 Salt in foods without reformulation eaten outside the home, adapted from (The impact on added sugar and salt *et al*, 2021).

This impact on salt increase can stimulate people on eating foods with less salt, Government can help undertake several strategies. Incorporating a salt decrease into the educational curriculums of food preparers, eliminating saltshakers and soy sauce from counters in restaurants. Providing targeted dietary recommendations to people visiting health centres. Schooling children and offering an encouraging condition for children so that they begin at an early with accepting low-salt diets. (World Organisation *et al*, 2020).

1.5 Salt Substitutes to Reduce the Sodium Content in Foods

Currently, the U.S. Food and Drug Administration projected amendments to the standards of identity (SOIs) for foods which includes salt, to approve the usage of secure and appropriate salt replacements (U.S. FDA *et al*, 2021).whilst the FDA is suggesting to adjust its SOI that stipulates salt as an obligatory or elective ingredient to licence the usages of safe and appropriate salt alternates in standardized foods, to decrease the sodium content (U.S FDA *et al*, 2021). An analyse was completed by the Food and Drug Administration in the United States US which highlights that Americans consume, approximetly, 3,400 milligrams of sodium on average per day (mg/day) (Dietary Guidelines for Americans, 2020-2025 *et al*, 2020). Decreasing sodium intake could assist with decreasing the probability of hypertension, a primary source of heart disease and stroke (U.S FDA *et al*, 2021). The objective of the FDA is to increase dietary agendas and decrease the obligation of dietary associated chronic diseases (U.S FDA *et al*, 2021). Decreasing sodium in processed foods may assist in the creation of a healthier food trade (Journal of the American Medical Association *et al*, 2017). Research conducted by the U.S Department of Health and Human Services illustrates that approximately 4 in 10 American adults have developed hypertension, by which that figure rises to almost 6 in 10 figure 1.8.1

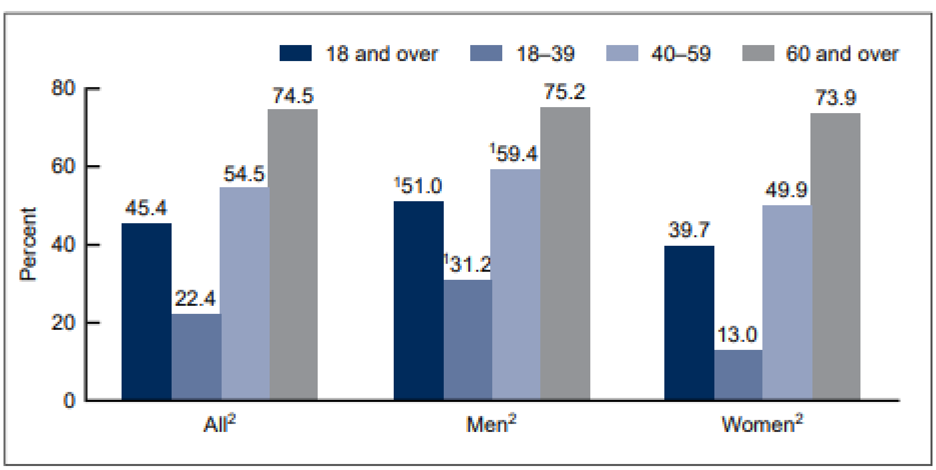


Figure 1.5.1 Prevalence of hypertension among adults aged 18 and over, by sex and age: United States, 2017–2018 taken from Hypertension Prevalence Among Adults Aged 18 and over.

1.6 Salt reduction at population levels.

According to a study on salt reduction in the population, level shows more than 90 countries have in place salt reduction initiatives, these consist of primarily high- and upper-middle-income nations figure 1.5.5.1 (Bethany Warren and Kate Mandeville e*t al*, 2022). Salt reduction interventions are often executed as a package. The most widely seen tactics comprise of interventions in environments (especially schools, 74 countries), reformulation through appointments within the food industries globally (64 countries), customer education (50 countries), front-of-pack classification schemes (48 countries), and government levies in the form of taxation (5 countries) (Santos *et al*, 2021)

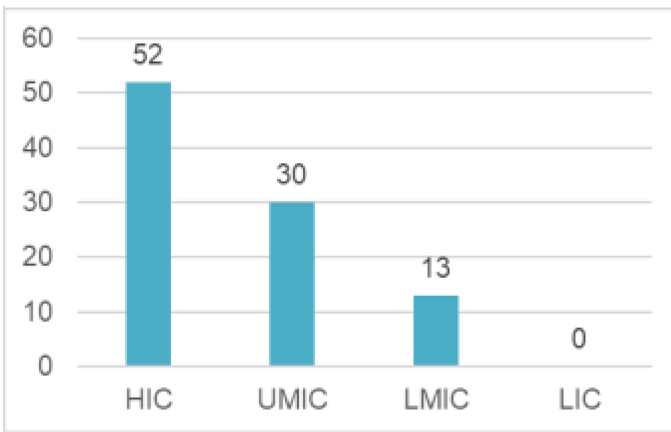


Figure 1.6.1 Countries with salt reduction initiative by income level, taken from (Santos *et al*, 2021) Country unclassified.

1.7 Salt and Health

Cardiovascular disease, comprising of heart disease, stroke and correlated diseases can be found to the primary highest attribute to the mortality rate in Ireland, contributing to approximately two in five (approximately 41%) of all deaths. High blood pressure is also one of the main variable causal reasons in the advance of cardiovascular disease. In current eras, a considerable body of suggestion has appeared from observational and experimental studies which proposes that a high dietary salt consumption is a significant causal aspect in the increase in blood pressure along with rising age and in the growth of crucial hypertension in industrialised regions such as Ireland. Throughout the development and implementation of programmes for decreasing salt intake, an attainable objective for the adult Irish population is a mean consumption of 2.4g/100 mmol sodium

(6g salt) on average per day. , this advice is steered at individual adults who should reflect the recommended daily allowance for sodium of 1.6g/70 mmol (4g salt) per adult per day is satisfactory to meet the physiological wants of 97.5% of the population (Food Safety Authority of Ireland *et al*, 2016).

Food/Food Category	g/day	% total
Meat & fish	**0.97**	**29.8**
Cured/processed meats	0.67	20.5
Meat/meat dishes	0.23	6.9
Fish/fish dishes	0.08	2.4
Bread & rolls	**0.84**	**25.9**
Milk & milk products	**0.27**	**8.5**
Cheese	0.12	3.5
Soups, sauces & miscellaneous foods	**0.23**	**7.0**
Spreading fats	**0.19**	**5.9**
Biscuits/cakes/pastries/confectionary	**0.15**	**4.5**
Breakfast cereals	**0.14**	**4.2**
Ready-to-eat breakfast cereals	0.13	4.1
Other	trace	0.1
Vegetables/processed vegetables	**0.13**	**4.0**
Processed vegetables/vegetable dishes	0.04	1.1
Savouries (e.g. pizza, mixed pasta dishes)	**0.095**	**2.9**
Egg/egg dishes	**0.049**	**1.5**
Desserts	**0.035**	**1.1**
Other foods	**0.15**	**4.7**
TOTAL	**3.25**	**100.0**

Table 1.7.1 Mean daily Sodium Intake from Foods in Irish Adults Aged 18-64 Years by Food Group (Report of the Scientific Committee of the Food Safety Authority of Ireland *et al*, 2016).

Decreases in salt consumption may be of specific advantage in senior citizens. In a randomized regulated trial comprising of men and women aged 60–78 years, a decrease in daily salt consumption from 10 to 5g for a time of one month was linked with an approximate fall in SBP of 7 mmHg. These impacts, which were seen in normotensive and hypertensive subjects, which converted into an estimated 36% decrease in stroke risk throughout a five-year period in this age segment (Cappuccio *et al*, 1997). Salt consumption in children must be consistently minimal in comparison to adults (based upon individual body weight). The Commission also supports the target quantities for average daily salt consumption advised for children in the UK SACN statement on 'Salt and Health' (2003): (Report of the Scientific Committee of the Food Safety Authority of Ireland *et al*, 2016).

Age 0-6 months	<1g
Age 7-12 months	1g
Age 1-3 years	2g
Age 4-6 years	3g
Age 7-10 years	5g
Age 11-14 years	6g

Table 1.7.2 Daily salt intake recommended, taken from (Food Safety Authority of Ireland *et al*, 2016).

Salt consumption in the Irish population is elevated. There is compelling evidence of a causal relationship linking high salt consumption and hypertension and of the value of decreasing salt consumption at population level. Hypertension is a substantial source of illness and death within the Irish population. With the co-operation of food industries and heightened awareness from individuals regarding the need to decrease their own salt consumption, it is probable to decrease adult population salt intake from an average of approximately 10 grams per day to about 6 grams per day. There is now a scientific consensus that the decrease of this scale may lead to a substantial reduction in blood pressure and considerable drops in suffering and death by the means of heart attacks, strokes, and associated conditions (Report of the Scientific Committee of the Food Safety Authority of Ireland *et al*, 2016).

1.8 United Kingdom 2024 guidelines.

The UK has taken a further step toward these new salt reduction guidelines and expanded to include fat and salt reductions. During July, the UK government published actions to confront the increasing epidemic of obesity throughout the United Kingdom (UK Guidelines *et al*, 2024). These stipulations would provide legislature on produces which have a high content of fat, salt, and sugar within them. The legislation would incorporate a complete online High in Fat, Salt, and Sugar HFSS marketing prohibition and its objective to prohibit High in saturated Fat, Salt, and Sugar produce marketed on TV and online prior to 9 pm (UK Guidelines *et al*, 2024).

1.8.1 Actions that should be taken by food industry.

Slowly adjusting salt levels in produce over a period of time so that end users can adjust to the taste and do not swop to a replacement product is recommended. Advocating for the values of eating decreased salt containing foods brought about by consumer awareness actions in food markets. Lowering salt in food and meals distributed throughout restaurants and catering outlets and the branding the sodium content of food and prepared meals (World Health Organization *et al*, 2020). Health Publik England publishes (PHE) placed a salt tax for indoors and outdoors. A salt tax of £6 per kilo would guide a price raise for foods acquired for consumption at home by approximately 0.9%, this could be decreased to 0.7% if organizations could entirely reformulate to PHE objectives.

Food at home per 100g	Salt tax
Fruit	0.06
Vegetables	0.2
Grains	0.32
Bread	2.38
Breakfast cereals	0.79
Dairy and eggs	1.77
Yogurt	0.99
Cheese fats	0.37
Red meat	1.41
Poultry and fish	1.06
Condiments and deli	0.49
Savoury snacks	1.19
Ready meals	1
Fruit juice	0.11
Milk drinks	0.39
Soft drinks	0.15
Sweet spreads	0.38
Biscuits	0.96
Confectionery	0.21
Desserts	0.4
Total	**0.75**

Table 1.8.1.1 Percentages Salt increase in prices by category**,** full reformulation**,** adapted from (The impact on added sugar and salt *et al*, 2021). The new policies impact retailers, manufacturers and food business operators selling their food and drink products (Campden BRI *et al,* 2022).

1.8.2 How can businesses be prepared for the new legislation.

Businesses must start by ensuring the implementation of the new legislation on reducing salt content in foods within their organisation. Food producers must attain satisfactory sensory quality in reduced salt products. (Food and Nutrition science *et al*, 2018). New legislation on salt reduction will be a challenge for food businesses, reformulation of products will not just be a recipe but a reformulation of existing products with the addition of positive nutrition for example protein or fibre and reducing the saturated fat, salt, and sugar. This will impact functional characteristics of food such as taste, shelf life, texture, stability, mouthfeel, handling, and production dependability (UK HFSS legislation *et al*, 2022).

Figure 1.8.2.1 Salt, taken from (Aptean salt reduction target *et al*, 2021)

Businesses will be facing two options: eliminating the mandatory quantity of salt completely from their products or substituting it with its counterparts. Removing salt entirely from the products is the favoured preference of the majority governmental health organisations because this will deliver on meeting the requirements of the salt target. However, removing salt without introducing a replacement will bring several technical issues for food businesses. Sodium replacers are the best alternative for business i.e., potassium-based, like potassium chloride, which will offer a comparable flavour to salt, and potassium is also consider to reduce blood pressure performing the exact reverse purpose of salt, which is known to raise blood pressure (Aptean salt reduction target *et al*, 2021). Replacing salt (NaCl) with potassium chloride (KCL) may be considered more varied amongst foods when various elements such as technical functions, food safety, sensory attributes, and manufacturing challenges are considered. Potassium chloride may taste salty and performs some technical functions within food, but it may also disclose bitter, chemical, or metallic sensations which may reduce its usage (Meeting Salt Reduction Targets in the Prepared Food Industry *et al*, 2021). Individual businesses within the food industries globally need to prepare and determine on the resolutions that may work best for them, this will demand that each product be reviewed and the recipe reformulated. This study will review the time and will assess the costs depending on the type of trial and error during the reformulation (Aptean Food and Beverage *et al*, 2021). The main objective for all food related businesses, retailers, manufacturers, and the eating out industries and takeaway is to accomplish the target of salt reduction (PHE Salt reduction *et al*, 2020).

1.8.2.1 Calorie reduction

According to Public Health England et al, 2020, we rely heavily on processed, purchased foods and meals and it is difficult to change an individual's behavior. The responsibility and involvement of the food industry to support good health through its accountability to manufacture healthier food and drinks are crucial.

1.8.2.2 Crisps and Snacks

A 5% decrease objective has been established for crisps and snacks; this includes the structure of many products within the grouping (Calorie reduction technical report *et al*, 2017).

1.8.2.3 Starters, side dishes, small plates

Side dishes or small dishes are offered both for individual utilization and for sharing, with sharing platters or plates. Calorie cutback recommendations aim for starters, side dishes, or smaller dishes possibly to be consumed by a single person. A limit recommendation guidelines for a single portion of 600kcal is advised as a best practice i.e., a sharing starter for 2 people should contain a limit of no more than 1.200kcal or a sharing started for 3 people limit of no more than 1,800kcal (Calorie reduction technical report *et al*, 2017).

1.8.2.4 Children's meal bundles

A 10% decrease has been set for Children's meal packages which includes a mixture of a starter, main meal, desert, and or a beverage for a set charge, this may incorporate products from other groupings such as pizza, pastry produces, starters which are eaten out, takeaway and delivery area (Calorie reduction technical report *et al*, 2017).

1.8.2.5 Pizzas

Guideline have issued at a 20% calorie decrease of eating out of home, takeaway, and delivery, the guidelines primarily focus on pizza possibly to be consumed by an individual on a single sitting grounded on the examination of these products that are defined as private, small, or medium up to 11.5 inches in diameter. The highest calorie guideline is 1,230 kcal, i.e., a splitting pizza for 2 people should have a limit of no more than 2,460 kcal or a pizza for 3 people a limit of no more than 3,690 kcal (Calorie reduction technical report *et al*, 2017).

1.8.2.6 Pastry products

The guideline for pastry products was consequential by pertaining a 20% calorie decrease on the simple approximate calories for helpings and a 5% calorie decrease for sandwiches consumed away from home, takeaway, and delivery areas (Calorie reduction technical report *et al*, 2017).

1.8.2.7 Sandwiches

The minimal objective of 5% calorie decrease indicates that there is less scope for a considerable reformulation or a decrease in portion size for some products incorporated within the classification (Calorie reduction technical report *et al*, 2017).

1.8.2.8 Food eaten out of the home.

The objective of this goal is to assist customers reduce their salt consumption by restricting the level of salt in prevalent dishes, to assist the sector to attain the salt reduction target (Salt reduction target *et al*, 2024)

Food out of home per 100g	Salt tax
Soft drink	0.02
Hot beverages	0.01
Sugar confectionery	0.11
Chocolate confectionery	0.22
Cake and desert	0.36
Savoury snacks	0.43
Sandwiches	0.62
Fruits and nuts	0.04
Vegetables	0.02
Meals	0.21
Other	0.28
Total	**0.2**

Table 1.8.2.9 Food eaten outside the home with reformulation**,** adapted from (The impact on added sugar and salt *et al*, 2021).

If customers are entirely receptive to the effects of increasing the salt tax, then this will bring a reduction of more than 1.0 grams of salt per person. Lowering the present salt consumption demands work in both commercial food manufacturing and consumer behavior respectively. With regards to commercial foods, the argue is to attain a further reduction within the salt content while sustaining acceptable taste, stability, and texture to ensure customers will like these reformulated products. Nonetheless, an adjustment in consumer behavior is also needed to ensure that lower-level salt products are accepted and that customers do not add salt throughout cooking or consumption (Science direct *et al*, 2016).

1.9 Salt Preference

According to a study in Australia (Nutrient *et al*, 2019), Australian children consume high amounts of salt. This study was focused on two commercially available foods with low and high salt. This study shows children's preferences and aptitude to discriminate between the salt level in two commercially accessible foods and if preferences or ability to discriminate salt levels changes after an introduction to an education system. Participants screening included 92 children, with over half being female 56% and the overage age was nine years old (Nutrient *et al*, 2019).

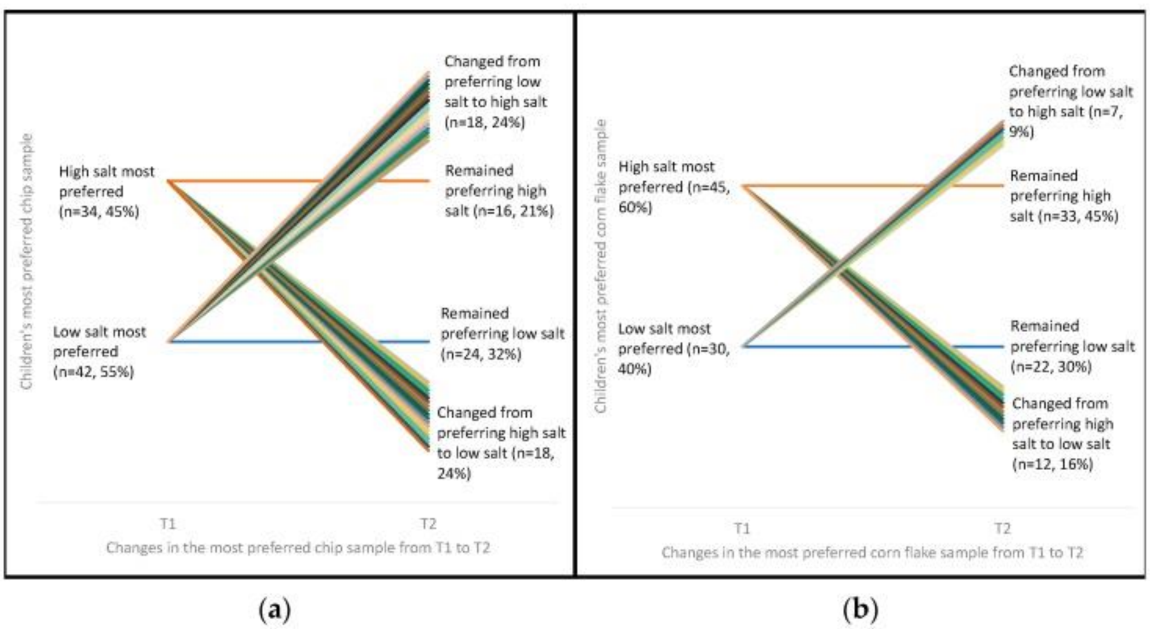


Figure 1.9.1 Salt Preferences, taken from (Nutrient *et al*, 2019).

Potato chips sample T1 (figure a) and cornflake sample T2 (figure b). Each line in different colour represents different child, with the changes of their preferences from T1 to T2. The figure 1.9.1 shows the changes over time (West *et al*, 2019). This study showed that the salt preference is related to changes in salt reduction of two products and participants who consumed a high salt diet preferred foods with high salt intake, compare with those that were consuming a lower salt diet (West *et al*, 2019).

1.9.1 Benefits of salt in food

Salt is the most frequent ingredient in foods, and one of the main reasons for the adding of salt to food was for conservation, added salt to food is one of the methods of food preservation (He and MacGregor *et al*, 2007). Historically sorbic acid and its sodium, potassium, and calcium salts are used against fungi and some bacteria, assuring a longer shelf life for food products (Branen *et al*, 2022). The most significant dairy product concerning the use of salt within cheese. Typically, salt is inserted to control the development of lactic acid bacteria and to avoid unwanted microbial growth, while also having the secondary function of supplying additional flavour to an otherwise bland-tasting cheese (Rowney *et al*, 2004).

1.9.2 Guideline daily amount GDA

An unnecessary consumption of salt (sodium) in the diet can enhance the risk of high blood pressure which poses the increased risk for heart disease and stroke. This is why it is normally advised to restrain the daily consumption of salt to 6 grams (2.4g sodium) and to examine and evaluate the salt/sodium content of a food on the front of pack or back of pack nutrition labels (GDA *et al*,2020).

Guideline Daily Amount Values			
Typical values	**Women**	**Men**	**Children (5-10 years)**
Calories	2,000 kcal	2,500 kcal	1,800 kcal
Protein	45 g	55 g	24 g
Carbohydrate	230 g	300g	220 g
Sugars	90 g	120 g	85 g
Fat	70 g	95 g	70 g
Saturates	20 g	30 g	20 g
Fibre	24 g	24 g	15 g
Salt	6 g	6 g	4 g

Table 1.9.2.1 Guideline Daily Amount**,** taken from GDA.

Chapter 2

Yeast extract

2.1 Yeast extract (YE)

Yeast extract contains approximately 50% protein content. Complex on vitamin B, biotin, amino acids, dextran's, and trehalose. 20% of protein content is glutathione, and trace of elements calcium, phosphorus can be found also.

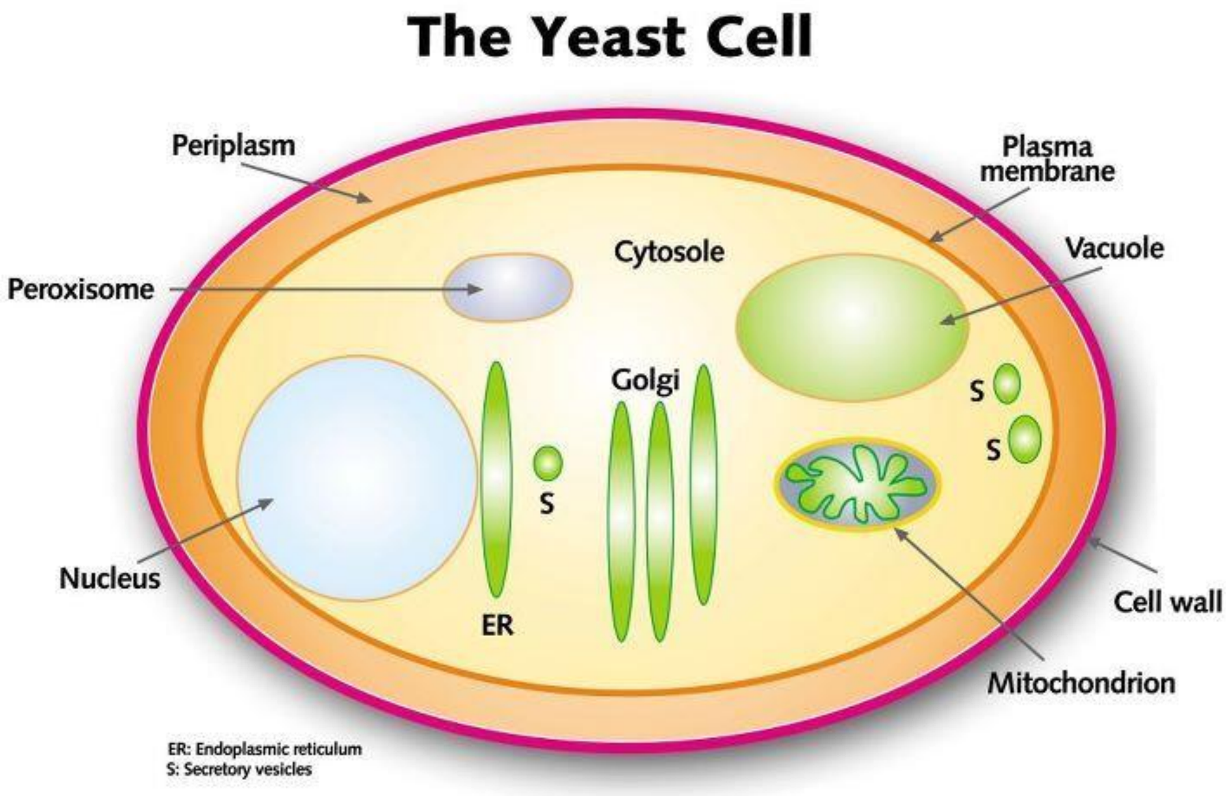


Figure 2.1.1 The Yeast Cell, taken from (Hyeast Biotech *et al,* 2021).

Yeast extract is currently one of the most effective solutions in the market to reduce salt by replacing salt with yeast extract. It provides a complimentary umami taste, and the arrangement of yeast (proteins, amino acids, and nucleotides) makes the yeast extract a valuable ingredient for food organisations. Yeast extract has been found to be among the appropriate salt substitutes, as a natural product that may be manufactured relatively simple (Taylor *et al*, 2018). YE can be generated by a variety of techniques, i.e., by enzymatic, chemical sonication, and plasmolysis treatment, or additionally by thermolysis techniques (Padmakumara *et al*, 2006).

2.1.2 Categories of yeast extract

Autolyzed yeast, the yeast extract is achieved by the breakdown of the yeast cell and the release of constituents in the mixture by its own enzymatic activities. The soluble elements are then split from insoluble parts of the mix. Hydrolysed yeast- is manufactured by the addition of acid or enzyme to the yeast and sugar mixture. This enzyme creates extracts by the process of hydrolysis. This type of yeast extract is commonly used within cosmetic industries globally (Hyeast Biotech *et al*, 2021).

Figure 2.1.2.1 Yeast Extract**,** taken from (ACS Publications *et al*, 2021).

With the advanced science in human technology progressively moving in the direction of natural foods additives, that provide additional benefits in foodstuff with regards to nutrients, increased flavours, stabilize the consistency, and also adds an additional element of time with regards to shelf life, the use of yeast extract has been investigated as being a natural source. The substance composition of yeast extracts varies on the techniques used and the composition of the medium (yeast slurry) employed for yeast culturing (Rocz Panstw and Zakl Hig *et al*, 2017). Yeast extract such, as β-glucans are commonly utilized as a food additive and in functional foods. It is safe to use and holds GRAS status (Generally Recognised as Safe). Additionally, it is used in the United States; permitting it for use by the Food and Drug Administration (FDA). Within the Europe

Union, β-glucan and yeast come beneath the Regulation of the European Parliament and Council Regulation (EC) No 1334/2008 ((EC) No 1334/2008 *et al*, 2008).

2.1.3 Different forms of yeast extract

The yeast extracts are obtainable in a variety of types in the market, powder, semi-pastry, flakes, oil embedded, or micro capsulised form (Hyeast Biotech *et al,* 2021).

Figure 2.1.3.1 Yeast Extract Powder, taken from (Hyeast Biotech *et al*, 2021).

Paste Production: When the cell wall is decomposed, the liquid material in the cell is freed, and a paste-like yeast extract is achieved. And so, the paste is the initial form obtained by the yeast extract, and the powder is then dried from the paste formula (Hyeast Biotech *et al,* 2021).

Figure 2.1.3.2 Yeast Extract Paste, taken from (Hyeast Biotech *et al,* 2021).

Flakes: This yeast extract is merged with water and is subsequently employed to produce the dough. This is then ground into miniscule flakes. Then the flakes are dissolved in water before used (Hyeast Biotech *et al,* 2021).

Figure 2.1.3.3 Yeast Extract Flakes, taken from (Hyeast Biotech *et al,* 2021).

2.1.4 The difference between fresh Yeast and Yeast Extract

Yeast extract is a food ingredient consumed in foods such as soups, sauces, ready meals, and savoury snacks. It's a widely used ingredient and is used as a flavour enhancer in food processing, to balance amino acid content in addition to flavour enhancement (Hyeast Biotech *et al*, 2021). Yeast extract is of natural origin and an ingredient which is derived from fresh yeast. Yeast is found to be a unicellular microorganism allocated to the fungus category, appearing in nature for millions of years. Yeast extract is a natural origin ingredient derived from fresh yeast (ACS Publications *et al*, 2021). Yeast extracts are highly different from fresh yeast, is fabricated from natural bakers' or brewers' yeast they are prepared in a liquid form to past like uniformity. Yeasts are in general coarse and grainy in both texture and manifestation, they have a very strong and salty flavour (Hyeast Biotech *et al,* 2021).

2.1.5 Applications of yeast extract YE.

Uses of YE are stated by the Regulation of the European Parliament and Council Regulation (EC) No 1334/2008 of 16th December 2008 on flavourings and particular food components with flavouring elements for use in and on food products, where YE are categorised as being natural flavourings. Distinguishing, naming, and arranging yeasts in their correct evolutionary context is of significance to a variety of segments of science, involving agriculture, medicine, the biological sciences, biotechnology, food industry (Teun Boekhout and Herman J. PHAFF *et al*, 2018). Yeast extracts may also hide sour and bitter flavours, therefore increasing food flavour, and concurrently serving as food colourings and antioxidants (Rocz Panstw and Zakl Hig *et al*, 2017). Yeast extracts in the form of pastes are significant elements of both vegetarian and conventional diets respectively, where they are employed for toast spreads and also as an ingredient within soups and readymade meals (Atwell E *et al*, 2002). Their application in powder form for vegetarian diets is completely acceptable as they inhibit all the fundamental amino acids, specifically large volumes of lysine, valine, and isoleucine along with Group B vitamins. As a result to their configuration, they can also be employed in those foodstuffs needing augmentation of amino acids and B vitamins, for instance in vegetarian and cereal produce derived from flour with a reduced wholemeal content or also within vegetable juices (Food Chemistry e*t al*, 2005).

2.1.6 Yeast extract is a potential substitute for salt in Baked crackers.

A study conducted by Loubna Abou Ghpush and Sami El Khatib *et al*, 2021 Yeast Extract (YE): A prospective alternative of Salt in Baked Crackers. Showed that YE is a good potential to reduce salt in food. Study shows the salt was reduced progressively and eventually switched by dried YE. Numerous mixes were acquired by lowering salt concentration by 20%, 50%, 75%, and 100%, and substituting the diminished amount with dried YE. Two sensory investigation tests were performed (the triangle test and the consumer's acceptance test) in order to assess the influence of YE on offering the same saltiness as the original crackers. The physiochemical characteristics of YE were established. Salinity, pH value, nitrogen amount, fat content, moisture content, density, number of calories, nucleotides content, glutamic acid concentration, and moisture content were all examined in order to completely characterize the YE (Loubna Abou Ghpush and Sami El Khatib *et al,* 2021).

Figure 2.1.6.1 Dissolved yeast in distilled water prepared in lab, taken from (*Loubna Abou Ghoush et al*, 2021).

Methods: The pH of the liquid yeast extract was calculated by applying a HannapH meter, in 30ml volume 100%, 24ml in 80%, 18ml in 60%, 12ml in 40% and 6ml volume in 20%, see table 2.1.6.2.

Volume ml	pH			Average
Replicates	**1**	**2**	**3**	
30ml (100%)	5.39	5.08	5.1	5.19±0.1
24ml (80%)	5.37	5.37	5.38	5.37±0.005
18ml (60%)	5.39	5.41	5.39	5.39±0.01
12ml (40%)	5.33	5.4	5.33	5.35±0.04
6ml (20%)	5.53	5.54	5.52	5.53±0.01

Table 2.1.6.2 pH values of yeast extract liquid concentration, adapted from (Loubna Abou Ghoush *et al*, 2021).

Salt content was reduced by 25%, 50%, 75% and 100% was replaced with yeast extract YE, table 2.1.6.3

	Salt	Yeast extract
Control	100%	0%
Sample 1	75%	25%
Sample 2	50%	50%
Sample 3	25%	75%
Sample 4	0%	10%

Table 2.1.6.3 Concentrations of salt and YE, taken from (Loubna Abou Ghoush *et al*, 2021).

Two tests were conducted: The sensory analysis test and the initial one is triangle test, four separate runs were made: Control and sample 1, Control and sample 2, Control and sample 3, and Control and sample 4. Only seven participants out of 25 were unable to distinguish the different samples, and the findings highlighted that there is a substantial difference between the control and sample 1. These findings stated that crackers samples having a ratio of 1:3 (YE: Salt) were clearly distinguished by participants who had the ability to taste the differentiation in flavour. An additional test, known as the consumer acceptance test. The panellists were each provided with one sample each in each run and asked to assess different characteristics of the cracker on a hedonic scale from 0 to 9. The participants were then provided with one sample in the second run which was conducted for comparison purposes with the control with sample 2 (50% YE, 50% salt). Out of 25 participants, 19 individuals gave the incorrect answer and were unable to distinguish the odd sample between the set and the difference was not substantial. When the amount of YE was increased and substituted 50% of salt, its saltiness increased, and the flavour was intensified. By employing this procedure, we could then decrease the level of salt in crackers to half, and replace it with a natural product, the YE, retaining the same flavour of the product. The findings of this study highlighted that samples with 50% decreased salt with YE was no variations in comparison to those produced with YE. The conclusions of this study stated that YE can be used as a partial alternative to replace table salt (Loubna Abou Ghoush *et al*, 2021).

2.2 Replacement of Salt with KCl and YE

Another study conducted by Majid Mohammadzadeh, Enayat Berizi, and Seyed Shahram *et al*, *2023* shows how the replacement of NaCl with KCl and YE in chicken sausage doesn't affect the organoleptic and shelf life of the product. In this study, products were replaced with 20% and 40% NaCl with KCl and YE 1% and 2% produced by Saccharomyces cerevisiae see table 2.2.1

Treatment group %	Control	T1	T2	T3	T4	T5	T6
NaCl	1.5	1.2	0.9	1.2	0.9	1.2	0.9
KCl	-	0.3	0.6	0.3	0.6	0.6	0.6
YE	-	-	-	1	1	2	2

Table 2.2.1 Percentage of NaCl, KCl and YE used in the emulsion type sausage. Adapted from (Influence of limited replacement of NaCl with KCl and YE *et al*, 2023).

The different types of meat and their respective pH plays a significant function in meat produce but the physicochemical characteristics of this study showed that salt reduction did not affect pH deviates and pH reduced drastically over time. The water activity values were not substantially altered both within the batter and baked sausage. The sodium content decreased from683.2mg/100g to 486.55mg/100g, this showed that the replacement of NaCl with KCl substantially reduces the sodium content of sausages (Majid Mohammadzadeh, Enayat Berizi and Seyed Shahram *et al*, 2023).

Sensory properties, the score of different parameters were comparable in all actions, no sizable variances could be discovered in color, taste, odor, mouthfeel, and texture table 2.2.1.1

Treatments	Color	Odor	Taste	Mouthfeel	Texture	Total acceptance
Control	3.11 ± 1.05[a]	3.33 ± 1.22[a]	3.11 ± 1.05[a]	3.11 ± 0.92[a]	3.22 ± 0.97[a]	3.27 ± 1.25[a]
T1	3.00 ± 1.00[a]	3.00 ± 1.32[a]	2.22 ± 1.20[a]	2.66 ± 0.86[a]	3.44 ± 0.72[a]	2.94 ± 0.88[a]
T2	2.88 ± 1.36[a]	2.88 ± 1.26[a]	2.88 ± 1.05[a]	2.55 ± 1.01[a]	3.22 ± 0.83[a]	3.05 ± 1.07[a]
T3	3.11 ± 1.05[a]	3.44 ± 1.01[a]	3.44 ± 0.88[a]	3.44 ± 1.01[a]	3.44 ± 0.88[a]	3.33 ± 0.70[a]
T4	3.11 ± 1.16[a]	3.11 ± 1.05[a]	2.77 ± 1.20[a]	2.88 ± 1.05[a]	3.44 ± 1.01[a]	3.38 ± 1.05[a]
T5	3.11 ± 1.16[a]	2.88 ± 1.05[a]	2.88 ± 1.16[a]	2.77 ± 0.83[a]	3.22 ± 0.83[a]	3.27 ± 0.90[a]
T6	3.11 ± 1.16[a]	3.77 ± 0.97[a]	3.55 ± 0.72[a]	3.55 ± 0.52[a]	3.44 ± 0.88[a]	3.72 ± 0.56[a]

Table 2.2.1.1 Sensory assessment of the creation of emulsion type sausage, with reduction of sodium contents. Taken from (Majid Mohammadzadeh, Enayat Berizi and Seyed Shahram *et al* 2023).

The result of this investigation shows that the substitution of NaCl with KCl and YE improved sensory evaluation compare with replacing NaCl with KCl alone. By using 2% YE treatments (T5 and T6) showing the best score of the sensory evaluation was achived, the result due to YE screening the metal taste of KCl (Majid Mohammadzadeh, Enayat Berizi and Seyed Shahram *et al*, 2023).

2.3 Replacement of NaCl with KCL and yeast extract in chicken sausage.

A study completed by Food Science & Nutrition *et al*, 2020 shows that by substitution of 20% to 40% KCL plus 15 or 2% yeast extract as an alternative of NaCl, the physical, chemical, microbiological, and sensory properties were not considerably influenced by those changes. Results show that salt substitution in sausage had no consequence on pH differences table 5.2.1

		Treatments						
	Days	Control	T1	T2	T3	T4	T5	T6
pH	0	6.16 ± 0.02^{a}	6.16 ± 0.02^{a}	6.15 ± 0.00^{a}	6.15 ± 0.00^{a}	6.15 ± 0.00^{a}	6.14 ± 0.00^{a}	6.15 ± 0.00^{a}
	7	6.17 ± 0.00^{a}	6.17 ± 0.00^{a}	6.17 ± 0.01^{a}	6.15 ± 0.00^{a}	6.16 ± 0.00^{a}	6.16 ± 0.01^{a}	6.16 ± 0.00^{a}
	14	6.19 ± 0.00^{b}	6.19 ± 0.00^{b}	6.190 ± 0.00^{b}	6.17 ± 0.00^{a}	6.17 ± 0.00^{a}	6.16 ± 0.00^{a}	6.17 ± 0.00^{a}
	21	6.16 ± 0.02^{c}	6.15 ± 0.00^{bc}	6.16 ± 0.01^{c}	6.13 ± 0.00^{ab}	6.14 ± 0.00^{abc}	6.11 ± 0.00^{a}	6.14 ± 0.00^{bc}
	28	6.13 ± 0.02^{a}	6.13 ± 0.02^{a}	6.13 ± 0.00^{a}	6.10 ± 0.00^{a}	6.12 ± 0.00^{a}	6.10 ± 0.07^{a}	6.12 ± 0.00^{a}
TBA (MDA/kg)	7	0.15 ± 0.00^{a}	0.15 ± 0.01^{a}	0.16 ± 0.01^{a}	0.15 ± 0.00^{a}	0.16 ± 0.00^{a}	0.16 ± 0.00^{a}	0.15 ± 0.00^{a}
	14	0.22 ± 0.00^{a}	0.23 ± 0.02^{a}	0.23 ± 0.00^{a}	0.23 ± 0.00^{a}	0.24 ± 0.00^{a}	0.23 ± 0.00^{a}	0.24 ± 0.00^{a}
	21	0.24 ± 0.00^{a}	0.24 ± 0.00^{a}	0.23 ± 0.00^{a}	0.23 ± 0.00^{a}	0.23 ± 0.00^{a}	0.23 ± 0.00^{a}	0.23 ± 0.00^{a}
	28	0.24 ± 0.00^{a}	0.25 ± 0.00^{a}	0.26 ± 0.00^{a}	0.25 ± 0.00^{a}	0.26 ± 0.00^{a}	0.26 ± 0.01^{a}	0.26 ± 0.00^{a}
a_w (batter)	0	0.96 ± 0.00^{a}	0.96 ± 0.00^{a}	0.96 ± 0.00^{a}	0.95 ± 0.00^{a}	0.95 ± 0.00^{a}	0.95 ± 0.00^{a}	0.95 ± 0.00^{a}
a_w (product)	0	0.98 ± 0.00^{a}	0.98 ± 0.00^{a}	0.98 ± 0.00^{a}	0.98 ± 0.00^{a}	0.98 ± 0.00^{a}	0.97 ± 0.00^{a}	0.98 ± 0.00^{a}
WHC (batter)	0	26 ± 10.60^{a}	25 ± 9.89^{a}	24 ± 16.97^{a}	29 ± 2.82^{a}	28 ± 2.82^{a}	35 ± 4.24^{a}	32 ± 2.82^{a}
Moisture	0	66.25 ± 0.14^{a}	66.33 ± 0.46^{a}	66.99 ± 0.69^{a}	66.15 ± 0.19^{a}	65.44 ± 0.59^{a}	65.01 ± 0.01^{a}	65.35 ± 1.15^{a}
Na (mg/100 g)	28	683.20 ± 21.35^{d}	539.15 ± 9.26^{b}	486.55 ± 14.49^{a}	552.60 ± 33.51^{bc}	510.90 ± 20.64^{ab}	592.80 ± 25.73^{c}	528.75 ± 10.53^{ab}

Note: Averages followed by the same letter, the same line, and the same day did not present significant difference ($p < .05$) by test. Control: 1.5% NaCl; T1: 1.2% NaCl + 0.3% KCl (20% of NaCl reduction); T2: 0.9% NaCl + 0.6% KCl (40% of NaCl reduction); T3: 1.2% NaCl + 0.3% KCl + 1% of commercial YE (20% of NaCl reduction); T4: 0.9% NaCl + 0.6% KCl + 1% commercial YE (40% of NaCl reduction); T5: 1.2% NaCl + 0.3% KCl + 2% of commercial YE (20% of NaCl reduction); and T6: 0.9% NaCl + 0.6% KCl + 2% commercial YE (40% of NaCl reduction).

Table 2.3.1 Replacement of NaCl with KCL, taken from Food Science and Nutrition distributed by Wiley Periodicals LLC. The value of water holding capacity WHC were numerically higher compare with the samples that contain NaCl (p>0.5).

2.3.1 Microbiological characteristics

The increase of microorganisms commenced on day 14 and persisted until day 28, approximately 3log cycles (table 5.2.2.1).

		Treatments						
	Day	Control	T1	T2	T3	T4	T5	T6
LAB	0	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$
	7	<1/(10-1 x 1	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$	$<1/(10^{-1} \times 1)$
	14	0.50 ± 0.70^{a}	1.55 ± 0.07^{a}	1.44 ± 0.05^{a}	1.00 ± 0.42^{a}	1.47 ± 0.24^{a}	1.30 ± 0.42^{a}	0.35 ± 0.49^{a}
	21	0.65 ± 0.91^{a}	1.80 ± 0.00^{a}	1.65 ± 0.06^{a}	1.23 ± 0.33^{a}	1.82 ± 0.18^{a}	1.57 ± 0.38^{a}	0.50 ± 0.70^{a}
	28	1.54 ± 0.33^{a}	1.90 ± 0.14^{a}	1.83 ± 0.07^{a}	1.45 ± 0.21^{a}	1.87 ± 0.03^{a}	2.01 ± 0.09^{a}	1.54 ± 0.08^{a}
TABC	0	$<1/(10^{-1} \times 1)^{a}$	1.47 ± 0.00^{c}	1.15 ± 0.21^{bc}	1.23 ± 0.33^{bc}	0.50 ± 0.70^{ab}	$<1/(10^{-1} \times 1)^{a}$	$<1/(10^{-1} \times 1)^{a}$
	7	1.84 ± 0.08^{a}	2.00 ± 0.14^{a}	1.84 ± 0.33^{a}	2.02 ± 0.25^{a}	1.95 ± 0.06^{a}	2.16 ± 0.45^{a}	2.17 ± 0.56^{a}
	14	2.63 ± 0.08^{b}	2.94 ± 0.05^{c}	2.27 ± 0.03^{a}	3.14 ± 0.04^{d}	2.91 ± 0.04^{c}	2.57 ± 0.03^{b}	3.16 ± 0.09^{d}
	21	2.99 ± 0.06^{a}	3.23 ± 0.12^{a}	2.47 ± 0.66^{a}	3.22 ± 0.03^{a}	3.02 ± 0.02^{a}	2.60 ± 0.61^{a}	3.23 ± 0.12^{a}
	28	3.20 ± 0.14^{a}	3.24 ± 0.05^{a}	3.06 ± 0.01^{a}	3.31 ± 0.01^{a}	3.15 ± 0.06^{a}	3.13 ± 0.01^{a}	3.26 ± 0.76^{a}

Note: Averages followed by the same letter, the same line, and the same day did not present significant difference ($p < 0.05$) by test. Control: 1.5% NaCl; T1: 1.2% NaCl + 0.3% KCl (20% of NaCl reduction); T2: 0.9% NaCl + 0.6% KCl (40% of NaCl reduction); T3: 1.2% NaCl + 0.3% KCl + 1% of commercial YE (20% of NaCl reduction); T4: 0.9% NaCl + 0.6% KCl + 1% commercial YE (40% of NaCl reduction); T5: 1.2% NaCl + 0.3% KCl + 2% of commercial YE (20% of NaCl reduction); and T6: 0.9% NaCl + 0.6% KCl + 2% commercial YE (40% of NaCl reduction).

Table 2.3.2 Microbiological characteristics of the chicken sausage with reduced sodium content, taken from (Food Science and Nutrition *et al*, 2020).

2.3.2 Sensory properties

The sensory properties are similar were no substantial differentiations amongst the results for taste and no substantial alternations in the colour, odour, mouthfeel, and texture (table 5.2.3.1).

Treatments	Color	Odor	Taste	Mouthfeel	Texture	Total acceptance
Control	3.11 ± 1.05^{a}	3.33 ± 1.22^{a}	3.11 ± 1.05^{a}	3.11 ± 0.92^{a}	3.22 ± 0.97^{a}	3.27 ± 1.25^{a}
T1	3.00 ± 1.00^{a}	3.00 ± 1.32^{a}	2.22 ± 1.20^{a}	2.66 ± 0.86^{a}	3.44 ± 0.72^{a}	2.94 ± 0.88^{a}
T2	2.88 ± 1.36^{a}	2.88 ± 1.26^{a}	2.88 ± 1.05^{a}	2.55 ± 1.01^{a}	3.22 ± 0.83^{a}	3.05 ± 1.07^{a}
T3	3.11 ± 1.05^{a}	3.44 ± 1.01^{a}	3.44 ± 0.88^{a}	3.44 ± 1.01^{a}	3.44 ± 0.88^{a}	3.33 ± 0.70^{a}
T4	3.11 ± 1.16^{a}	3.11 ± 1.05^{a}	2.77 ± 1.20^{a}	2.88 ± 1.05^{a}	3.44 ± 1.01^{a}	3.38 ± 1.05^{a}
T5	3.11 ± 1.16^{a}	2.88 ± 1.05^{a}	2.88 ± 1.16^{a}	2.77 ± 0.83^{a}	3.22 ± 0.83^{a}	3.27 ± 0.90^{a}
T6	3.11 ± 1.16^{a}	3.77 ± 0.97^{a}	3.55 ± 0.72^{a}	3.55 ± 0.52^{a}	3.44 ± 0.88^{a}	3.72 ± 0.56^{a}

Note: Averages followed by the same letter, the same line, and the same day did not present significant difference ($p < .05$) by test. Control: 1.5% NaCl; T1: 1.2% NaCl + 0.3% KCl (20% of NaCl reduction); T2: 0.9% NaCl + 0.6% KCl (40% of NaCl reduction); T3: 1.2% NaCl + 0.3% KCl + 1% of commercial YE (20% of NaCl reduction); T4: 0.9% NaCl + 0.6% KCl + 1% commercial YE (40% of NaCl reduction); T5: 1.2% NaCl + 0.3% KCl + 2% of commercial YE (20% of NaCl reduction); and T6: 0.9% NaCl + 0.6% KCl + 2% commercial YE (40% of NaCl reduction).

Table 2.3.2.1 Sensory evaluation of chicken sausage with reduced sodium content, taken from (Food Science and Nutrition *et al*, 2020).

Replacing 20% to 40% NaCl in the emulsion-form of sausages with KCl didn't show any side effect on texture, microbiological, and sensory elements, and did not produce any substantial deviations in the complete satisfactory appeal. Emulsion-type sausage treated with yeast extract had a better water capacity holding WCH than sausage treated with KCl (Food Science and Nutrition *et al*, 2020).

Chapter 3

Methodology and Materials

3.1 Methodology

The challenges and benefits of replacing salt with YE in Sage and Onion Stuffing and Parsley Butter. For this research both qualitative and quantitative data were collected, the first method prosed was organoleptic testing. For the testing panel, I chose to do it in my workplace Mr Crumb (Quality Irish Foods Limited T/A). Only people working for Quality Irish Foods LTD T/A can participate, this involved a range of departments from marketing, sales, technical, quality, and manufacturing. I chose to do the testing panel in Mr Crumb because most of the employers had pen part of the testing session before and they are internally trained by the organization in the NPD kitchen but not professionally trained. Age, gender, and other personal information weren’t required and weren’t collected from the voluntary participants, due to the limitation of company employees’ potential gender, and age skews weren’t considered as part of the research. In the testing panel were excluded people with allergies, special requirements, and dietary choices. A participant information sheet was circulated to all employees detailing the objectives of the study and requesting participation in the test panel. Participants were asked to sign a consent form before the taste panel, in the consent form was explained that participants are free to opt out at any time. Of the employees that agreed to volunteer in the testing panel, were chosen 10 from the voluntary, and information about the testing panel procedure was explained. Participants within the testing panel were offered samples of both products (that contained salt and YE). and were requested to give feedback on whether they liked or disliked each sample and the reason why?

Recipe Formulation and Product Development:

To see the challenges and benefits of replacing salt with YE, this study will evaluate two different products: Sage and Onion Stuffing and Parsley Butter. In total four “products” two that contains salt and two that contains YE, two existing products that contain salt and the same two products that replace salt with yeast extract.

1. Sage and Onion Stuffing contains 0.4g of salt in 100g of stuffing (sample 303).
2. Parsley Butter that contains 0.77g salt in 100g of Parsley butter (sample 103)
3. Sage and Onion Stuffing that contains yeast extract (sample 304)
4. Parsley Butter that contains yeast extract (sample 104)

YE sample from NPD kitchen, were used in accordance with EC 1334/2008, table 3.1.1

PRODUCT NAME	Yeast Extract Powder
PRODUCT CODE	F13925
COUNTRY OF MANUFACTURE	UK
LABELLING GUIDELINES FOR FOODSTUFFS	Possible flavouring designations (according to Regulation (EC) 1334/2008): "Natural flavouring", "Yeast flavouring" or "Flavouring"

Table 3.1.1 Yeast extract specification, taken from product specification Elixarome Limited UK.

MICROBIOLOGICAL TESTS					
Laboratory	ALS Laboratories (UK) Limited		**Accreditation**	UKAS	
Frequency of examination	Random samples are tested during the year as generally flavours are biocidal and do not support micro-organisms				
Test	**Units**	**Method Number**	**Acceptable limit**	**Rejection limit**	**Action when ≥ rejection limit**
Total Viable Count	cfu/g	ESGM-M300	< 10 000	≥ 10 000	Quarantined
Yeasts and moulds	cfu/g	ESGM-M309	< 100	≥ 100	Quarantined
Coagulase positive Staphylococci	cfu/g	ESGM/M/307	< 20	≥ 20	Quarantined
Enterobacteriaceae (presumptive)	cfu/g	ESGM-M303	< 10	≥ 10	Quarantined
Coliforms (presumptive)	cfu/g	ESGM/M/302	< 10	≥ 10	Quarantined
Escherichia coli (β-Glucuronidase positive)	cfu/g	ESGM-M304	< 10	≥ 10	Quarantined
Listeria sp. (ELISA)	/25g	ESGM-M523	Not detected	Detected	Quarantined
Salmonella sp. (ELISA)	/25g	ESGM-M515	Not detected	Detected	Quarantined

Table 3.1.1.1 Yeast extract Micro specification, taken from product specification Elixarome Limited

Product Selection: The sample selection process chose Sage and Onion Stuffing and Parsley Butter because it was found that they had complicated composition - ingredients table 6.1.2 and table 6.1.3

Sample 303 that contains Salt	
Sage and Onion Stuffing	Onion (33%) Fresh Breadcrumbs [**Wheat** Flour (**Wheat** Flour, Calcium Carbonate, Iron, Niacin (B3), Thiamin (B1)), Water, Salt, Flour Treatment Agent (Ascorbic Acid)], Dried Breadcrumbs [**Wheat** Flour (**Wheat** Flour, Calcium Carbonate, Iron, Niacin (B3), Thiamin (B1)), Salt, **Wheat** Gluten, Flour Treatment Agent (Ascorbic Acid)], Water, Rapeseed Oil, Butter (5%) [(**Milk**), Salt], Sage (3%), Vegetable Bouillon [Salt, Maltodextrin (Potato), Lactose (**Milk**), Turmeric Extract, Sage Extract, Onion Extract,

	Parsley Extract, Ground Thyme], Thyme, Salt, Dried Parsley, White Pepper.

Table 3.1.1.2 Ingredients declaration, Sample 303 Sage and Onion Stuffing that contains salt, adapted from (Mr Crumb ingredients pack *et al*, 2023).

Sample 103 that contains Salt	
Parsley Butter	Butter (62%) [(Milk), Salt], Corn flour, Garlic Puree (9%), Parsley (3%), Salt, White Pepper, Onion powder, Garlic Powder (0.03%).

Table 3.1.1.3 Ingredients declaration, Sample 103 Parsley Butter that contains Salt, adapted from (Mr Crumb ingredients pack *et al* 2023)

Baseline trials for each of the products completed in the NPD kitchen, were achieved the same organoleptic results in sample 303 Sage and onion Stuffing (salt contains) with the existing recipe compared with sample 304 Sage and Onion Stuffing (YE contains) with the new reformulation. The same procedure was followed for sample 104 Parsley Butter with the existing recipe salt content, compare with sample 104 with the new reformulation YE content. The process was repeated to assess the correct concentration of the YE, for both samples 304 and 104, figure 6.1.4 and figure 6.1.5

Sample 304 that contains Yeast Extract	
Sage and Onion Stuffing	Onion (33%) Fresh Breadcrumbs [**Wheat** Flour (**Wheat** Flour, Calcium Carbonate, Iron, Niacin (B3), Thiamin (B1)), Water, Yeast Extract, Flour Treatment Agent (Ascorbic Acid)], Dried Breadcrumbs [**Wheat** Flour (**Wheat** Flour, Calcium Carbonate, Iron, Niacin (B3), Thiamin (B1)), Salt, **Wheat** Gluten, Flour Treatment Agent (Ascorbic Acid)], Water, Rapeseed Oil, Butter (5%) [(**Milk**), Salt], Sage (3%), Vegetable Bouillon [Salt, Maltodextrin (Potato), Lactose (**Milk**), Turmeric Extract, Sage Extract, Onion Extract, Parsley Extract, Ground Thyme], Thyme, Dried Parsley, White Pepper.

Table 3.1.1.4 Ingredients declaration, Sample 304 Sage and Onion Stuffing with the new reformulation, adapted from (Mr Crumb ingredients pack *et al*, 2023).

Sample 104 that contains Yeast Extract	
Parsley Butter	Butter (62%) [(Milk), Salt], Corn flour, Garlic Puree (9%), Parsley (3%), Yeast Extract, White Pepper, Onion powder, Garlic Powder (0.03%).

Table 3.1.1.5 Ingredients declaration, Sample 104 Parsley Butter with the new reformulation, adapted from (Mr Crumb ingredients pack *et al*, 2023).

3.2 Replacement of salt with yeast extract in sample 304 Sage and Onion Stuffing and sample 104 Parsley Butter.

After the completion of baseline trials in the NPD kitchen to establish organoleptic results, it was decided to replace quantities for Sage and Onion Stuffing in the actual recipe we use 0.004g of salt for 1g of stuffing with the new reformulation using 0.003g YE for 1g of stuffing. For 100g Parsley Butter was used 0.3g YE, and the difference was 0.1g for 100g stuffing. For Parsley butter in the actual recipe, it uses 0.0077g salt in 1g Parsley butter, with the new reformulation 0.0059g YE was used for 1g of butter. For 100g of butter, 0.59g YE was used, a difference of 0.18g for 100g butter. Clear instructions were given to the test panel on how to complete the assessment. Organoleptic Assessment Sheet A for Sage and Onion Stuffing which contains salt sample 303 and Sage and Onion Stuffing which contains yeast extract sample 304. Organoleptic testing or properties includes the aspects of food or other substances part of the food, including taste, sight, smell, and touch. For this research were used two sample testing also known as the independent samples test (JMP *et al*, 2023). Samples were labelled using three-digit codes: 303,304, 103, and 104 and were served in identical containers, (Image 3.2.1 and 3.2.2).

Uncooked samples, sample 303 and sample 304

Image 3.2.1 Sample 303 and sample 304, taken during samples preparation, in NPD kitchen.

Image 3.2.2 Sample 103 and sample 104, taken during samples preparation in NPD kitchen.

Uncooked samples for Parsley Butter that contains salt 103, and Parsley butter that contains YE sample 104.

Organoleptic Assessment Sheet A:

DATE: **PRODUCT CODE: 303& 304**

Please taste products labelled with 3-digit code and if possible, please write a brief comment on each parameter.

Dislike-D	Neutral-N	Pleasant-P

Assessment	Product 303	Product 304	Comments
Appearance			
Aroma			
Taste			
Texture			
Total			

1-Which product was your favourite product 303 or 304? Explain why?

2- Would you buy product 303 or 304?

3- Comment your choice

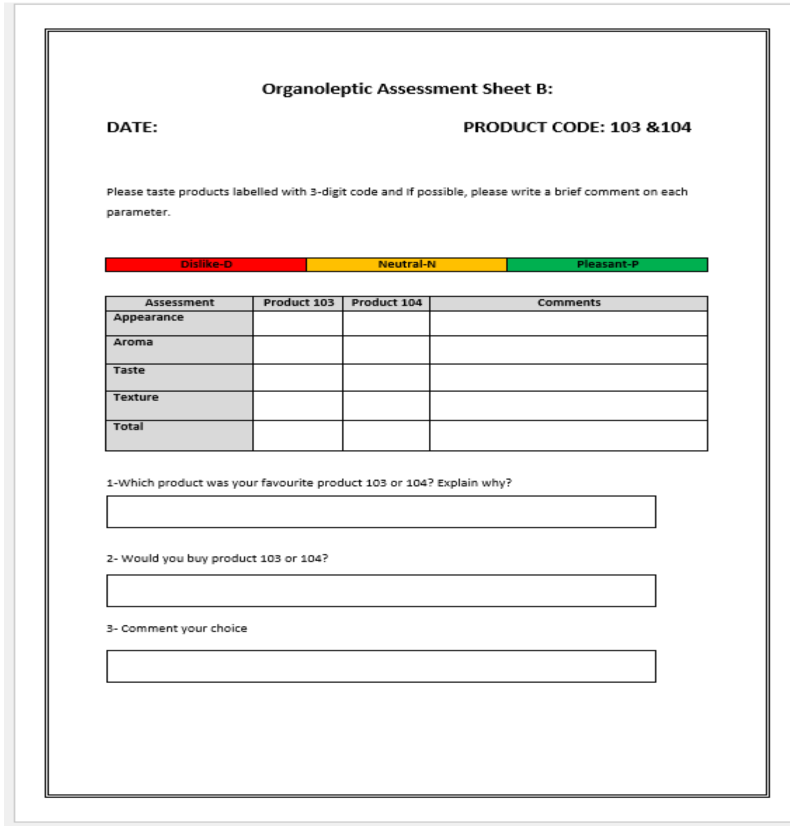
Figure 3.2.3 Organoleptic Assessment Sheet A, sample 303 that contains salt and sample 304 that contains yeast extract.

The participants within the testing panel were offered samples of both products that contain salt and yeast extract and were requested to provide feedback on whether they liked or dislike each sample. Samples were labelled using three-digit codes i.e., 303 and 304 this to avoid bias.

Image 3.2.4 Cooked Samples 303 and 304**,** taken during testing panel in NPD kitchen.

Before organoleptic testing I asked the panellists to not drink coffee or smoke for at least 30 mins before entering the testing session, water was provided between tastings to facilitate a neutral palate. Each sample was presented in identical containers, with the same quantity (fig 6.2.4). Samples were cooked by the Development chef, and served by me, each panellist were offered 2 samples product 303 and 304, and water.

After the first Organoleptic testing, panellists were introduced with the second organoleptic sheet B, and samples 103 and 104 for Parsley Butter.



Organoleptic Assessment Sheet B:

DATE: PRODUCT CODE: 103 &104

Please taste products labelled with 3-digit code and if possible, please write a brief comment on each parameter.

Dislike-D	Neutral-N	Pleasant-P

Assessment	Product 103	Product 104	Comments
Appearance			
Aroma			
Taste			
Texture			
Total			

1-Which product was your favourite product 103 or 104? Explain why?

2- Would you buy product 103 or 104?

3- Comment your choice

Figure 3.2.5 Organoleptic Assessment Sheet B, Mr Crumb Parsley Butter that contains salt product 103 and Mr Crumb Parsley Butter that contains yeast extract product 104.

The same procedure was followed for Mr Crumb Parsley Butter which contains salt product 103 and Mr Crumb Parsley Butter which contains yeast extract product 104. Samples were served with bread for organoleptic testing, and clean label bread was used with Goods Receive Note (GRN: 2383-01262) photo 6.2.6.

Image 6.2.6 Cooked samples 103 and 104**,** taken during testing panel in NPD kitchen 2023.

NPD kitchen was used for the testing session, samples were cooked following the cooking instruction, temperature probe Sensor – Tech datalogger with serial number 1304025 calibration date: 13/09/2022 were used to check the temperature of each sample.

Image 3.3.1 Temperature probe (Sensor Tech LTD), taken during the cooking procedure in NPD kitchen 2023.

Calibration of the temperature probe was done before the cooking procedure following the calibration procedure SOP Calibration and verification procedure, master probe temperature was used for reference. Calibration of the temperature probe was done in Ice <0 and boiling water

<100. Samples were cooked by the Development chef, according to cooking instructions and following food safety and hygiene protocols.

3.4 Shelf life.

Shelf-life testing is a vital stage in the development process, it is important when a shelf-life test is carried out, that the product is subjected to realistic storage conditions. After a few trials in the NPD kitchen on both samples chosen for this research, Sage and Onion Stuffing and Parsley Butter were sent for Shelf-life testing. Shelf-life procedure was followed: the chilled product should be stored at 5°C to +- 1°C for the first ¾ of its shelf life. Then the product should be transferred to a storage temperature room 22°C for 2 hours and then transferred to 8°C for the remaining of its estimated shelf life. Frozen products stored at between -15°C to -18°C for the duration of their shelf life FSAI *Guidance Note No. 18: Validation of Product Shelf-life (Revision 3)*, Following FSAI Guidance, were prepared 6 samples of Sage and Onion Stuffing with the existing recipe and 6 other samples of Sage and Onion Stuffing with the new reformulation (replaced salt with YE). Samples were marked with a three-digit code and the day of testing sample i.e., 303 shelf-life day 1 testing date xxx, sample 303 shelf-life day 6,12,16 (left open and re-tested on day 17),17,18, and day 21. In the same day were prepared samples for Sage and Onion Stuffing that contains YE and marked with three-digit code sample 304 shelf-life day 1 testing day xxx, day 6,12, 16 (left open and re-tested on day 17),17,18, and day 21. The same procedure was followed for Parsley Butter that contains salt sample 103 and YE sample 104, sample 103/104 shelf-life day 1 12,16 (left open and re-tested on day 17, 17, 18 and day 21 testing day xxx. In total was sent for shelf-life testing 24 samples, table 3.4.1

Shelf-life testing							
	Testing day:						
Sample code	Day 1	Day 6	Day 12	Day 16	Day 17	Day 18	Day 21
303	x	x	x	x	x	x	x
304	x	x	x	x	x	x	x
103	x	x	x	x	x	x	x
104	x	x	x	x	x	x	x

Table 3.4.1 Shelf-life testing

All samples of Sage and Onion Stuffing (303 and 304) and Parsley Butter (103 and 104) were sent to an external lab for testing Advanced Laboratory Testing ALT, figure 3.4.2

Figure 3.4.2 Sample Acquisition, taken from (ALT lab *et al*, 2023).

Each sample were tested for following microorganisms: Aerobic Colony Count 30°C 48hrs, Presumptive Enterobacteriaceae, Presumptive Coliforms, Presumptive Escherichia Coli, Coagulase-Positive Staphylococci, Bacillus cereus (presumptive), Presumptive Clostridium perfringens, Presumptive Yeast, Presumptive Moulds, Listeria spp, and Salmonella ssp. I used industry standard for retailers, EC No 2073/2005 and ISO 17025:2017. Each sample was tested on Day 1, Day 6, Day 12, and Day 16 (the samples were left open for 24hrs and retested on Day 17, Day 18, and Day 21.

Chapter 4

Organoleptic Results

4.1 Organoleptic results for sample 303 & 304

Organoleptic testing was conducted in the NPD kitchen, first uncooked samples was compared to see if there was any difference in the appearance, it was noted there was no difference in appearance. After sample of Sage and Onion and Parsley Butter weas cooked, (cooked sample 303 and 304 fig 7.1). Participants in organoleptic testing had the same assessment in relation to the appearance of products 303 and 304, 8/10 participants said that they both appeared the same.

Image 4.1.1 Sample 303 and 304 taken during testing panel in NPD kitchen.

Organoleptic results were similar for both samples golden visual and green herbs, minor difference in appearance noted, sample 304 appeared a bit wet compare with sample 303. Both tasted the same, fresh bread crumb, strong aroma of sage and onions, good texture free flowing.

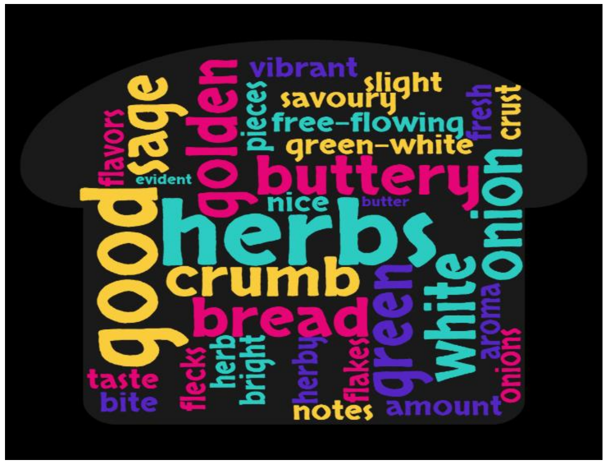


Figure 4.1.2 Organoleptic comments from participant in testing panel, for sample 303

Figure 4.1.3 Organoleptic comments from participant in testing panel, for sample 304

From 10 panellists completing organoleptic testing, 8 participants comment that: they both appeared the same, with very good visuals of breadcrumbs, herbs, and onions. One of the testing panels disliked the visual appearance of sample 304, lumpy and too moist, and for one of the panellists, sample 304 was neutral.

Conclusions: Both samples were presented with the same procedure, and they both appeared satisfactory. The only difference was sample 304 which contains yeast extract was a bit wetter compared to sample 303 photo 4.1.4 This can be because sample 303 which contains salt was prepared in the production area in a big quantity. Sample 303, Sage and Onion Stuffing that contains salt was preferred, about taste more salty and well balanced of herbs and bread crumb.

Image 4.1.4 Sample 303 and 304 Sage and Onion Stuffing

4.2 Favourite Sample

5 of 10 panellists ranked sample 303 Sage and Onion Stuffing that contains salt most preferred, well balanced and rounded, better flavour, and saltier. 4 of 10 panellists ranked sample 304 as their favourite product because it wasn't too salty and exhibited a more balanced taste. One of the panellists liked both samples 303 and 304.

Figure 4.2.1 Favourite Sample

4.3 Organoleptic results for sample 103 & 104

Samples 103 Parsley Butter that contains salt and 104 Parsley butter that contains yeast extract.

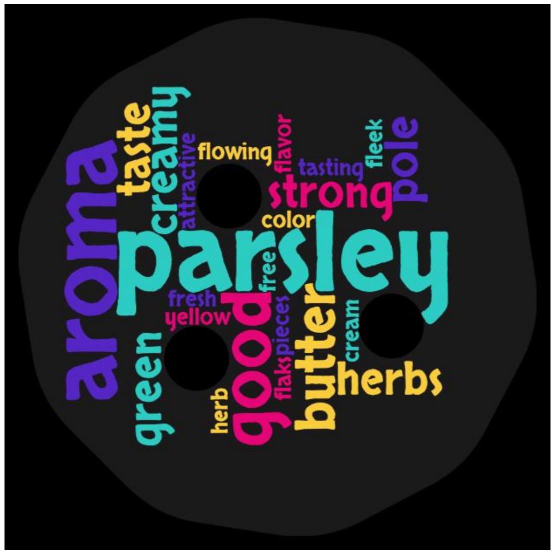


Figure 4.3.1 Organoleptic comments from participant in testing panel, for sample 103

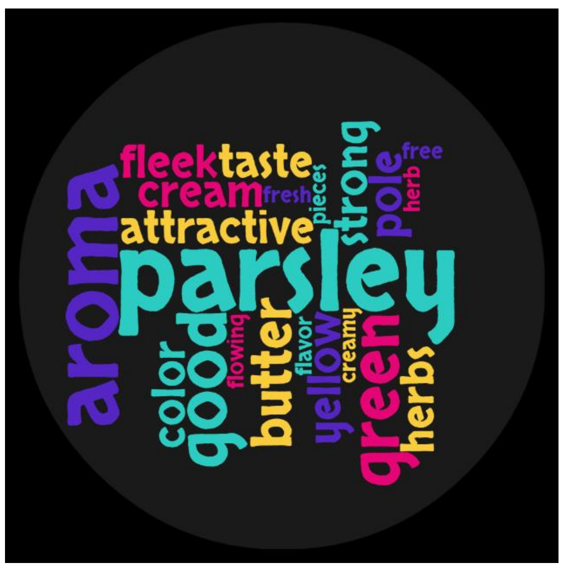


Figure 4.3.2 Organoleptic comments from participant in testing panel, for sample 104

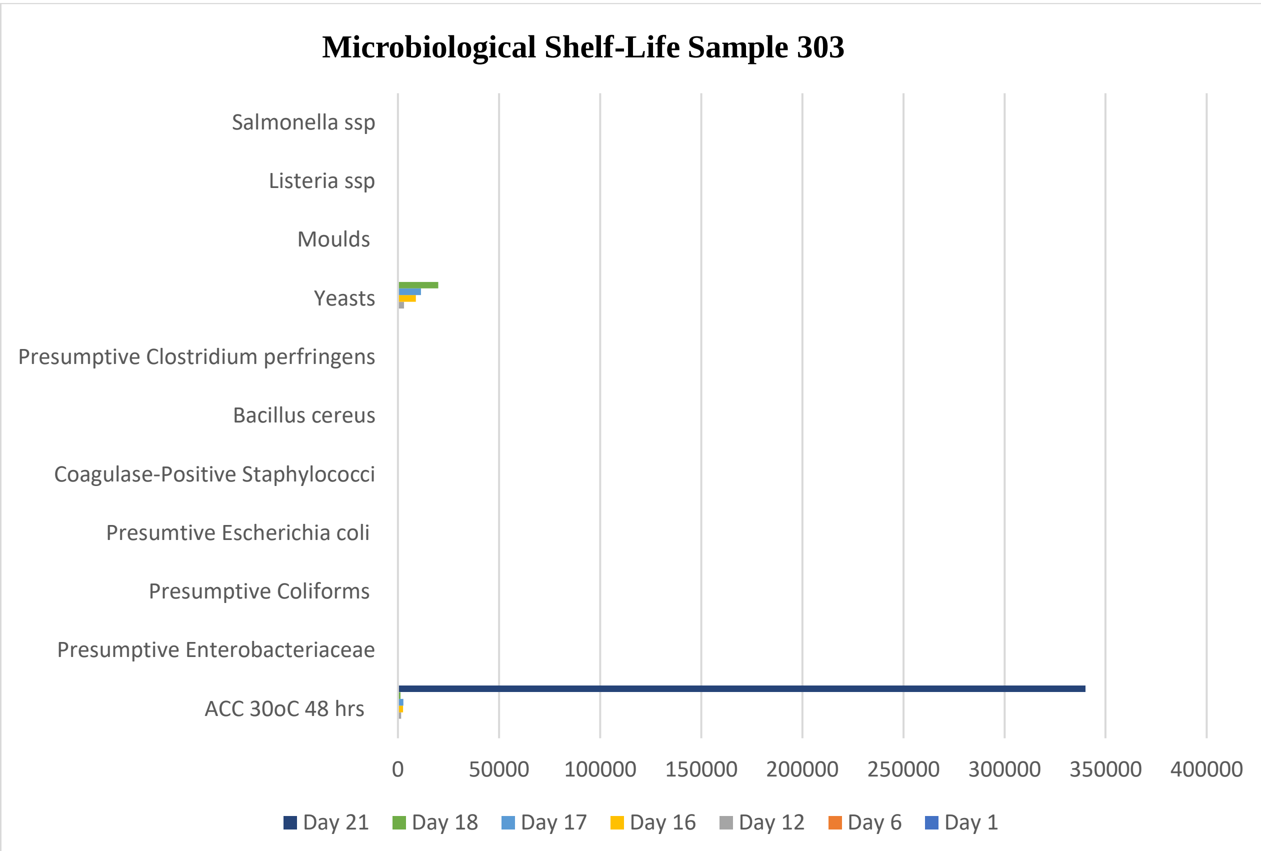
Organoleptic results in relation to Parsley Butter showed no difference in appearance, aroma, and texture. Both appeared nice, with a good colour of butter and parsley, and a nice aroma of garlic and butter. The only difference was in taste, sample 104 tested less salty. This was pleasant for the panellists.

Chapter 5

Shelf-life Results

5.1. Shelf-Life Assessment Sample 303

Shelf-life samples were sent at the same time for both samples Sage and Onion Stuffing and Parsley Butter, which contains salt and yeast extract. Graph 5.1.1 shows the results of shelf-life testing for sample 303 stuffing.



Graph 5.1.1 Microbiological results for sample 303

Shelf life for sample 303 day 1, day 6, day 12, day 16 open sample retest on day 17, day 18, and day 21. The graph demonstrates there was no detection of pathogens spp, and Aerobic Colony Count 30 48hrs increased from day 12 with 1000cfu/g until day 21 with 340000cfu/g table 6.1.2 There was an increase in yeast from day 12 with 3000cfu/g until day 21 with >150000cfu/g table 6.1.2

5.1.2 Microbiological shelf-life results, sample 303

Table 8.1.3 shows shelf-life results for days 1, 6, 12, and day 16, sample tested on day 16 was left open and retested on day 17, day 18, and day 21.

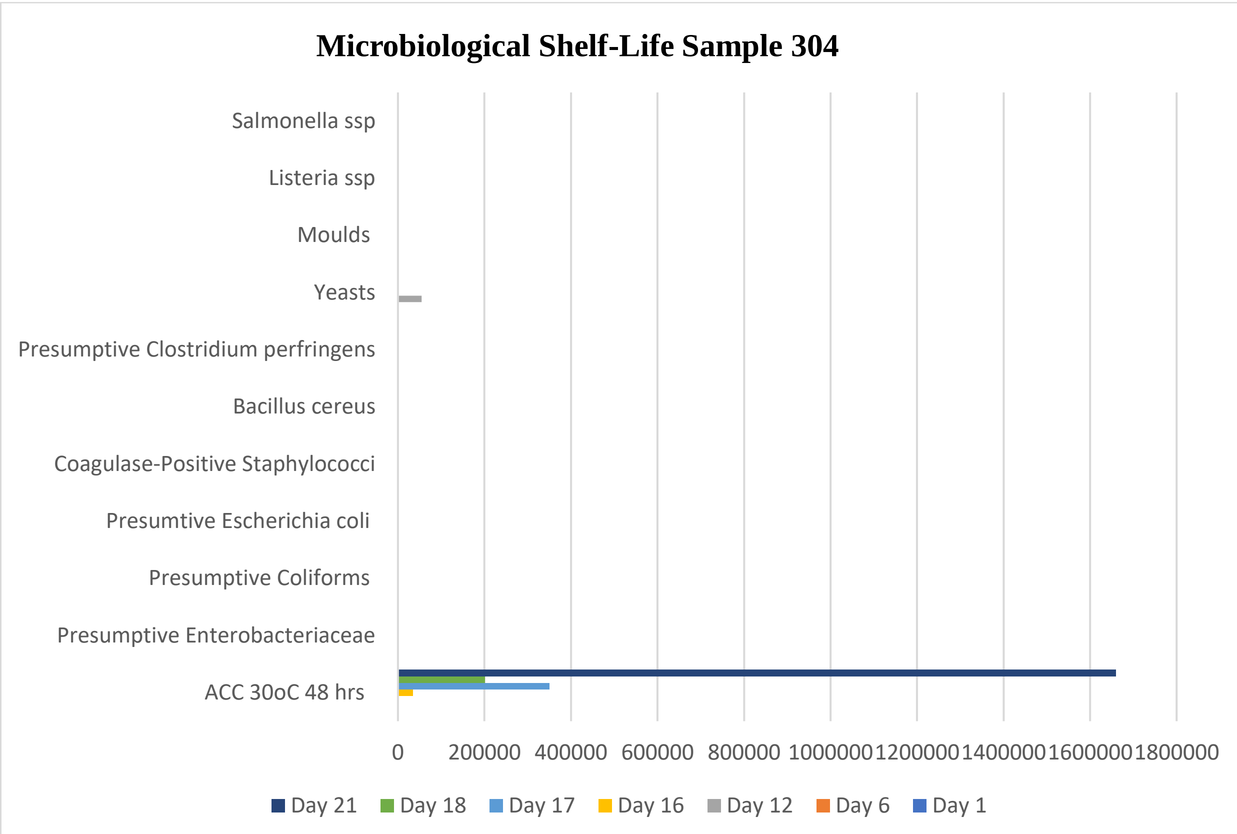
Chilled Shelf-life Day of life	Day 1	Day 6	Day 12	Day 16	Day 17	Day 18	Day 21
ACC 30oC 48 hrs	<100	<100	1600	2,600	2,700	1300	340000
Presumptive Enterobacteriaceae	<10	<10	<10	<10	<10	<10	<10
Presumptive Coliforms	<10	<10	<10	<10	<10	<10	<10
Presumptive Escherichia coli	<10	<10	<10	<10	<10	<10	<10
Coagulase-Positive Staphylococci	<20	<20	<20	<20	<20	<20	<20
Bacillus cereus	<100	<100	<100	<100	<100	<100	<100
Presumptive Clostridium perfringens	<10	<10	<10	<10	<10	<10	<10
Yeasts	<100	<10	3000	8800	11400	20000	>150000
Moulds	<100	<100	<100	<100	<100	<100	<100
Listeria ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Salmonella ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

Table 5.1.2.1 Shelf-life results for sample 303 Sage and Onion Stuffing that contains salt.

From the results below we can see that Aerobic Colony Count 30 48hrs are present on Day 12 and increase through time progression on Day 16 and Day 17. The shelf life on Day 18 shows less Aerobic Colony Count 30 48hrs for cfu/g. Sage and Onion Stuffing is given 18 days shelf life, from table 8.1.3 we can see that ACC 30 48hrs increased.

5.1.3 Sample 304 Shelf-Life Assessment:

Results of the shelf life of sample 304 shown in graph 8.1.5 shows that on Day 1 and Day 6 there is no detection of Microorganisms. Detection of Aerobic Colony Count 30 48hrs (ACC 30 48hrs) starts on Day 12 with 1000cfu/g and increases on Day 16 with 350000cfu/g, Day 17 with 350000cfu/g, Day18 201000cfu/g and Day 21 1660000cfu/g.



Graph 5.1.3.1 Microbiological results for sample 304 Sage and Onion Stuffing that contains YE. From the results, we can see that Aerobic Colony Count 30 48hrs are exceeding limits on Day 16 with 350000cfu/g and the shelf life failed. No detection of pathogenic micro on the sample, this shows that yeast extract Sage and Onion Stuffing 304 that contains YE gives the same shelf life compared to sample 303 that contains salt till Day 12 table 5.1.4.1.

5.1.4 Microbiological shelf-life results, sample 304

Table 5.1.4.1 represent the results of shelf-life testing from day 1 till day 21, from the results there is evident presence of ACC on day 12 with 1000cfu/g this is within limits according to the microbiological specification and out of spec on the following days 16, 17, 18 and day 21 >350,000cfu/g.

Chilled Shelf-life Day of life	Day 1	Day 6	Day 12	Day 16	Day 17	Day 18	Day 21
ACC 30oC 48 hrs	<100	<100	1000	350000	350000	201000	1660000
Presumptive Enterobacteriaceae	<10	<10	<10	<10	<10	<10	>1500
Presumptive Coliforms	<10	<10	<10	<10	<10	<10	<10
Presumptive Escherichia coli	<10	<10	<10	<10	<10	<10	<10
Coagulase-Positive Staphylococci	<20	<20	<20	<20	<20	<20	<20
Bacillus cereus	<100	<100	<100	<100	<100	<100	<100
Presumptive Clostridium perfringens	<10	<10	<10	<10	<10	<10	<10
Yeasts	<100	300	55000	>150000	>150000	>150000	>150000
Moulds	<100	<100	<100	<1000	<100	<100	<100
Listeria ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Salmonella ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

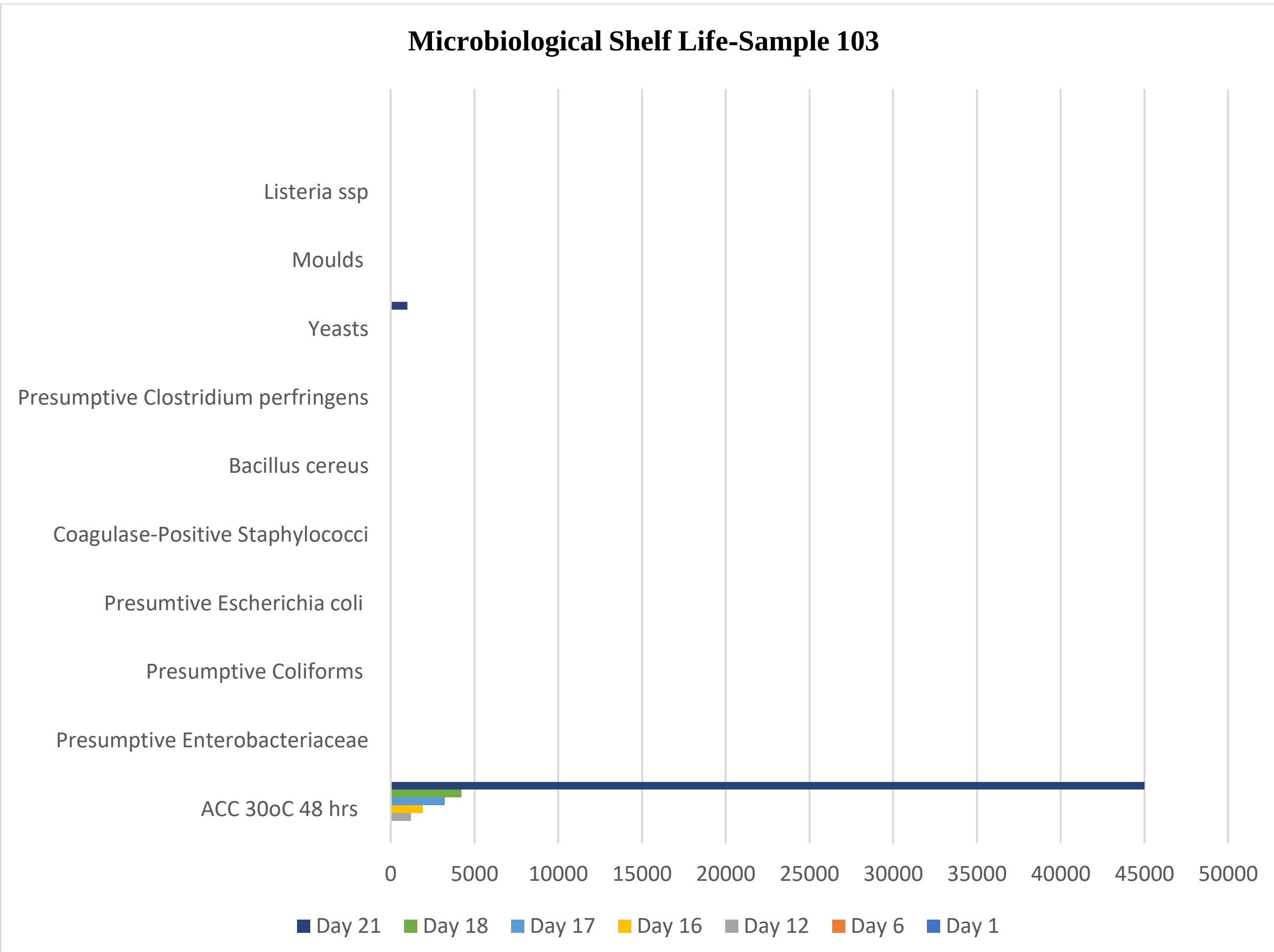
Table 5.1.4.1 Shelf-life results for Sage and Onion Stuffing 304 that contains YE.

Detection of yeast on day 1 with 300cfu/g, day 12 with 55,000, and >150,000cfu/g on days 16,17,18, and day 21. No presence of Listeria ssp or salmonella ssp was detected.

Shelf-life results show that sample 303 that contains salt has a longer shelf life compared with sample 304 that contains yeast extract.

5.1.5 Sample 103 Shelf-Life Assessment

Graph 5.1.5.1 shows shelf-life results for sample 103, day 1, till day 21, presence of ACC 30oC 48 hrs and yeast.



Graph 5.1.5.1 Microbiological results for sample 103 parsley butter that contains salt.

5.1.6 Microbiological shelf-life results, sample 103

From the results below, we see the presence of ACC 30oC 48 hrs on day 12, 1000cfu/g, day 16, 2,600cfu/g, day 17 sample was left open on day 16 and retested again on day 17, 2,700cfu/g, day 18 1300cfu/g and failed on day 21 with 340,000cfu/g.

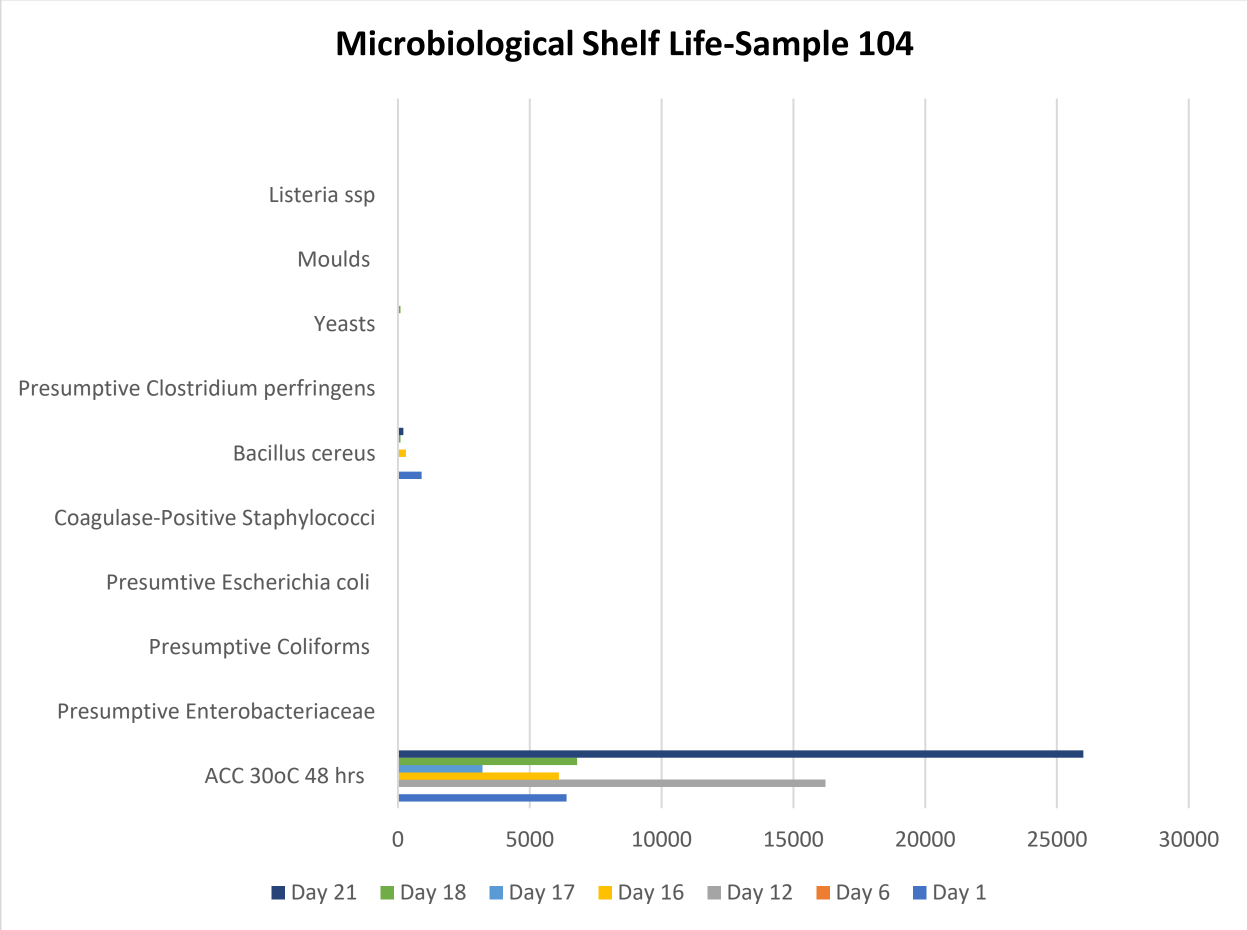
Chilled Shelf-life Day of life	Day 1	Day 6	Day 12	Day 16	Day 17	Day 18	Day 21
ACC 30oC 48 hrs	<100	<100	1000	2,600	2,700	1300	340000
Presumptive Enterobacteriaceae	<10	<10	<10	<10	<10	<10	<10
Presumptive Coliforms	<10	<10	<10	<10	<10	<10	<10
Presumptive Escherichia coli	<10	<10	<10	<10	<10	<10	<10
Coagulase-Positive Staphylococci	<20	<20	<20	<20	<20	<20	<20
Bacillus cereus	<100	<100	<100	<100	<100	<100	<100
Presumptive Clostridium perfringens	<10	<10	<10	<10	<10	<10	<10
Yeasts	<100	<10	3000	8800	11400	20000	>150000
Moulds	<100	<100	<100	<100	<100	<100	<100
Listeria ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Salmonella ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

Table 5.1.6.1 Microbiological shelf-life results for sample 103

Detection of yeast on day 12 with 3000cfu/g, day 16 with 8800cfu/g, day 17 with 11400cfu/g day, 18 with 20,000cfu/g, and on day 21 >150,000cfu/g, within limits on days 1,6 and day 16. Out of spec on days 17, 18, and day 21.

5.1.7 Mr Crumb Parsley Butter-product 104 that contains yeast extract.

Results of shelf-life graph 8.2.5 shows that Day 1 was the detection of Aerobic Colony Count 30°*c* 48hrs with 6400cfu/g and no detection <100cfu/g on Day 6 and detection on Day 12 16200cfu/g and increased on following days.



Graph 5.1.7.1 Microbiological results for sample 104 parsley butter that contains YE. Detection of ACC 30oC 48 hrs, Bacillus cereus, and Yeast.

5.1.8 Microbiological shelf-life results, sample 104

From the table below 8.2.7 we see that sample 103 failed on day 12 with 16200cfu/g ACC 30oC 48 hrs, out of the spec. target <10,000cfu/g. This can happen because of cross-contamination during sample preparation, handling, or packaging.

Chilled Shelf-life Day of life	Day 1	Day 6	Day 12	Day 16	Day 17	Day 18	Day 21
ACC 30oC 48 hrs	6400	<100	16200	6100	3,200	6800	26000
Presumptive Enterobacteriaceae	<10	<10	<10	<10	<10	<10	<10
Presumptive Coliforms	<10	<10	<10	<10	<10	<10	<10
Presumptive Escherichia coli	<10	<10	<10	<10	<10	<10	<10
Coagulase-Positive Staphylococci	<20	<20	<20	<20	<20	<20	<20
Bacillus cereus	900	<100	<100	300	<100	100	200
Presumptive Clostridium perfringens	<10	<10	<10	<10	<10	<10	<10
Yeasts	<100	<100	<100	<100	<280	100	<100
Moulds	<100	<100	<100	<100	<100	<100	<100
Listeria ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Salmonella ssp	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected

Table 5.1.8.1 Microbiological shelf-life results for sample 104 parsley butter that contains YE.

From the table above we see that we have detection of Bacillus cereus on day 1 900cfu/g, <100cfu/g on day 6 and day 12, detection again on day 16, no detected-on day 17 sample was left open on fridge temperature less than 4°c and detected on day 18 with 100cfu/g and day 21 with 200cfu/g. Detection of the yeast on day 17 detection of Bacillus cereus is within limits according to the spec, table 5.2.1 Detection of the yeast on day 17, <280cfu/g and on day 18, 100cfu/g within limits table 5.2.1

5.2 Microbiological Criteria

The FSAI's Guidance Note No.3 Table 5.2.1 shows the limits of pathogens for food ready to cook. Many factors affect the high micro in the product, for example, poor hygiene, process factory, ingredient transportation, storage, temperature abuse, pH, water activity, sample preparation, and transportation (FSAI *et al*, 2020). Micro targets vary depending on product specification and supply.

Test	Target cfu/g	Rejected	Frequency	Method
ACC 30oC 48 hrs	<10,000	>100,000	Monthly	External Lab ISO
Presumptive Enterobacteriaceae	<10	>100	Monthly	External Lab ISO
Presumptive Coliforms	Not detected	Detected	Monthly	External Lab ISO
Presumptive Escherichia coli	<10	>10	Monthly	External Lab ISO
Coagulase-Positive Staphylococci	<20	>100	Monthly	External Lab ISO
Bacillus cereus	<1000	>100,000	Monthly	External Lab ISO
Presumptive Clostridium perfringens	Not detected	Detected	Monthly	External Lab ISO
Yeasts	<10,000	>100,000	Monthly	External Lab ISO
Moulds	<10,000	>100,000	Monthly	External Lab ISO
Listeria ssp	Not detected	Detected	Monthly	External Lab ISO
Salmonella ssp	Not detected	Detected	Monthly	External Lab ISO

Table 5.2.1 Microbiological Criteria, adapted from Food Safety Authority Ireland (Guidance note 3).

Chapter 6

Discussion

6.Discussion:

The purpose and objective of this study was to assess the role of salt in food and carry out a trial to replace salt with yeast extract. Through this study it was hoped to investigate the challenges, risks, and the potential benefits of this replacement. This study was completed within an established manufacturing facility and would follow the general process a company would undertake in order to assess the viability of salt replacement. This study was novel in its approach to consider the intrinsic details of this process. Studies have shown that by reducing the amount of salt consumed by people there is a reduction in the percentage of people showing the adverse health effects and conditions such as blood pressure issues and heart conditions related to high intake of salt. This will have a positive effect on the health care system which would reduce medical costs and pressure on the system as there would be a decrease in the number of people being treated for these medical conditions (W.; Li, N *et al*, 2007). The general concerns are that a lot of the world population use processed food as part of their daily diet. These processed foods contain a high volume of salt and even if people reduce the amount of salt, they use on a daily basis they are still consuming large amounts of salt through these processed foods. This means that even if the population is aware of their daily salt usage (the salt used during cooking or at the table) it still only contributed to a fraction of their daily salt intake (Int. J. Hypertens *et al*, 2012). The challenge for food manufactures will be to meet the UK guidelines on salt reduction targets for 2024, distributed in July 2019, the UK government's Prevention Green Paper committed to continuing to better the nutritional substance contained in food and drink. Concerning salt, the government's desire is to further decrease the population's salt consumption to approximately 7g per day. Development of 2024 salt decrease targets has been developed based on the 2017 salt targets. Compared with 2017 targets, the 2024 targets comprised of a salt cutback set per 100g of food for all segments, retailers, manufacturers, as well as eating out, takeaway, and delivery division (Public Health England *et al*, 2022). The food business sector should work in discussion with the FSAI and other significant organizations to realise a steady, sustained, and universal decline in the salt contents of processed foods and foods formulated by the food service area. The food industry should attribute a high significance to investigations targeted at concentrating on technological processes, shelf-life, preservation, and taste concerns in relation to the decrease of the salt contents of processed food (FSA *et al*, 2016). Similar to Ireland who have implemented a sugar tax, the government could implement a salt tax therefore increasing the cost of foods which are high in salt therefore making them less appealing for the consumer to purchase therefore opting to buy foods with a reduced salt content making the population healthier overall. Grants could also be made available to companies' research and development departments to assist with the trialling and development of foods which contain less salt or salt substitutes.

Seventeen countries (nine in Europe, four in the Americas and four in the Western Pacific Region) reported a reduction in salt levels in one or more product categories and all except Malaysia include a reduction in bread. Five countries (France, Ireland, Malaysia, the UK and USA) reported reductions across a wide range of product categories. Canada, Finland, Italy, and Australia reported reductions in three product categories table 6.1. The approach to industry engagement is one of the key differentiating factors between salt reduction initiatives, with some countries establishing mandatory targets, whilst the majority chose voluntary agreements and others negotiated commitments through meetings (Nutrients *et al*, 2014).

Country	Approach	Method	Reduction in Salt Levels	Timeframe
Argentina	V *	Food analysis	Bread: 18% [21]	2009–2010
Australia [22]	V	Product label survey	Bread: 9% Breakfast cereals: 25% Processed meats: 8%	2010–2013
Austria	V	Industry self-report	Not across the sector-surveyed 112 bakeries and found 30 tonnes of salt reduced in bread/pastry	2011–2013
Belgium	M	Food analysis	Bread: 6% [23]	1990–2009
Canada	V	Product label survey	Not across the sector-small survey of sodium levels on labels found a 11% reduction in pantry breads, 14% in breakfast cereals and 8% in canned soups	2009–2011
Chile	V	Food analysis	Bread (maraquetta): 38% [24]	2010–2012
Finland	V	Food analysis	Bread: 20% [25] Meat products, cheese and ready meals: 20%–25% [26]	1990s–2009
France [27]	V	Food analysis	Bread: 12% Pizzas & quiches: 23% Soups: 32% Mixed dishes: 17%	2008–2011 2003–2011 2003–2011 2003–2011
Ireland [28]	V	Food analysis	White Bread: 18% Wholemeal bread: 29% Breakfast cereals: 30% in biscuit based cereals to 59% in cornflake based cereals Fresh and packet soups: 12% and 19% respectively Cooking sauces: 35% in Bolognese sauce to 71% in black bean sauce Butter: 18%	2003–2013 2003–2011 2005–2013 2004–2012 2007–2011
Italy	V (bread)	Industry self-report (currently being analyzed)	Reductions in baking products, sauces, processed meats (salami, ham)	2013
Malaysia	IM	Industry self-report	Not across the sector. 30 high in salt food items have reduced salt content by 1% to 40% Biscuit categories: 11%–35% Tomato sauce: 9.5%–40% Instant noodles: 2%–20% Flavorings cubes/powder: 1.1%–16% Frozen meat: 13%	2011–2012

Table 6.1 Reduction in salt levels, taken from Target Salt 2025 (Nutrients *et al*,2014).

In our modern society there is continuous awareness on the effects of a high intake of salt. A large percentage of the world population are made aware of the health implications from salt and through this awareness food business operators are positively looking at ways of to reduce the amount of salt used in production or remove salt from products altogether. Since the awareness, many countries have seen a noticeable reduction in the amount of salt used in products by food business operators (Nutrients *et al*, 2014).

The study gave an overview of how replacing salt with yeast extract affects shelf life and organoleptic results in two different products, Sage and Onion Stuffing, and Parsley Butter.

Will businesses be prepared to meet the new requirements of salt targets for 2024-2025 (Nutrients *et al* 2014), will need a few steps to be taken by food manufacturers to meet the new requirement.

- Reducing the total amount of added salt in a recipe. This is best achieved through gradual, incremental changes over time.
- Considering alternatives to flavor food (i.e., herbs and spices) and using innovative approaches to reduce the need for salt whilst still delivering flavor (i.e., incorporating umami).
- Using innovation to reduce salt through a multi-factorial approach, including direct salt reduction, flavor enhancers, and natural flavorings.
- Reducing the use of high-salt ingredients where appropriate; and/or sourcing naturally lower salt versions of high-salt ingredients such as soy sauce i.e., consider using unsalted ingredients: butter, stock extracts and bouillons, tomato/vegetable and herb purees, breadcrumbs, and condiments.

From this research, it has been established that is possible to reduce and replace salt with the alternatives on the market, and to reach the same properties of the product, organoleptic (Appearance, aroma, texture, and taste), and shelf life. But how this replacement will affect the food manufacturers remains to see as how consumers will embrace this change.

Will food manufacturers be able to afford the costs of reformulation?

The costs of replacing salt with yeast extract will affect directly on costs of the end of product and the final price, this will affect the sales. How much these changes will affect the price of the product, will it be affordable?

Will consumers be able to afford the changes in costs?

- For example, in my workplace we produce 867,213 tonne of Sage and Onion Stuffing a year.

Salt per 100kg of finished product = 0.391kg

Salt per 1 tonne of finished product = 3.91kg

1kg salt = €0.46

Cost of salt in 1 tonne of stuffing = €0.46 x 3.91kg = €1.80 per tonne of stuffing

To produce 867,213 x €1.80 = €1,560.9834 costs of salt ingredient.

- To replace this salt with yeast extract for Sage and Onion Stuffing the costs will be:

Yeast extract per 100kg of finished product = 0.300kg

Yeast Extract per 1 tonne of finished product = 3kg

1kg yeast extract = €73.18

Cost of yeast extract in 1 tonne of stuffing = €73.18 x 3kg = €219.54 per tonne of stuffing

To produce 867,213 x €219.54 = €190,387.942 costs of yeast extract for the same quantity.

- Annually production of Parsley Butter its 754,136 tonne a year.

Salt per 100kg of finished product = 0.793kg

Salt per 1 tonne of finished product = 7.93kg

1kg salt = €0.46

Cost of salt in 1 tonne of stuffing = €0.46 x 7.93kg = €3.65 per tonne of stuffing

For 754,136 x €3.65 = €2,752.5964 cost of salt for parsley butter.

- To replace this salt with yeast extract for Parsley Butter the costs will be:

Yeast Extract per 100kg of finished product = 0.600kg

Yeast Extract per 1 tonne of finished product = 6kg

1kg yeast extract = €73.18

Cost of yeast extract in 1 tonne of stuffing = €73.18 x 6kg = €439.08 per tonne of stuffing

For 754,136 x €439.08 = €331,126.035 costs of yeast extract for the same quantity.

The finding of this study shows that food companies aren't prepared to meet the new legislation on salt reduction, costs of reducing salt and replacing salt with one of the alternatives on the market are high and will be a challenge for the manufacturers to afford them. In this research finding the supplier for yeast extract was one of the challenges, the low quantity ordered made the request harder to fill from a supplier, and the high price of the yeast extract. I ordered a small quantity for NPD sample, through a supplier that supply as with other ingredients.

Vulnerability Assessment Critical Control Points VACCP concerns, Vulnerability assessment for food fraud is a necessary aspect of meeting customer and regulatory expectations of safe, legal, authentic product. Food Fraud is the deliberate and intentional substitution, addition, tampering or misrepresentation of food, food ingredients or food packaging for gain. It includes mislabelling and providing false product information which could impact on consumer health or adversely affect customer brands. Food fraud is economically driven and could result in food safety compromise. The price of yeast extract compare with price of salt is much high, has a short life (the quantity ordered will be less compared with salt) this will be a challenged for the supply chain. Another concern is: food manufactures will try to find cheaper alternatives i.e., a yeast extract that cost less (extracted in the lab, no organic etc). The risk of purchasing fraudulent or adulterated raw materials will be increased.

Identification of threats and vulnerabilities			
Raw material	**Threat**	**Vulnerability**	**Probability of the threat occurring**
Salt supply, and other ingredients	Fraudulent replacement	Little cost advantage for the scammer	It can happen
Yeast extract supply	Fraudulent replacement	Little cost advantage for the scammer	Very high

Table 6.1.1 Identification of threats and vulnerabilities of salt and yeast extract

Vulnerability assessment is based on the likelihood of the occurrence of food fraud motivated by economic incentive and deception. The objective of the vulnerability assessment is consumer safety and protection from brand damage, loss of customer trust and adverse financial impact. The range of incidents considered includes.

- Adulteration
- Incorrect labelling
- Grey market and theft
- Dilution
- Unapproved enhancement

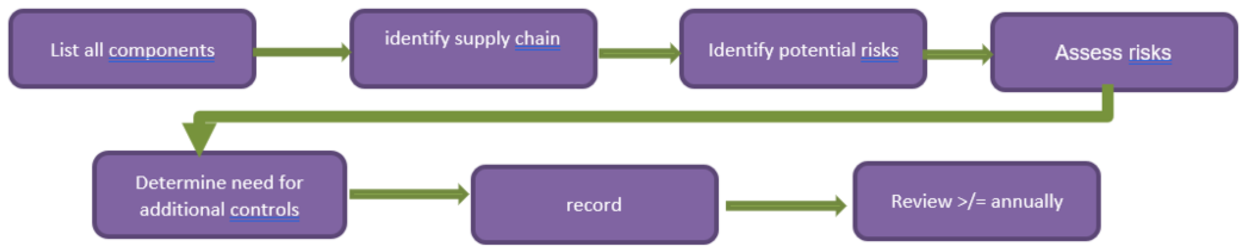


Figure 6.1.2 Vulnerability for each ingredient

Taken together, the findings in this research show that yeast extract is a good alternative to reduce and replace salt, taking into consideration shelf life and organoleptic results for sample 303,304,103, and sample 104.

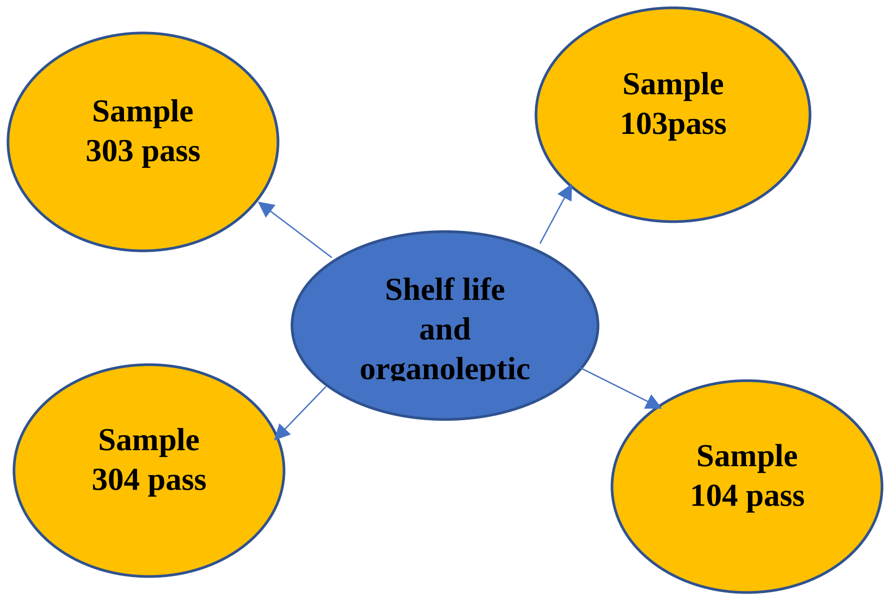


Figure 6.1.3 Shelf life and organoleptic results

Chapter 7

Conclusions, Limitations and Future Work

7.1 Conclusions:

From the research in this study on salt completed and its effect on health, it's proven that the daily intake is high in relation to the Guideline Daily Amount GDA 6g salt per day. The World Health Organization *et al,* 2020 advise that salt intake per adult should be <5g**.** In 2017 salt guidelines were published in the UK and all the Irish retailers began to adapt to the guidelines as well to reduce salt in food products. It focused mainly on retail food products, but guidelines were also developed for food service and restaurants. According to World Health Organization (WHO *et al*, 2020), most people consume on overage 9-12 grams per day or twice than recommended salt intake. In adults, salt intake of fewer than 5 grams per day helps to reduce blood pressure and risk of cardiovascular disease, stroke, and coronary heart attack (WHO *et al*, 2022). The World Health Organization WHO has agreed to reduce the global population's intake of salt by a relative 30% by 2025 (WHO *et al*, 2021). It is a factor that affects our health, and it forms a component of most foods that we consume daily. Salt reduction has been shown to help prevent the level of obesity, heart-associated issues, and high blood pressure in patients. The new legislation will be implemented in 2023 detailing that salt intake should be less than 5g per day per person (UK Guidelines *et al*, 2024)**.** New requirements for salt intake of 6g per day should be reached between 2024 and 2025. The replacement of salt with Yeast Extracts is one of the alternatives. This research and results of this study show that yeast extract gives the same properties and the shelf life of the product (table 7.1.1). Organoleptic testing showed that panellists didn't notice the low salt on sample 304 Sage and onion stuffing and sample 104 Parsley butter, 8 from 10 participants said that they both taste the same. This showed that food producers can use salt substitute. Whilst the panellists did not notice the low salt contents this could show that food producers may not need to use the salt quantities currently being used and may assist with the added health benefits and this will not also effect the shelf life, appearance, taste, and aroma providing a better quality product overall which is also better for overall health.

Shelf-life results showed that yeast extract gives the same shelf life to the product compared with samples that contain salt. But this will be depended on the characteristics of the product, water holding, ingredients, etc. the data from the shelf-life results shows no significant difference in the micro present in samples. Considering organoleptic testing was no significant data between the two samples 303,304 and 103, 104 table 7.1.2 and table 7.1.3

Shelf-life Results							
Samples	**Day 1**	**Day 6**	**Day 12**	**Day 16**	**Day 17**	**Day 18**	**Day 21**
303 Sage and Onion Stuffing that contains Salt	Pass	Pass	Pass	Pass	Pass	Pass	Fail
304 Sage and Onion Stuffing that contains Yeast Extract	Pass	Pass	Pass	Pass	Pass	Pass	Fail
103 Parsley Butter that contains Salt	Pass	Pass	Pass	Pass	Pass	Pass	Fail
104 Parsley Butter that contains Yeast Extract	Pass	Pass	Pass	Pass	Pass	Pass	Fail

Table 7.1.1 Shelf-life results for sample 303,304,103, and sample 104

Organoleptic Results							
Samples	**Day 1**	**Day 6**	**Day 12**	**Day 16**	**Day 17**	**Day 18**	**Day 21**
303 Sage and Onion Stuffing that contains Salt	Pass	Pass	Pass	Pass	Pass	Pass	Fail
304 Sage and Onion Stuffing that contains Yeast Extract	Pass	Pass	Pass	Pass	Pass	Pass	Fail
103 Parsley Butter that contains Salt	Pass	Pass	Pass	Pass	Pass	Pass	Fail
104 Parsley Butter that contains Yeast Extract	Pass	Pass	Pass	Pass	Pass	Pass	Fail

Table 7.1.2 Shelf-life results for sample 303,304,103, and sample 104

7.2 Limitations of the research:

The limitations of this research were time dependent: there wasn't sufficient time to run additional trails, with additional time more trials should be completed in the four samples 303,304,103, and sample 104, and trials in different products that contain a diversity of ingredients to see if replacing salt with yeast extract will give the same results. If this study will be carried out in another food manufacturer is the possibility to have different results outcomes. Shelf-life trials, due to budget constraints were also limited, this would be reflective of the nature of a business the size in which the study was completed.

7.3 Future work:

The study should be conducted on different products to see if we have any changes in shelf life and organoleptic testing, including different factors, i.e., Composition of the product, Origin of Ingredients (climatic effects on the ingredients), Physical/chemical properties (water activity, pH), Treatment & Processing (e.g., heat, freezing, salting), Packaging (modified atmosphere, vacuum etc.), Storage & distribution (with specified temperatures), Target shelf-life Preservation characteristics etc.

Research on yeast extract, shelf life, health benefits, costs, usage etc

Manufacture sector should be helped the part of the study and research, for manufacturers to try to reduce salt and replace it will take a lot of work, human resources, and money.

Education is also needed about salt and salt intake and their effect on our health.

Expand taste panels to consumers outside of the business.

In order for society as a whole to reduce its salt consumption, it could be beneficially for the government to implement a salt tax on products which are high in salt. This will sway consumers to purchase products with a reduced salt content therefore proving beneficial for everyone. The additional income received by the government may be invested in health research and company grants to assist with product development which are in line with salt reduction guideline. As society reduces its salt consumption, it may be found that there could be a reduction in hospital admissions for illnesses related to high salt consumption therefore a saving in the health sector payable by the government.

7.4 Ethical approval:

Ethic category 2 form, approved by TU Dublin, Tallaght.

Chapter 8

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