“Why So Salty?”

Reducing Salt in Meatballs with Heterogenous Distribution

Department of Food Technology, Engineering and Nutrition | Lund University
Maria Thurfjell & Clara Scholander | Master Thesis in Engineering 2022

Lund University
Faculty of Engineering

Master Thesis - Food Technology, Engineering and Nutrition 30 HP

"WHY SO SALTY?"

REDUCING SALT IN MEATBALLS WITH HETEROGENOUS DISTRIBUTION

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15/06/2022

Abstract

Processed food is a big contribution to the increasing intake of salt among the population, which today is the double of the recommendation stated by the World Health Organization. This high intake of salt affects the human health in such a way that it can increase blood pressure, which in turn can lead to cardiovascular diseases, which are already the main cause of death cause among the world's population. A step forward in trying to decrease the intake of salt is thus to lower the salt content in processed food, though this is challenging since the salt both affects the acceptance of the product and other important food characteristics, such as the texture.

The aim of this thesis was to investigate if the salt content in meatballs produced by Orkla Foods Sweden, could be lowered without affecting the salt intensity, and moreover how this decrease would affect the texture and the overall flavour. The strategy used was to immerse the meatballs in a salt solution, leading to an uneven distribution of the salt by resulting in a higher concentration of salt on the exterior than in the interior of the meatball. This should, according to hypotheses, increase the perception of salt, and thereby it was thought that the salt intensity of the meatballs could be retained.

Trials were performed to get an understanding of how the immersion would affect the perception of salt of a neutral meatball and how different concentrations of salt in the batter would affect the texture. Thereafter, meatballs with different salt-in-batter and salt concentration in the solution were combined, resulting in a meatball with around 0.6 %-units less than a reference. The meatballs that best could achieve the aims of this thesis were then evaluated in a sensory evaluation together with a reference meatball and a meatball which has not been immersed in a salt solution but have the same salt content as the combined meatballs.

The result of the sensory evaluation concluded that the heterogeneous distribution of salt in the meatball would not increase its salt intensity, and thereby should not be used as a method for salt reduction in meatballs. It was also concluded that texture parameters, such as cohesion, would be affected, but the juiciness of the meatball and its overall flavour would not be affected when regarding a decrease of salt of 0.6 %-units and less.

Popular Summary - Salt Reduction in Meatballs

Whether it was your favourite lunch during your school years, your go-to dinner solution for stressful days, or simply your main intake during traditional holiday festivities: if you have ever lived in Sweden, meatballs have probably played a big role in your life.

But what if we told you they contain a great amount of salt, and that salt consumption, in fact, is one of the biggest threats to human health today? According to the World Health Organization, the average human consumes twice the recommended salt intake daily. This can be related to cardiovascular diseases, that in turn represent the number one cause of death in the world right now. To be able to lower the salt content of our favourite every-day foods, without changing any taste or texture, would therefore be a dream come true.

In this study, a method of doing this, by unevenly distributing the salt throughout the meatball, was examined. More precisely, the goal was to have a higher concentration of salt on the exterior than in the interior of the meatball. The theory used, was that the salt that we taste, is the salt that is in touch with our taste buds. Therefore, much salt is swallowed without contributing to any salty flavour. Thus, that the saltiness in the first bite of a food, is of importance to our sensory experience. If this method were successful, it could be applied to other processed products and give salt reduction in a great variety of foods.

Concretely, a salt solution was made, where meatballs containing a lower content of salt were immersed, resulting in a salted coating around the product. The best combinations of salt within the batter and on the surface of the meatball were chosen to be tested, along with a reference, and a meatball that had not been immersed but had the same lower content of salt, during a sensory trial. Results from this trial showed that immersing meatballs in salt solution did not make them appear more salty-tasting, and lowering the salt content also made the texture less cohesive. However, they were still seen as both equally juicy and enjoyable as the reference meatball. Possible suggestions for future work were therefore to examine ways to improve texture despite the salt reduction, as this was a major set-back in choosing method-combinations for the sensory evaluation and might have had an effect on the answers and thereby on the conclusion.

Acknowledgements

The work on this project has been a great learning experience for both of us. We have learnt how to work with product development, and have improved our abilities to structure and plan big projects. The conducting of this project would not have been possible without Orkla Foods Sweden, to whom we are very grateful for giving us the possibility to work on their idea, believing in the work we did and letting us use their test kitchen in Eslöv.

We would also like to thank our supervisors, Jennie Otterström at Orkla and Lars Nilsson at LTH, for supporting us with your knowledge and valuable discussions throughout the project.

Thank you to the personnel in the chemistry lab at Orkla, for analysing an awful lot of meatballs, and for explaining the analyses to us. Finally, thanks to Gert Olofsson for always being available to help us during our time in the test kitchen, and to Lars Bolinsson for your help with the texture analysis.

Contents

1. Introduction

1.1 Background

The World Health Organization (WHO) has concluded that the consumption of salt among adults and children today is above the recommendation, and that the salt intake should be minimized to less than 5 g/day for adults. In comparison, the Nordic Nutrition Recommendations (NNR), which the residents of Sweden follow, recommends 6 g/day. Both WHO and NNR states that for the younger population, the consumption of salt should be less than for adults [1], [2]. The explanation for these recommendations is that salt, which in this context is sodium chloride (NaCl), consists of sodium, which is an essential element for basic body functions such as maintenance of nerve impulses and the acid-base balance. However, an excessive intake of salt can have devastating consequences on the human health, as it will impact the blood pressure which will increase. This can in turn increase the risk of cardiovascular diseases and stroke [1].

A step forward in trying to solve this problem is to decrease the salt content in processed food, since it is a big contribution to the excessive intake of salt [3]. Therefore, this project was in collaboration with Orkla Foods Sweden, who in turn collaborates with RISE and other companies in the Vinnova-financed project "ReduSalt". The goal of "ReduSalt" is to lower the salt intake among the population by implementing methods to reduce salt in processed food [4]. This project will investigate if the salt content in meatballs can be reduced by distributing the salt heterogeneously throughout the product. If the method succeeds it could be a success for the human health, as meatballs are a daily food product on the dinner table for families, in schools and in restaurants.

1.2 Objectives

The aim of this project was to investigate if the salt content in meatballs, produced by Orkla, could be decreased without compromising on the salt intensity. Moreover, it was to investigate how the decrease of salt would affect the texture and the overall flavour. The strategy for this investigation was to distribute the salt unevenly throughout the meatball by immersing the meatball in a salt solution during the production, resulting in a higher concentration of salt on the exterior than in the interior of the product.

To be able to reach this goal, the experimental design was divided into two parts. During the first part, two trials were conducted. One trial investigated how different concentrations of salt in a salt solution would add up to the total amount of salt in the overall meatball and how salty this would appear. The other trial investigated how added salt affected the texture of the meatball, by using different amounts of salt in the batter. These meatballs were then compared to a reference meatball, which was also prepared in this part. The second part was conducted by analysing the results from the first part, which gave an understanding of how to combine the amount of salt in the batter and the concentration of salt in the solution. Several combinations were then made to receive a meatball that could be comparable with the reference meatball. The two meatballs that had the highest probability of answering the objectives were chosen for a sensory evaluation. During the evaluation, two more meatballs were also tried, one containing the same amount of salt as the two combinations but not immersed and a reference. This was done in order to find differences or similarities between all of them.

1.3 Specific Aims

To investigate if the method used to reduce the salt content would affect the perception of salt and how it would affect the texture and overall flavour, this report aims to answer the main task by using the sub-tasks as support.

Main task:

- How does the perception of the salt intensity change when lowering the amount of salt but distributing it as a gradient throughout the product, and how does this affect the overall flavour and texture properties?

Sub-tasks:

- How does the sensory attributes, such as salt intensity, overall flavour and texture properties, of the meatballs change when lowering the amount of added salt?
- How can the salt best be distributed to receive a minimum salt-taste difference despite a lower concentration of added salt?

1.4 Scope and Limitations

The scope of this project was to investigate if the salt content could be decreased without compromising on the salty taste by distributing the salt heterogeneously in the product and how this would affect the texture and overall flavour. Thereby, no trials for investigating if other methods could lower the salt content without affecting the salty taste were conducted. Likewise, no other trials were conducted to improve the texture if the result showed that the texture changed.

The work of this project was performed from January to June 2022 during a total of 20 weeks. Thereby, the time for experimental trials was limited. Moreover, all analyses of the product, except for the texture analysis, were made by the personnel in the chemistry lab at Orkla in Eslöv. Therefore, the authors were not as involved with the analyses as they would have been if they had been made by themselves. However, they received good information from the lab on how the analyses were performed, and could always contact them if there were any questions.

Furthermore, as the experimental trials were performed in a test kitchen, the process parameters were not exactly the same as the parameters used in production. Moreover, the sensory evaluation performed on the meatballs in the end were only considering the meatballs alone and not meatballs as a complete meal. Both of these examples may have an influence on the outcome of some results.

2. Theoretical Background

2.1 Meat Proteins

In the following sections, the meat proteins and their functionality in relation to salt content will be described.

2.1.1 Meat Proteins

Meat tissue consists of four different main components. One of them is water, which takes up roughly 75 % of the total meat tissue. Proteins are the second-biggest component with a total of 22 %, and the last percentage are intramuscular fat (2-4 %) and other components (2 %) [5]. The meat protein content is divided into three classes due to their different solubility. These three classes are sarcoplasmic, myofibrillar and stromal proteins [6].

Sarcoplasmic proteins are mostly water-soluble (some are soluble in very low concentrations of salt) and are the second-largest group of the meat proteins (30 %) [5]. The proteins in this group are for example haemoglobin, myoglobin, and glycolic enzymes. They are distributed in the sarcoplasma of the tissue, and myoglobin is the protein responsible for giving the meat its red colour [6].

Myofibrillar proteins are the main fraction of the three classes and are salt soluble. 50 % of the meat proteins belong to this class, and the main proteins are actin and myosin. Actin and myosin are responsible for building up the thin filament and the thick filament in the muscle respectively [5].

The last group are the stromal proteins, these proteins are non-soluble in water and in salt solutions. The main proteins in this group are collagen and elastin [6].

2.1.2 Solubility of the Myofibrillar Proteins

As mentioned in section 2.1.1 the three different classes of meat proteins have different solubility. Since this project regards reducing the salt content in meatballs, the salt soluble proteins, the myofibrillar proteins, will be discussed in this section, as their solubility will be affected by changing the salt content.

The functionality of the myofibrillar proteins is connected to their solubility. When solubilised they can support the gelation process, incorporate water, and emulsify fat. The amount of salt, i.e. ionic strength, is an important factor for solubility [7]. The task of the salt, most often NaCl which dissociate into Na^+ and Cl^-, is to interact with the opposite charge residues of the myofibrillar proteins, since it has both positively and negatively charged residues. The amount of positive contra negative residues on the protein will depend on the pH and increasing the salt content will increase the solubility after a certain concentration, but the forces responsible for the solubilisaton are discussed [8]. Gerald Offer and John Trinick [9] showed in 1983 that electrostatic repulsion between the proteins due to interaction of Cl^- was responsible for the increasing solubility of the protein [9]. Another study, made by Lijun Wu et al. in 2016 [8] instead concluded that repulsive hydration forces, where ions have been hydrated and absorbed to the surface, were responsible for the increased solubility with increased salt content [8].

The pH will influence the solubility as it affects the charges of the protein surface. The myofibrillar proteins have an isoelectric point (pI) around 5.3, meaning that if the pH is equal to this pI, the net charge of the protein is zero, meaning that the proteins are equally negatively and positively charged. With a higher pH, there are more negatively charged residues and at a lower pH there are more positively charged residues. Lijun Wu et al. [8] made a study on extracted myofibrillar proteins and how pH and salt affected their solubility. The results showed that, depending on the pH, the amount of salt needed for an increased solubility of extracted myofibrillar proteins will vary. This gives an idea of how pH can have an effect on meat products. The result of the study can be seen in Figure 1 [8].

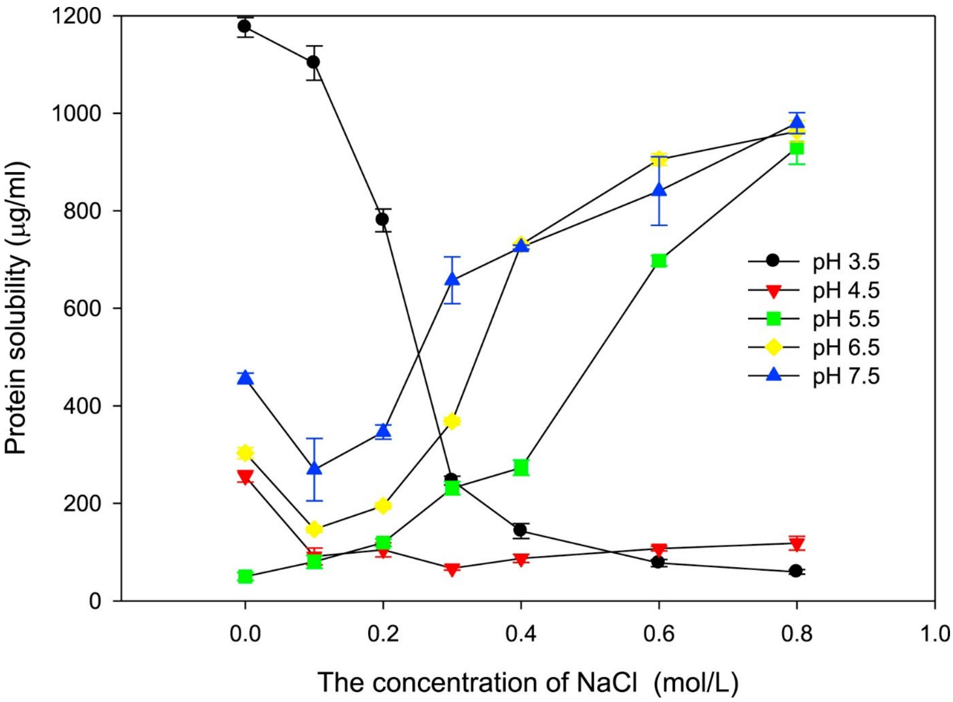

Figure 1: The solubility of myofibrillar proteins, depending on pH and salt content [8].

As the figure shows, if no added salt, the solubility at pH 7.5 was higher than for pH 6.5, and for both these pH, the solubility decreased with small additions of salt. When adding salt above 0.2 mol/L the solubility increased again. For a pH closer to the pI, the addition of NaCl increased the solubility. For a pH below pI, an increase in NaCl decreased the solubility [8].

As can therefore be understood, pH will be an important parameter for how much salt that is needed to receive an adequate solubility of the myofibrillar proteins [8].

2.1.3 The Gelation Process and its Functionality

In meat products, the three different classes of meat proteins have different roles. Sarcoplasmic proteins can work as an emulsifier due to its high surface activity, and stromal proteins might affect the structure due to collagen, which can form gelatine in appropriate cooking conditions. Myofibrillar proteins will have a key role in processed meat products, due to its ability to form a gel, to hold water and to emulsify fat. The ability to form a gel is limited, both by the sarcoplasmic and stromal proteins. Thus, the gelation of myofibrillar proteins will have an impact on the texture of the meat product [7], such as the hardness and the cohesiveness of the product [10].

To be able to have these functionalities, myofibrillar proteins must be solubilized and for this, salt is an important compound (see section 2.1.2). When solubilized it can function as an emulsifier of the fat when making the meat batter, and it also enables it to form a gel during the heat treatment [11]. During heat treatment, the gelation process is induced. Myofibrillar proteins are believed to create two kinds of gels, one which the myosin itself is responsible for, the myosin gel, and one which is formed by the different kinds of myofibrillar proteins, a mixed myofibrillar protein gel. The latter is the gel which is mostly formed in meat products [7].

When making the batter, the meat proteins will create a network which will be formed by different interactions, both due to the interaction between the proteins, but also between proteins and fat or water respectively. When heat treatment is applied, the denaturation of the meat proteins will occur, meaning that the protein will begin to unfold and expose new areas. These exposed areas will reveal more hydrophobic interactions between the proteins, leading to further aggregation and creation of a gel [12], a formation of a 3D-network. How strong the gel is will depend on the amount of salt. At a concentration of 0.6-0.8 % NaCl in meat, comparable to 0.2 mol/L, the gel created is more brittle, and increasing salt concentration will give a more adequate gel formation, around 2 % in meat. However, the gel is not dependent on the concentration alone, pH, protein concentration, and heat treatment will affect the formation of the gel as well [7].

This network will entrap water and thus impact the water holding capacity [13], which will be explained in the following section.

2.1.4 Water Holding Capacity and its Effect on the Texture

Water holding capacity (WHC) is described as the water that is enabled to be retained to the meat while it is processed, for example during mincing and cooking. The WHC is an important parameter since it will influence the cooking loss and the sensory properties of the product, such as the juiciness, which influences the acceptability of the product. The WHC is affected by the gel creation and thereby it is impacted by the solubility of the myofibrillar proteins, and thus the salt concentration. Increasing the NaCl content will increase the WHC, and more moisture will be stuck in the gel, perceived as juicier. On the opposite, a lower WHC, will result in a stronger water release during cooking, giving a higher cooking loss and lower water content in the finished product. This influences the perception of the product as drier [14].

A study made by Xiong et al. [15] showed that increased cooking loss due to a lower content of NaCl in frankfurters, affected the hardness and the cohesiveness (texture parameters) which were increased. These results were suggested to be a consequence of fewer proteins being hydrated, leading to a harder texture of the product. However, this result was the opposite of other studies, which showed a decrease in these parameters [15].

2.2 Salt

With salt reduction being the main goal of this project, information regarding sodium chloride, its effect on food, health and potential salt reduction methods will be described in the following sections.

2.2.1 Salt as Taste Contributor

In everyday language, salt refers to the chemical compound sodium chloride (NaCl). When consumed, NaCl is perceived as salty. This is due to the positively charged sodium ions which are detected by cation channels in the mouth. In foods, these sensory channels are reached when the ions are released into the saliva during eating. Throughout history, NaCl has been added to foods by humans, presumably both as a means of food preservation and for taste reasons [16]. Because in many foods, an addition of NaCl typically increases the liking. At a certain point, this liking of NaCl reaches its peak and adding more decreases its likeability. This point can be found by examining the acceptance of NaCl concentrations of consumers. However, the optimal concentration varies based on, for example, the salting habits of different individuals [17].

Saltiness, along with sweetness, bitterness, sourness, and umami are often referred to as the five basic flavours. Still, food products have more complex flavour profiles than only these five. Additional flavours that contribute to the taste of a food, are volatile aroma compounds. These are detected in the nasal cavity as air compounds that have been released from the food matrix. Apart from giving a salty taste, the addition of NaCl has been seen to affect the perception of foods. Some effects are improvement of product thickness in liquids, enhancement of sweetness, masking of certain off-notes, improvement of flavour intensity and rounding out of overall flavour. Even though the mechanisms for this are not fully understood, there are theories. For example, NaCl decreases water activity, which could in turn increase the flavour concentration and volatility of aroma compounds. When more aroma compounds are released to the nasal cavity, flavour is increased [16].

2.2.2 Salt and Health

Sodium is essential to the human body and has roles such as maintaining the acid-base balance, transmitting nerve impulses, and sustaining normal cell function. For this functioning, a minimum daily intake of 575 mg has been estimated. Almost all ingested sodium is taken up by the body, and the main excretion way is through the urine via the kidneys [18].

However, a large sodium intake is related to high blood pressure. The mechanisms behind this are much debated, but evidence exists. High blood pressure is in turn a major risk for cardiovascular disease, and cardiovascular diseases are the main cause of death throughout the world today [19], [20]. In parallel, several studies have shown that a decrease in sodium intake, can lower blood pressure. Due to this, a recommended limit of <2 g sodium/day, corresponding to 5 grams of NaCl per day, has been set by the WHO. As a comparison, the Nordic population target is 6 g/day, and the common daily intake of the human population is estimated to be between 9-12 grams daily [18], [21].

2.2.3 Salt Reduction Methods in Food Products

Industrially reducing NaCl in foods face several challenges, some of which are technical and some due to consumer acceptability. The most prominent of these techniques, will shortly be described below.

2.2.3.1 Reducing by Stealth

Reducing by stealth means gradually and slowly changing the recipe of a product so that it contains less NaCl. By doing this in several steps over a long time, the consumer does not notice the change and in the end, a big reduction can be made. However, this strategy is limited to the functions the NaCl displays in the product and cannot be reduced lower than the acceptability limits of these functions. Another limitation is that the brand preference of the food product could change due to the salinity change, and reducing by stealth should then in an ideal world require the lowering of NaCl by all manufacturers of the product category [22], [23].

2.2.3.2 Replacement and Enhancement by Other Ingredients

By using molecules that stimulate the same receptors as NaCl, similar salty effects can be experienced even though the dangers of sodium have been removed. Therefore, other salts as well as mixtures of these with NaCl have been tried out as NaCl replacers. Examples of these are lithium chloride (LiCl), ammonium chloride (NH_4Cl) and, most feasible, potassium chloride (KCl). Unfortunately, LiCl and NH_4Cl, are unstable and give smell. Lithium is also considered toxic, and combinations of these downsides make these NaCl replacers non-optimal. KCl has successfully been used in several partial NaCl substitutions, and mixtures of NaCl and KCl salts are commercially available. The downside of KCl is however that the potassium provides not only saltiness, but bitterness as well. It could also potentially be harmful to some groups of people, for example those suffering from type 1 diabetes and particular renal diseases [23], [24].

A strategy to hide bitter tastes from KCl, or to enhance saltiness, is to use Monosodium glutamate (MSG), various peptides or other umami-inducing flavours. One implication in using MSG, known for its umami characteristics that bring an increase in body and experience of other flavour compounds, is that it also contains sodium itself. Thus, an addition of MSG with the goal of lowering NaCl could result in an unchanged or greater amount of sodium [22]–[24].

As earlier mentioned in section 2.2.1, NaCl is a flavour carrier, and reducing NaCl may result in a suffering flavour profile. By simultaneously giving stimuli to other receptors than the ion channels giving saltiness, tastes can be both suppressed or enhanced. This can be practised by using aroma-compounds. For this to be successful, the aroma-compound enhancing the saltiness must be tested for the individual product [23], [24].

The sections above have mentioned substances that can affect the flavour to help reduce NaCl content. However, by making use of compounds that alter the texture of the food similarly to how an addition of NaCl would, the NaCl reduction can also be increased. Examples of compounds useful for this in meat products, are phosphates. They can improve sensory aspects and emulsion stability of NaCl reduced products [24]. By adding phosphates, pH rises and becomes further away from the pI, which increases electrostatical forces between proteins. With this increase, the proteins can retain more water. Thus, addition of phosphates lead to increased water holding capacity. This effect of phosphates is increased by adding NaCl, acting in synergy with each other [24], [25]. Several other ingredients, such as hydrocolloids, fibres, functional proteins and starches have also been tried as improvers of meat texture. They act as binding agents through protein coagulation and gel formation, and do not directly react with the meat proteins [24].

2.2.3.3 Changing the Physical Form

In changing the shape of the NaCl crystal, the functional properties of NaCl can be optimized. A reason for this, is that very large crystals do not dissolve enough for all available ions to reach the ion channels of the mouth, and therefore much NaCl is swallowed without contributing to any taste. Altering the shape of the NaCl, so that receptors are reached to a larger extent, could then increase the NaCl experience. Smaller crystals with low bulk density give a larger surface area and dissolve quicker. Crystals that have a dendritic shape similarly have a large surface area and a faster dissolution. Other studies state that flake-crystals give better solubility, cooking yield and higher pH, leading to increased solubilization of myofibrillar proteins, compared to granular crystals [23], [24].

2.2.3.4 Heterogeneous Salt Distribution

Studies have shown that a heterogeneous distribution of NaCl in foods, gels and solutions result in an enhanced perception [26]–[30]. For example, Meiselman and Halpern [28] showed that by changing the concentration of NaCl in a solution, delivered in pulses, the experience of saltiness is increased. The effect is explained as due to a hindrance of the taste receptor adaptation response, which occurs during long and continuous exposure to high NaCl doses [28]. Noort et al. [26] who reduced the NaCl content of bread by a non-uniform distribution, found this enhancement of perception to increase with the contrast. This would mean that the larger the NaCl concentration difference within the product, the saltier the product is perceived. Thus, by minimizing the mass diffusion, movement of NaCl due to a concentration gradient, in the product, the NaCl experience for that specific salinity could be maximized [26].

Because meatballs and other meat products are high moisture foods, mass diffusion occurs easily and creating a heterogeneous NaCl distribution is therefore difficult. However, one study, made by Xiong et al. [15] examined this theory by creating an edible NaCl-coating on frankfurter sausages. The coating was made from NaCl, water, gelatine and sorbitol, and NaCl concentrations were made in a range between 1.5 % to 15 %. With this strategy, researchers were successful in reducing the NaCl content by more than 50 % whilst maintaining experienced salt intensity, pH, colour, and a high consumer acceptability. Most successful in sensory acceptability were the frankfurters with a coating of 7.5 % and 10.5 % NaCl content. However, in all samples, problems with the gel forming ability in meat occurred, which in turn affected the texture and juiciness. Nevertheless, the study showed possibilities for future NaCl reduction experiments using salted coatings [15].

Mass diffusion of NaCl occurs when there is a concentration gradient, where high concentration NaCl areas migrate towards lower concentration NaCl areas. Things that could affect the NaCl mass diffusion in meat is, amongst others, the water content, the NaCl concentration gradient, the temperature and the pH. Where the NaCl mass diffusion is increased when increasing water content, increasing NaCl gradient, increasing temperature and lowering pH (5.4-5.5) [31].

3. Materials and Methods

3.1 Materials

For the experimental trials, the innovation kitchen at Orkla in Eslöv was used. The recipe for a reference meatball was provided by Orkla, and the ingredients needed for this, i.e. meat, potatoes, onions, and dry ingredients, were supplied by the company. Process parameters to imitate production, were also provided by Orkla. Ingredients and parameters used are further explained in the following section and can be seen in Figure 2 in section 3.2.

To analyse the meatballs made during the trials, the chemistry lab at Orkla was used to analyse water content, pH, and NaCl content. For texture analysis, the TA-XT2i texture analyser from Stable Micro Systems at Kemicentrum at the Faculty of Engineering, LTH, was used.

3.2 Experimental Set-up

The aim to heterogenously distribute the NaCl, was to be achieved by immersing meatballs in a solution of NaCl and water, creating an external NaCl coating on the meatball. Firstly, a meatball using the given recipe by Orkla was made to be used as a reference throughout the study. Thereafter, meatballs with no added NaCl into the batter, but immersed in different NaCl concentration solutions were made, to examine how an immersion would affect the total NaCl content. Then, meatballs with added NaCl, but with less so than the reference, were made, to evaluate how this would affect NaCl content but also texture. Lastly, the two methods were combined and from these, two combinations were chosen for the sensory evaluation. The different trials are described in Table 1 below.

Table 1: Overview of the different trials.

Trial	**Modifications of reference recipe**
1. Reference meatball	None
2. Different concentration solutions	Remove added NaCl from batter. Make three batters immersed in NaCl solutions of 5 %, 10 % and 15 % respectively.
3. Different concentration batters	Change amount of added NaCl in batter to 0.5 %, 0.75 %, 1 % and 1.25 %.
4. Combinations of solutions and batters	Use results from trial 2 & 3 to make combinations of the methods.

The method of making, cooking and immersing meatballs will be described in order below, and an overview can be seen in Figure 2.

Before any experimental trials could be done, the meat for the batters had to be minced. The meat used during the trials were from the same batch and was minced on the first day and subsequently stored in a freezer until being used in meatball batter. The meatballs made for the sensory evaluation were made from a new batch of meat that was minced and frozen in the same way as that used for the experimental trials.

As mentioned, the reference meat batter was made according to a recipe given by Orkla, and the modified recipes were based on this. Using a stick mixer, onions and potatoes were firstly mixed to purées and added to the minced meat. Together, these were blended in a household appliance from Kitchen Aid for two minutes. Measured dry ingredients were then added and blended for two more minutes. Finally, water was added, and the meat batter was blended for one minute. The homogenous meat batter was then divided into samples of specified weight and rolled into balls. The meatballs were then cooked in a convection oven from Rational for approximately 5 minutes at 250 °C and 50 % humidity to simulate the process. In connection to the cooking step, the meatballs were immersed in a NaCl and water solution for five seconds.

For each finished experiment, 1500 grams of meatballs were collected for pH, water content and NaCl content, giving 500 grams in each triplicate, and the meatballs that were left were used for texture analysis. All finished samples were tasted before freezing and afterwards to receive a hint of the perception of salt and texture compared to the reference meatball.

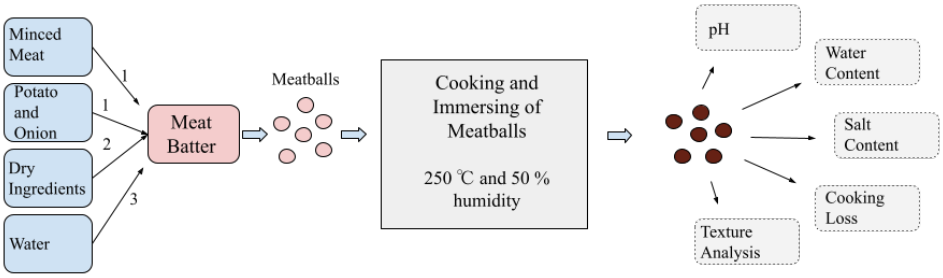

Figure 2: Figure displaying an overview of how the meatball process was performed.

3.2.1 Reference Meatball

Prior to all other experiments, a reference meatball using the original meatball recipe was made to be used as a reference to all following meatballs. The reference had the highest amount of added NaCl in the batter and was not immersed in a NaCl solution. The reference meatball batter of 2.5 kg was prepared as described in section 3.2. The analyses of the batters were made in triplicates.

3.2.2 Different Concentration Solutions

To examine how different NaCl concentration solutions would affect a neutral meatball, three meatball batters of 2.3 kg each were made, according to the recipe given by Orkla, but excluding added NaCl in the batter. Solutions of 5 % w/w, 10 % w/w and 15 % w/w NaCl concentration were prepared. Each of the three batters were divided into three, and each of the three concentrations were tested for all three batters, giving analyse triplicates.

3.2.3 Different Concentration Batters

For this experimental trial, different concentrations of NaCl in the meatball batter were prepared. The aim was to get an understanding of how much NaCl that was needed to receive a proper gelation of the meat proteins, and thereby a texture similar to the reference. The meatball batter contained 0.5 % w/w, 0.75 % w/w, 1.0 % w/w and 1.25 % w/w added NaCl, respectively. For every concentration, a meatball batter of 2.3 kg was prepared in the same set-up as mentioned in section 3.2 but changing the amount of added NaCl to the batter, and not immersed in a NaCl solution. The analyses of the batters were made in triplicates.

3.2.4 Combinations of Solutions and Batters

Using the results from the trials above and calculating their increase in NaCl content, a method to choose combinations with a reduction of NaCl was found, and from this method seven different combinations of immersion and NaCl-in-batter were chosen. These were calculated to receive NaCl decreases of 0.3-0.4 %-units from the result of the reference meatball. For all the combinations, batters of 2.3 kg were prepared in the same set-up as mentioned in section 3.2 but changing the amount of added NaCl in both batter and solution. The analyses of the batters were made in triplicates. Further information on the chosen combinations and discussion behind why they were selected and how the method for evaluating NaCl increase was done are described in section 4.4.

3.3 Analyses Performed on the Meatballs

3.3.1 Texture Analysis

As mentioned in section 2.1.3, the gel formation of the meat proteins will affect the texture and thereby a texture analysis was performed. To perform the texture analyses, a texture profile analysis (TPA) was performed using a TA-XT2i texture analyser from Stable Micro Systems. The analyses were performed in room temperature and the samples were prepared in triplicates. Samples were removed from the freezer into the fridge the evening before, in order to thaw. For each TPA, a full-size meatball was used. To compress the sample, a cylindrical probe with a diameter of 35 mm was used. The probe was set to compress the sample twice, with a pause of 5 seconds in between, called a two-cycle compression. The sample was compressed with 25 % with a speed of 2 mm/s and the applied force was 5 g, equal to 0.049 N. From the TPA, values of three different parameters were collected; hardness, cohesiveness, and gumminess. Hardness and cohesiveness were chosen since it was seen in section 2.1.4 that these parameters were affected by the cooking loss and water holding capacity. As gumminess is the product of these two parameters, it was also analysed. The values obtained during the texture analysis were compared to the reference meatball, to get a numerical difference between the meatballs. Their definitions can be found in Table 2.

Table 2: Parameters analysed during texture analysis.

Texture Parameters	**Definition**
Hardness	*The force needed to compress the sample the first cycle [32], in these analyses to compress it 25 %.*
Cohesiveness	*The ability of the sample to tolerate the second compression, compared to the first compression. This also refers to the internal bonds and their strength [32].*
Gumminess	*Used for semi-solid foods. How much energy needed to decompose the sample before it can be swallowed. The product of hardness and cohesiveness [32].*

3.3.2 pH-measurements

Given that the pH of the meat affects the solubility (see section 2.1.2) a pH analysis of each trial was done. The method, AOAC 981.12, uses an electrode connected to a pH-meter to measure the pH of the semi-solid meatball, blended into a paste. 10 g of paste was combined with 10 mL of distilled water and pH was then measured by the electrode. Before the measurement, the pH-meter was calibrated using buffers with pH 4.01 and 7.0. The measurements were made at the same temperature as the calibration ± 5 °C.

The pH-analysis had a measurement uncertainty of ± 0.1 pH-units.

3.3.3 Salt Content Measurements

The main goal was to reduce NaCl content in the product and to check for this, a NaCl content measurement using Corning 926 was done on each sample. Corning 926 is an instrument (Sherwood MKII Chloride Analyzer 926, Sherwood Scientific Ltd. England) measuring chloride content using coulometric titration of silver ions as the silver ions and chloride create an insoluble salt. The silver ions pass between electrodes at a constant current. When all chloride ions are used up, excess silver ions result in a conductivity change which is noticed by detector electrodes and give an end to the measurement. The chloride content measured can be directly converted into NaCl content. The homogenized meatball paste was diluted with distilled water to receive a chloride value of between 200-600 mg/L. After leaving the solution for at least 15 minutes, the fluid was filtered out and measured by the electrode.

The instrument had a measurement uncertainty of ± 8 %.

3.3.4 Water Content Measurements

Because water holding capacity is affected by the NaCl content, the water content of finished meatballs was measured. To determine the water content, the method NMLK no 6 was used. 5 g of homogenized meatball paste was placed in a container, where weight was recorded, and put overnight in a 105 °C oven until all water had evaporated. To check if all water had evaporated, the samples were removed from the oven and weighed, and then placed back into the oven for one more hour. This procedure was repeated until two measurements after each other showed the same weight. After it had stabilized, Equation 1 was used to calculate the dry matter (TS). To transmit it into water content, the TS value was subtracted from 100.

$$TS = \frac{w_a - w_c}{w_b - w_c} \tag{1}$$

Where w_a is the weight of the container and sample after drying, w_c the weight of the container and w_b the weight of the container and sample before drying. The analysis had a measurement uncertainty of ± 2 %.

3.3.5 Cooking Loss of Meatballs

Apart from doing a water content measurement, an initial idea of the water holding capacity was found by directly calculating the cooking loss. This was done by weighing the meatballs before cooking in the oven (w_1) and after cooking in the oven (w_2). The cooking loss was then calculated using Equation 2.

$$Cooking\ Loss = \frac{w_1 - w_2}{w_1} * 100\ \% \tag{2}$$

The scale where the meatballs were measured had a measurement uncertainty of ± 0.1 gram.

3.4 Sensory Evaluation

When the meatballs of different combinations of NaCl-in-batter and NaCl solution had been made, these were tasted to check for saltiness and texture properties. The most adequate meatballs from this trial, according to the analysis results and personal perceptions of the meatballs, were chosen to be evaluated in a sensory evaluation together with the reference meatball and a meatball with less NaCl in the batter. The meatball with less NaCl in the batter had the same overall NaCl content as the combination meatballs, when considering the measurement uncertainty of 8 %. This meatball was a part of the sensory evaluation to be able to evaluate if the method of immersing the meatball in a NaCl solution would make the meatball to be perceived as saltier. The meatballs evaluated in the sensory evaluation can be seen in Table 3.

Table 3: Table of the four meatballs evaluated in the Sensory Evaluation.

Meatballs Evaluated	**NaCl Content**
Reference meatball	2.1 %
Meatball with 0.5 % NaCl in batter, 17 % NaCl solution (Sample 1)	1.5 %
Meatball with 1.0 % NaCl in batter, 5 % NaCl solution (Sample 5)	1.6 %
Meatball with 1.0 % NaCl in batter	1.5 %

The chosen sensory evaluation was an analytical, descriptive sensory evaluation. Panellists in these types of evaluations are often trained, which means that they have been educated in the different attributes that should be evaluated. Thus, they should have the same understanding of what these attributes consider and be able to understand each other when analysing them [33]. The time and the expertise to be able to educate a panel for this sensory evaluation was limited, and thereby no training of the panellists was made. However, the sensory attributes that were evaluated were both attempted to be described in writing thoroughly in the hand-out form for the evaluation, as well as described verbally by the authors before the panellists started the test.

According to Lawless and Heyman [33] there are some principles which are good to follow when planning and implementing a sensory evaluation. When the principles are followed, the result will be more accurate and reliable since the data is collected with a consistent method. The principles pointed out includes the environment where the evaluation is implemented and how the evaluation setup should be considered. The environmental aspect brings up the importance of having a room where the panellists are separated from each other, but also about the climate in the room, meaning a temperature around 20-22 °C and that the room is free from any odour. The evaluation setup includes sample size, serving temperature, containers, palate cleansing, instructions to the panellists and randomization and blind-labelled samples but also how many samples and how the panellist shall be recruited, amongst others [33]. These principles were followed to as high extent as possible during the sensory evaluation to try to optimize the results.

The aim with this analytical, descriptive sensory evaluation was to answer the objectives of the project (see section 1.2). Thereby, the questions in this evaluation were connected to the sensory attributes; salt intensity, overall flavour intensity, juiciness, hardness and cohesion of the product. The evaluators evaluated these attributes from a scale from one to seven. The panellists also evaluated their liking for each sample, since it was good to receive information about how sensory attributes will affect the acceptance of the product. According to Carpenter et al. [34] at least 30 panellists should participate in a ranking sensory evaluation [34]. The room available to perform the sensory evaluation was located at Kemicentrum, LTH, a room prepared for sensory evaluations. This room only had place for eight persons at a time, and thereby the evaluation was divided into six subgroups leading to an overall of 48 places. 30 persons signed up for the sensory evaluation. For every subgroup the following method was used: The meatballs were prepared before the sensory evaluation began. The meatballs were cooked in a convection oven for ten minutes in 160 °C and 20 % humidity to an inner temperature of 70 °C. The meatballs, which were prepared by the authors, had somewhat different size and shapes both within the group of meatballs and between the group of meatballs. This was unfortunately difficult to avoid, but many meatballs were made and the more similar ones were chosen for the evaluation. Before the panellists arrived, their places were arranged with evaluation forms, cups of water and crackers for neutralization of the palate. When they arrived, instructions were given to them orally, to inform them how the evaluation would be executed and how the meatballs should be ingested, including information on consumption of water and crackers in between tastings of different meatballs. They were also told to read the instructions in the evaluation form.

Thereafter, the samples were placed on white paper plates with three-digit codes and served to the panellists. All subgroups were advised to not speak about opinions of the samples with people from subsequent subgroups, to avoid subjective results. The front page with information, as well as an example of a sample questionnaire can be seen in Figures D1 and D2 in Appendix D.

3.5 Statistical Analyses

One-way Analysis of Variance (ANOVA) with a confidence level of 95 % (alpha equal to 0.05) was made on the results of all analyses at every trial respectively to check for statistically significant differences between the means of the results. For the trials, the null hypothesis (H_0) stated that all the means compared within the experimental trials were equal. ANOVA calculates an F-value, and a critical F-value (Fcrit). When the F-value value was found to be larger than Fcrit, it was concluded that a significant difference existed between the different results [35]. ANOVA was calculated using Excel version 2112 with the assumption that the results were normally distributed.

While one-way ANOVA shows the existence of a significant difference within the result, it does not distinguish which pairs this applies to. Therefore, when one-way ANOVA found a significant result, the Tukey-Kramer post-hoc test, at a 95 % confidence level, was used. Tukey-Kramer compares the difference of the means of a pair to a critical Q-value. When the difference exceeds this value, a significant difference between the pairs is concluded [36].

One-way ANOVA was also used for the results of the sensory evaluation, which was assumed to be normally distributed, to see if there were any significant differences between the evaluated meatballs. Since individuals have different scale references and may answer differently according to this, the results from the raw data were centered and standardised, to be able to rightfully compare the answers. Centering the data, gives the variable average a value of 0. Standardising the data, also called using z-scores, makes use of the centered value to give the variables a standard deviation of 1. All the data will then have the same scale [37].

When the results are presented, in tables and figures, the values or staples with different letters are significant different from each other.

4. Results and Discussion

4.1 Result of the Different Concentration Solutions

Meatballs containing no added NaCl in the batter, immersed in 5 %, 10 % and 15 % NaCl solutions were analysed and compared to the meatball made with the original recipe (the reference). Results from the analyses are found in the sections below. A summary of these results is presented in Table A1 in Appendix A. The raw data and one-way ANOVA together with Tukey-Kramer post-hoc test is presented in Table A2 -A17 in Appendix A. For this part of the results, no professional sensory evaluations with external participants were made, but all meatballs were tasted and examined by the authors to give a sense of the sensory attributes.

4.1.1 Salt Content

Analyses of NaCl content showed the reference containing an average of 2.1 % NaCl, the 5 % solution an average of 0.47 % NaCl, 10 % had an average of 0.67 % NaCl and 15 % an average value of 0.87 % NaCl, as can be seen in Figure 3. One-way ANOVA analyses and Tukey-Kramer post-hoc test showed a significant difference between all samples ($F=648.33 > Fcrit=4.07$). During tastings, the 5 % NaCl immersion gave nearly no salty perception, while the 15 % NaCl immersion was found rather salty on the surface. The 10 % NaCl immersion was perceived somewhere in-between.

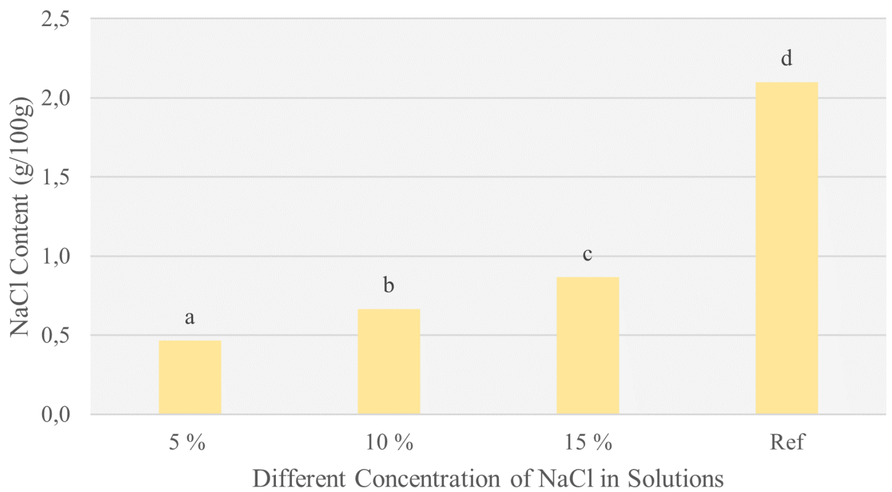

Figure 3: Graph showing the average NaCl Content of meatballs (g/100g) with no added salt in the batter immersed in different percentages of NaCl solutions, as well as a reference meatball, a meatball with NaCl added to the batter and not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. Compiling a linear regression on the NaCl content in the immersed meatballs versus the concentration of NaCl in solution gave the equation $y = 0.04x + 0.267$.

4.1.2 Texture

The parameters cohesiveness, hardness and gumminess were examined. For cohesiveness, the reference gave the highest result of about 0.76 m^2/m^2, compared to the other samples, that had approximately 0.72 m^2/m^2, as can be seen in Figure 4. For hardness, the reference received the lowest result of just above 1200 g, the other samples had results of about 1400 g, see Figure 5. For gumminess, all samples received results of about 1000 g, showed in Figure 6. From the statistical analyses, significant differences between samples were found only for cohesiveness (F=4.46 > Fcrit=4.07), according to one-way ANOVA. However, applying post-hoc Tukey-Kramer on this result, showed that there was no significant difference between any of the results, despite the immersion meatballs having a lower result than the reference. Tukey-Kramer removes false positives, and it was concluded that this was the case for the one-way ANOVA result. For hardness, one-way ANOVA gave F=0.89 < Fcrit=4.07 and for gumminess, F=0.28 < Fcrit=4.07.

During tastings, the texture of the three immersed meatballs had an equally dry mouthfeel. When chewing, they were not as cohesive as the reference meatball, as they fell apart more easily. There were also visible textural differences between the reference and immersed NaCl meatballs, which can be seen in Figure 7.

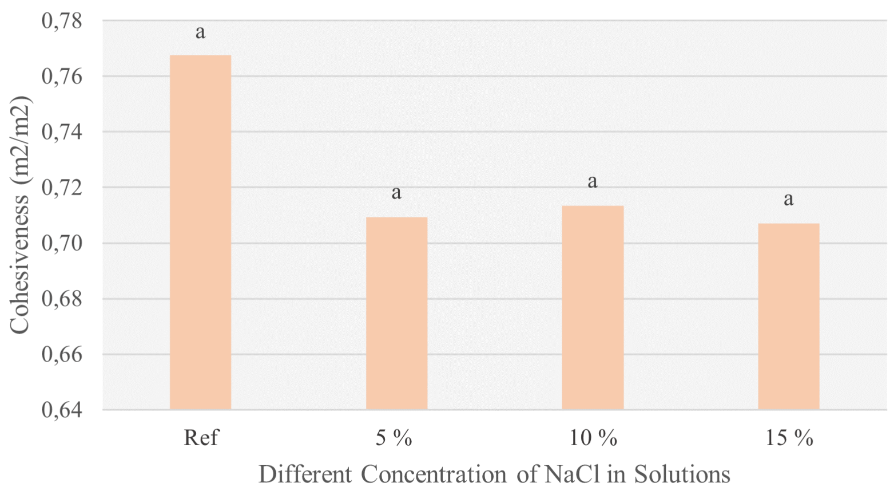

Figure 4: Graph showing the average Cohesiveness (m^2/m^2) of meatballs with no added salt in the batter immersed in different concentration of NaCl solutions as well as a reference meatball, a meatball with only NaCl added to the batter and not immersed in a NaCl solution. No significant difference between the meatballs was seen when performing Tukey-Kramer on significant one-way ANOVA results.

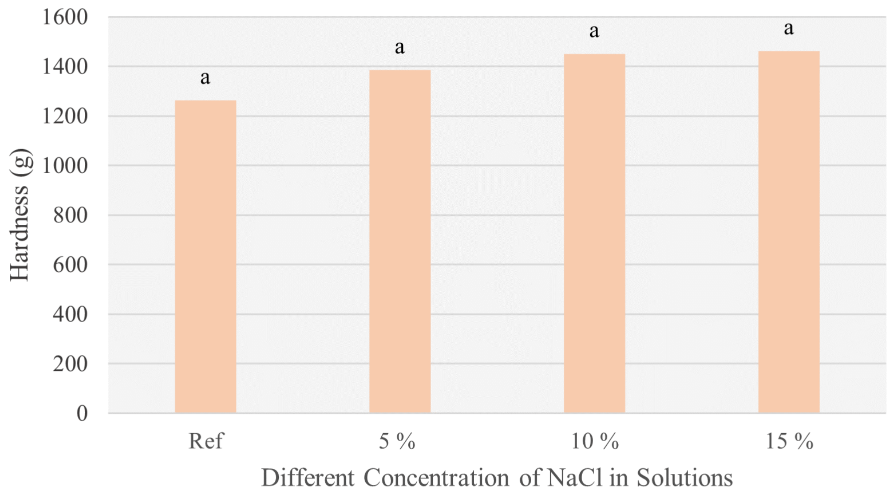

Figure 5: Graph showing the average Hardness (Force in grams) of meatballs immersed in different concentration of NaCl solutions as well as a reference meatball, a meatball with only NaCl added to the batter and not immersed in a NaCl solution. No significant difference between the meatballs was seen when performing one-way ANOVA.

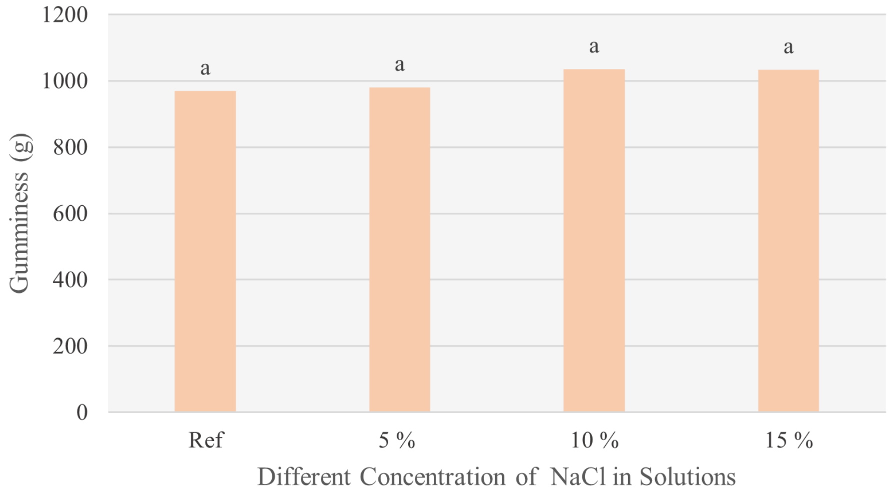

Figure 6: Graph showing the average Gumminess (Force in grams) of meatballs with no added salt in the batter immersed in different concentration of NaCl solutions as well as a reference meatball, a meatball with only NaCl added to the batter, but not immersed in a NaCl solution. No significant difference between the meatballs was seen when performing one-way ANOVA.

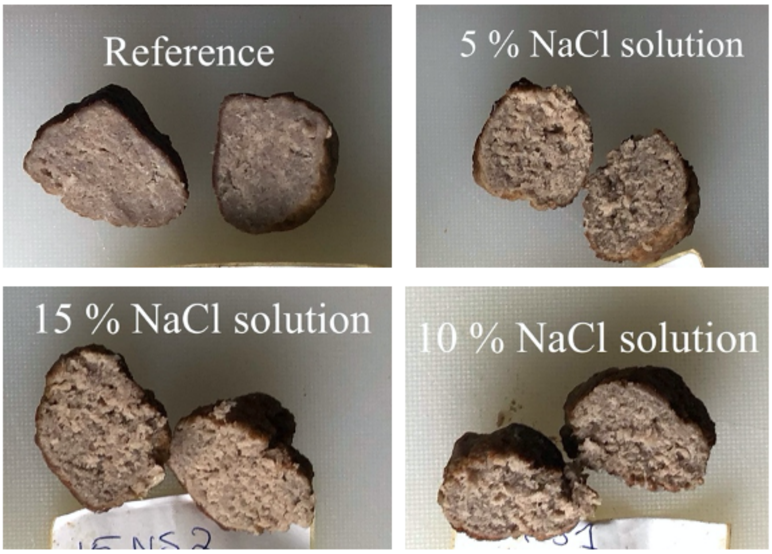

Figure 7: Cross-section pictures of the reference, with added NaCl in the batter and not immersed in a NaCl solution, and the meatballs with no added salt in batter immersed in 5 %, 10 %, and 15 % NaCl solutions cut in cross-section to observe textural differences.

4.1.3 Cooking Loss

The result of the cooking loss showed that meatballs immersed in 5 % and 10 % NaCl solutions had similar cooking loss, around 20 %, and the meatball immersed in 15 % NaCl solution had a cooking loss around 19 %. The reference experienced a lower cooking loss of 17 %. According to one-way ANOVA, a significant difference in cooking loss was found ($F = 3.31 > Fcrit = 3.10$), where 5 % and 10 % solutions significantly differed from the reference according to Tukey-Kramers post-hoc test. The 15 % solution was not significantly different from either the reference or the other solutions. The result of the cooking loss can be viewed in Figure 8.

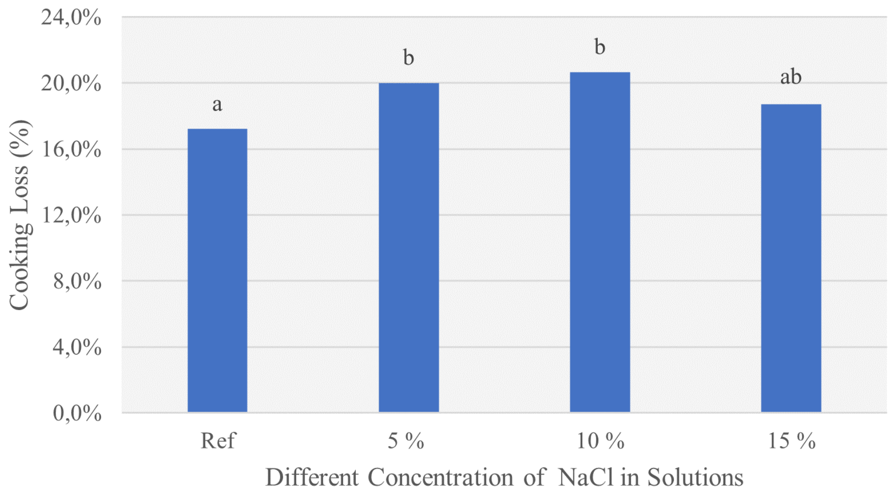

Figure 8: Graph showing the average Cooking Loss (%) of meatballs with no added salt in the batter immersed in different concentration of NaCl solutions as well as a reference meatball, a meatball with only NaCl added to the batter and not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results.

4.1.4 Water Content

Analysing the water content showed that the sample immersed in 5 % NaCl solution displayed the highest water content, while the reference displayed the lowest. No significant difference was found between samples when analysing water content using one-way ANOVA ($F=0.38 < Fcrit=4.07$). The result means can be seen in Figure 9.

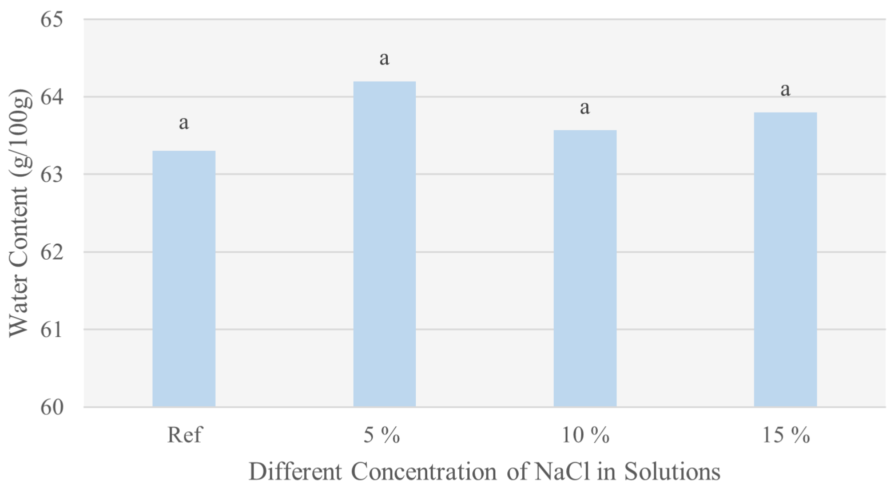

Figure 9: Graph showing the average Water Content (g/100g) of meatballs with no added salt in the batter immersed in different concentration of NaCl solutions as well as a reference meatball, a meatball with only NaCl added to the batter and not immersed in a NaCl solution. No significant different between the meatballs was seen when performing one-way ANOVA.

4.1.5 pH

The result of the pH showed that the pH of the reference was 6 and for the other meatballs 5.9. When performing one-way ANOVA, a significant difference between the meatballs could be seen ($F=8.5 * 10^{27} > Fcrit=4.07$), and Tukey-Kramer post-hoc test showed that the reference meatball was significantly difference from the immersed meatballs, as can be seen in Figure 10.

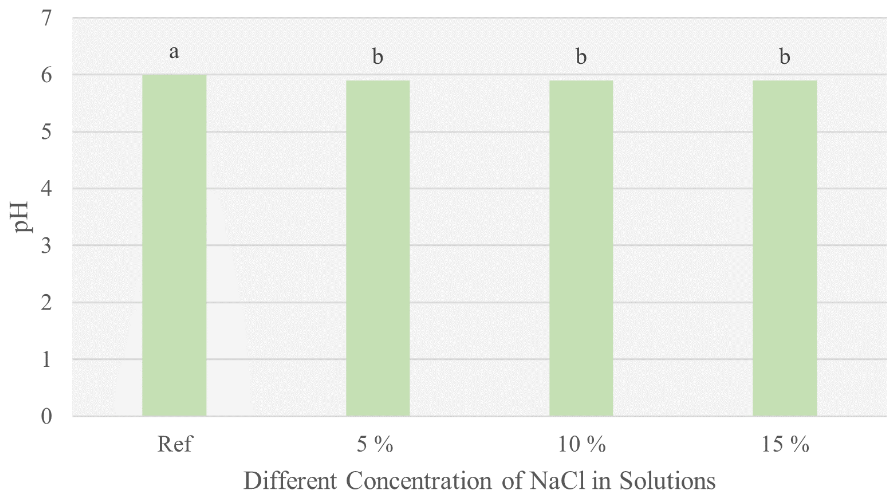

Figure 10: Graph showing the average pH of meatballs with no added salt in the batterimmersed in different concentration of NaCl solutions as well as a reference meatball, a meatball with only NaCl added to the batter and not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results.

4.2 Result of the Different Concentration Batters

Meatballs containing different amount of added NaCl within the batter (0.5 %, 0.75 %, 1.0 % and 1.25 %) were analysed and compared to the meatball made with the original recipe (the reference). Results from the analyses are found in the sections below. A summary of these data is presented in Table B1 and B2 in Appendix B. The raw data and ANOVA together with Tukey-Kramer post-hoc test is presented in Table B3-B21 in Appendix B. For this part of the results, no professional sensory evaluations with external participants were made, but all meatballs were tasted and examined by the authors to give a sense of the sensory attributes.

4.2.1 Salt Content

The results of the NaCl content can be seen in Figure 11 below. The concentration of added NaCl in the meatballs was increased after cooking, though all the meatballs were concentrated differently. The meatball with the lowest amount of added NaCl, 0.5 %, was concentrated the least (increased in concentration with 0.33 g/100g) and then the more NaCl that was added, the more the sample was concentrated. The reference meatball was concentrated the most. Performing one-way ANOVA showed that there was a significant difference between the samples ($F=345 > Fcrit=3.48$) and Tukey-Kramer post-hoc test showed that each sample was significantly different compared to the other samples.

It was also noted that with less NaCl, the salty taste was perceived less, and that the flavour of the meatballs was perceived more tasteless. For example, the flavour of the pepper was inhibited.

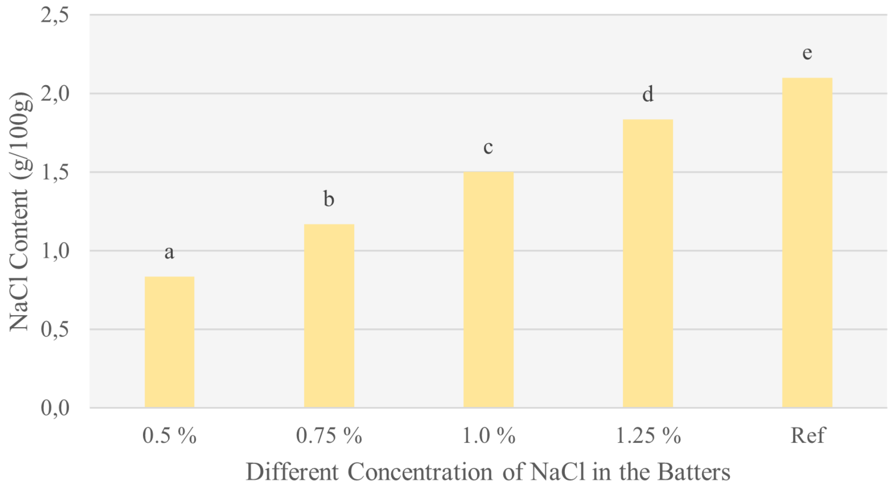

Figure 11: Graph showing the average NaCl content of meatballs with different concentrations of added NaCl in the batters and not immersed in a NaCl solution, as well as a reference, which contained more added NaCl than the others and was not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. Compiling a linear regression over the NaCl content in the meatballs versus the added NaCl in the batter gave the equation $y = 1.28x + 0.206$.

4.2.2 Texture

The parameters cohesiveness, hardness and gumminess were examined. The result of cohesiveness, as can be seen in Figure 12, showed that increasing the amount of added NaCl, increased the value of the cohesiveness, with only the reference not following the trend. Significant differences between the samples according to one-way ANOVA were found ($F=8.00 > Fcrit=3.48$), and according to Tukey-Kramer post-hoc test, the meatball containing 1.25 % added NaCl had a significantly higher result than the meatballs containing 0.5 %, 0.75 % and 1.0 % added NaCl respectively. Compared to the reference meatball, no significant difference was seen.

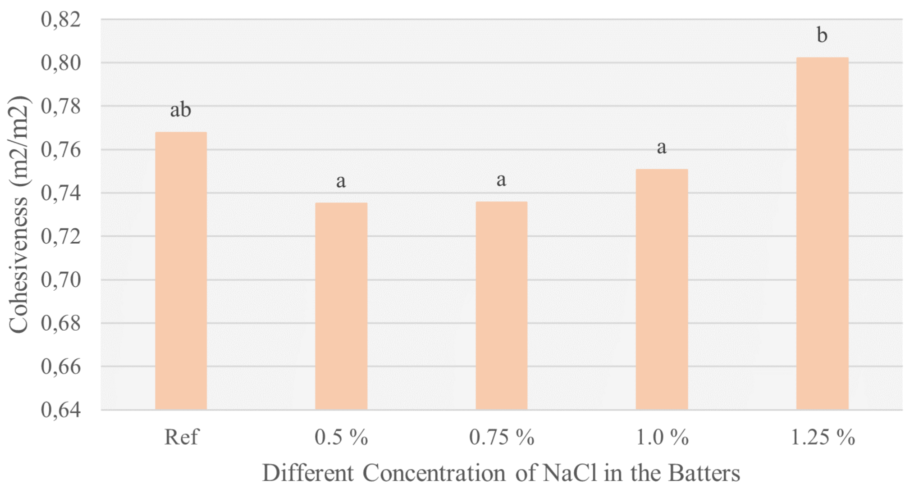

Figure 12: Graph showing the average Cohesiveness (m^2/m^2) *of meatballs with different concentrations of added NaCl in the batters and not immersed in a NaCl solution, as well as a reference, which contained more added NaCl than the others and was not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results.*

The result of the hardness parameter, seen in Figure 13, showed that the meatball with 0.5 % added NaCl had the highest hardness value, and the value of the hardness decreased with increased NaCl concentration. Only the reference did not follow the trend, since it had a hardness value of approximately the same as the 1.0 % meatball (1300 ± 190 g and 1300 ± 120 g respectively). Performing one-way ANOVA on the hardness yielded a result of $F=2.85 < Fcrit=3.48$ (no significant difference). For the gumminess parameter, the magnitude of the values varied in the same shape as the hardness parameter. According to one-way ANOVA, there were no significant difference between the samples ($F=1.53 < Fcrit=3.48$). The result for hardness and gumminess are presented in Figure 13 and 14.

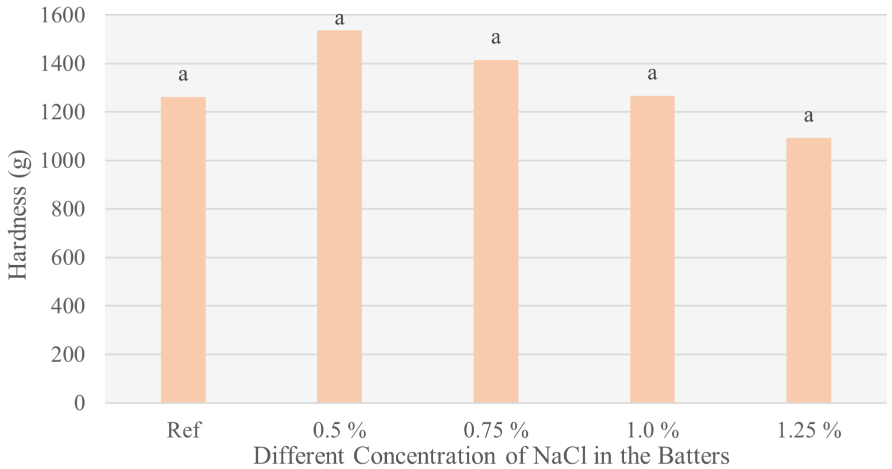

Figure 13: Graph showing the average Hardness (Force in grams) of meatballs with different concentrations of added NaCl in the batters and not immersed in a NaCl solution, as well as a reference, which contained more added NaCl than the others and was not immersed in a NaCl solution. No significant difference between the meatballs was seen when performing one-way ANOVA.

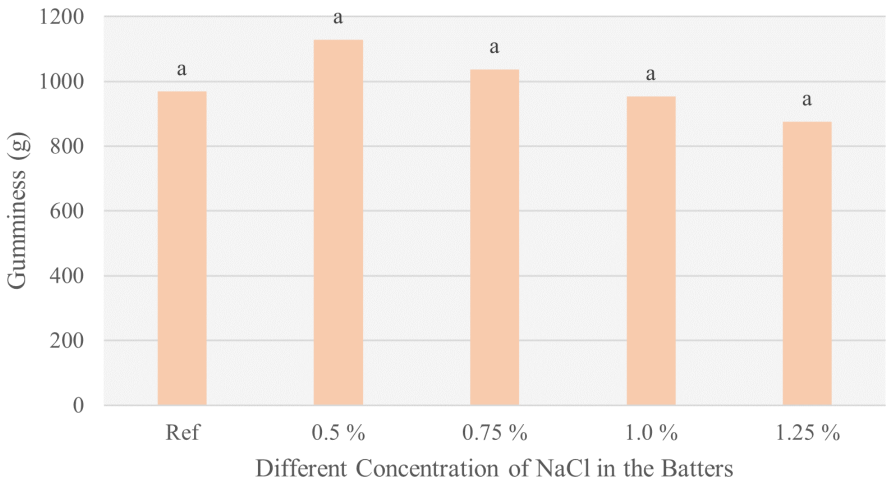

Figure 14: Graph showing the average Gumminess (Force in grams) of meatballs with different concentrations of added NaCl in the batters and not immersed in a NaCl solution, as well as a reference, which contained more added NaCl than the others and was not immersed in a NaCl solution. No significant difference between the meatballs was seen when performing one-way ANOVA.

When the different meatballs were tasted and compared to each other, it was noted that the meatballs containing higher amount of added NaCl (1.0 %, 1.25 % and the reference), had visible differences as well as a different mouthfeel (considering cohesion and how juicy they felt). As can be seen in Figure 15, the texture looks crumblier for the meatballs with lower addition NaCl (0.5 % and 0.75 %) compared to the others, which was more even and smooth. These were also easier to cut. This difference was also noticed when tasting the meatball, since the meatballs with 0.5 % and 0.75 % added NaCl felt less juicy compared to the ones with more added NaCl, however the meatball with 0.75 % added NaCl was more juicy than meatball with 0.5 % added NaCl. The mouthfeel between 1.0 %, 1.25 % added NaCl and reference were similar. Moreover, it could be noticed that increasing NaCl also affected the cohesion, the authors' personal opinions were that the more NaCl the better the meatball held together during chewing.

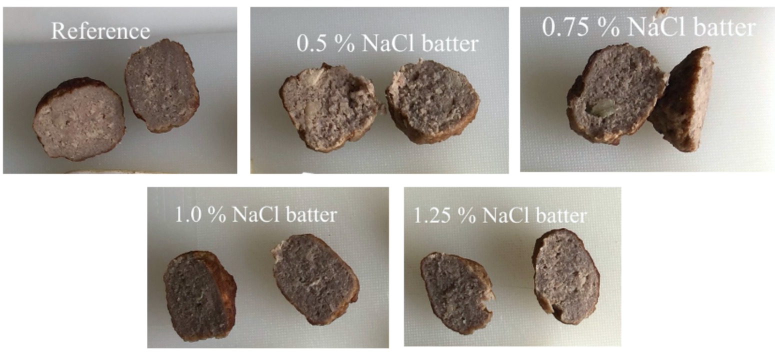

Figure 15: Cross-section pictures of the reference, with a higher amount of added NaCl and not immersed in a NaCl solution, 0.5 %, 0.75 %, 1.0 % and 1.25 % added NaCl in the batters and not immersed in a NaCl solution.

4.2.3 Cooking Loss

The result of the cooking loss showed that the cooking loss of the meatballs with added NaCl from 0.5 %-1.25 % was similar, around 20 %. The reference had a lower cooking loss, around 17 %. When performing one-way ANOVA, a significant difference between the samples was found ($F=6.03 > Fcrit=2.76$). Tukey-Kramer post-hoc test showed that the reference displayed a significantly lower cooking loss than all the other meatballs. Between the meatballs of 0.5 %-1.25 % added NaCl in the batter, there was no significant difference. The result can be seen in Figure 16.

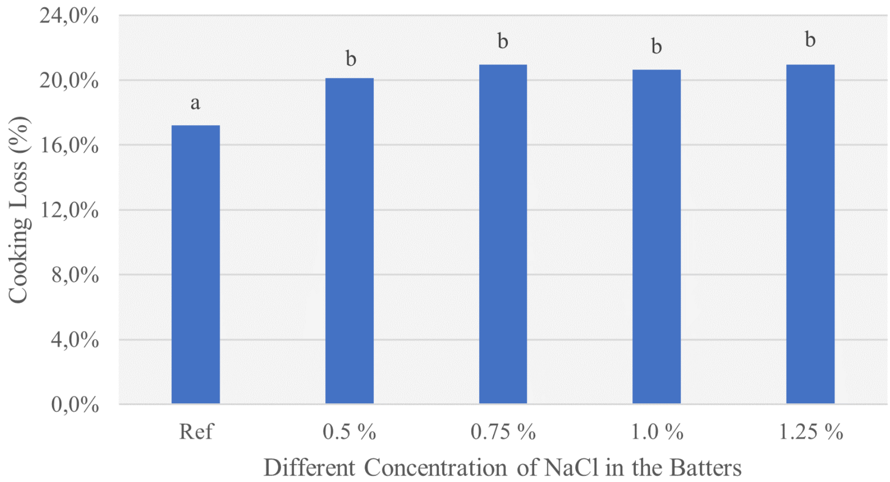

Figure 16: Graph showing the average Cooking Loss (%) of meatballs with different concentrations of added NaCl in the batters and was not immersed in a NaCl solution, as well as a reference, which contained more added NaCl than the others and not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results.

4.2.4 Water Content

When analysing the water content, it could be seen that the reference had the lowest value, although the difference between the samples was small. The average water content of all samples had a value between 63.3 g/100g and 65.1 g/100g. A significant difference was found between samples when analysing water content using one-way ANOVA ($F=18.4 > Fcrit=3.48$). When applying Tukey-Kramer post-hoc test, significant differences were seen between the reference compared to all the other samples respectively, as well as the meatball with 0.5 % added NaCl in batter compared to the meatball with 1.0 % added NaCl in batter. The result can be seen in Figure 17 below.

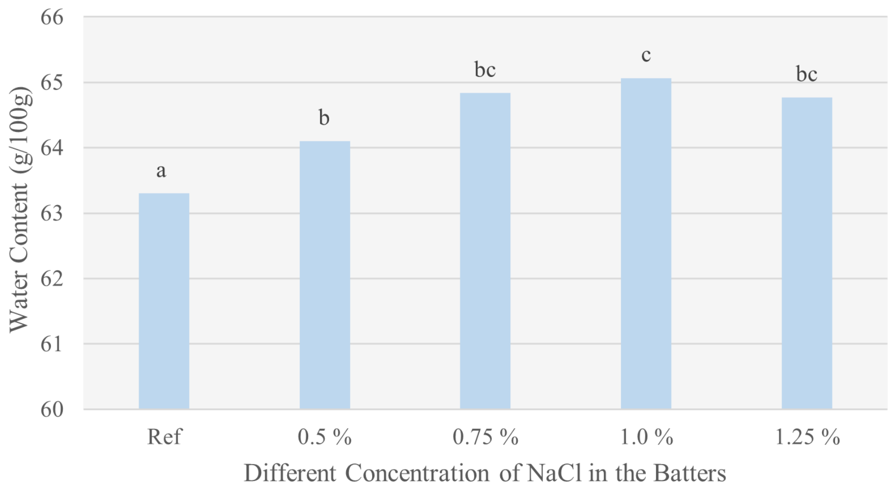

Figure 17: Graph showing the average Water Content (g/100g) of meatballs with different concentrations of added NaCl in the batters and not immersed in a NaCl solution, as well as a reference, which contained more added NaCl than the others and was not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results.

4.2.5 pH

For the pH result, the result was close as the values were between 5.9 and 6.0. The biggest difference was displayed between the reference and the meatballs with 1.0 % and 1.25 % added NaCl, which differed with 0.1 pH units. One-way ANOVA showed that the samples were significantly different (F=4.25 > Fcrit=3.48) from each other. The pairs of samples that were significantly different according to Tukey-Kramers post-hoc test was the reference compared to the meatball with 1.0 % added NaCl, and the reference compared to meatball with 1.25 % added NaCl. The result can be seen in Figure 18.

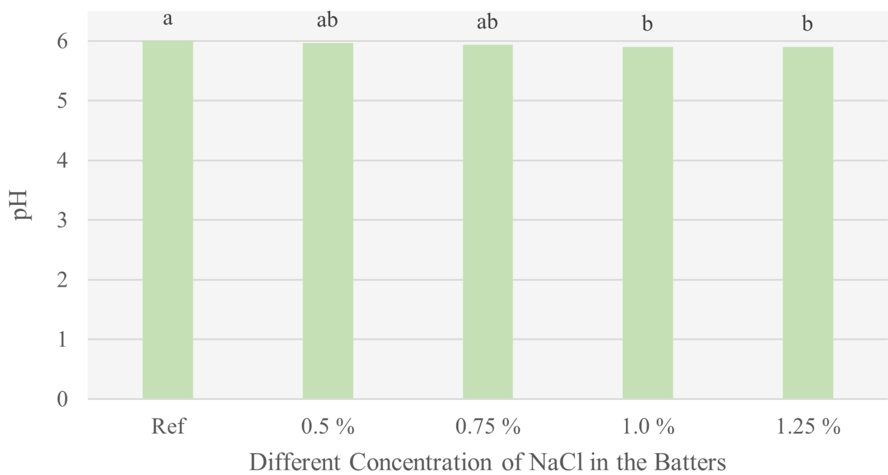

Figure 18: Graph showing the average pH of meatballs with different concentrations of added NaCl in the batters and not immersed in a NaCl solution, as well as a reference, which contained more added NaCl than the others and was not immersed in a NaCl solution. Different letters above the staple means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results.

4.3 Discussion of Results from Different Salt Solutions and Batters

When analysing the NaCl content and cooking loss of the reference as a finished product, it could be noticed that it receives both a higher concentration of NaCl and a higher cooking loss compared with the original meatball produced in the industrial process. Since the trials were performed in a test kitchen, a higher concentration was expected due to the higher cooking loss, as it is not totally comparable to the industrial process. However, the difference were not thought to be this large. By using the cooking loss of the reference to calculate the theoretical end concentration, a lower result was obtained than the actual outcome. This means that the reference meatball has experienced a higher concentrating effect, i.e. the NaCl increased in concentration more than expected.

This concentrating effect was also true for the result of the meatballs with different amount of added NaCl in the batters, though it was seen that increasing the amount of NaCl in the batter lead to a higher increase in concentration. This result was the contrary of the belief, that the NaCl content in the batters containing a lower amount of added NaCl than the reference, would be more concentrated as finished products than the reference, and that the meatball with the lowest amount of NaCl would display the highest concentrating effect. This expectation was based on the literature that implies that a decrease of NaCl will affect the capacity of the meat proteins to solubilize and thereby also affect their functionality to gel properly. The gel entraps water, and a looser gel due to a decrease of NaCl will not be able to hold the water as good as a harder gel, and thereby displaying a higher cooking loss [7], [14]. However, this concentrating effect could not be explained by the cooking loss, as the results showed that meatballs with 0.5 %-1.25 % added NaCl significantly differed from the reference by being higher, but the meatballs with 0.5 %-1.25 % added NaCl had no significant difference between each other. This means that the expected concentrating effect would have been bigger and similar for the meatballs with 0.5 %-1.25 % added NaCl, which was not the case either. A result that had been comparable to this expectation would have been that the cooking loss had increased in the following order, and thereby also the concentrating effect: reference, 1.25 % added NaCl, 0.75 % added NaCl and 0.5 % added NaCl. When looking at the result of the immersed meatballs, it is seen that they also display a higher cooking loss than the reference, and the 15 %-immersion did not display any significant difference. They increased with 0.2 g/100g of NaCl content for every 0.5 % increase of NaCl in solution, making the increase consistent. All the meatballs except for the reference had cooking losses around 20 %. Thus, for both these trials, cooking loss might not be correlated to the NaCl content. However, to be noted here, is that the cooking loss varied a lot in each trial and that only 6 meatballs per concentration was collected to measure cooking loss.

The water content was also measured to understand the water holding capacity of the meat. The results from these showed that they were not comparable to the result of the cooking loss. As mentioned, the different concentration of added NaCl in the batters, 0.5 %-1.25 %, received similar cooking losses, higher than the reference. Regarding water content, this value was also higher than the reference, for all samples in both different concentration of added NaCl in the batters and different NaCl solution batters. In the latter, the results were however not significantly different from the reference. A higher cooking loss should have led to a decrease in water content, and thus, a higher water content in the reference compared to the others would have been expected. The results from the water content were therefore not in accordance with the cooking loss, and neither with the literature stating that increasing the amount of NaCl should have led to a higher

WHC [14].

A suggested explanation for the water content and the relatively higher increase of the NaCl concentration when adding more NaCl, is due to the water-fat collection that could be seen on the oven plate, that was released from the meatballs during cooking. It can be discussed that NaCl was released from the meatball into the water-fat collection. The lower the amount of NaCl in the batters, the looser the meat batter. The batters that had no added NaCl, and the batter that had 0.5 % added NaCl also released water during rest. The shaping of these meatballs with a looser texture, were more difficult to form. It could be thought that the NaCl in these meatballs was not entrapped as well in the gel and therefore released more easily to the water-fat collection during cooking. Consequently, the NaCl concentration increase was smaller for these meatballs. In terms of the water content, it can be believed that more fat also was released from the batters with less NaCl due to the weak gel. Thus, when analysing the water content, the relative water content becomes higher for these, than for the reference where both fat and water stayed inside the gel. However, for this explanation, the significant difference between the 0.5 % and 1.0 % meatball for water content was not considered.

When considering the tasting of the meatballs and the analysing of the overall flavour, these were in accordance to expectations. It could be noticed that when tasting the meatballs with lower NaCl content, the meatballs were more tasteless and the flavour of pepper could be perceived much stronger in the reference meatball. This is in line with the literature, stating that NaCl increases the perception of other flavours [16].

When analysing the result of the texture analysis, it was seen that for both meatballs immersed in NaCl solution, and meatballs with different amount of added NaCl in the batter, no significant difference could be seen in hardness and gumminess, but there was significant difference in cohesiveness, according to one-way ANOVA. For the immersed meatballs, the significance was not proven with Tukey-Kramer post-hoc test. For the meatballs with different amount of added NaCl in the batter, the value increased with an increasing amount of NaCl. Only the reference was an exception to the trend, having a cohesiveness with a value in between that of the 1.0 % and 1.25 % added NaCl batters. This increase, which could be seen between the meatballs of different amount of added NaCl, implies that increasing NaCl will mean a higher internal strength between the bonds, leading to a stronger gel. For meatballs immersed in different NaCl solution, it could be seen that without NaCl in the batter, the cohesiveness will be somewhat lowered. This indicates that NaCl is needed in the batter, and not only present on the outside during the cooking. This result aligns with the personal experience of the cohesion of the meatball during tasting. The cohesion of the meatball increased during chewing when the NaCl concentration increased.

Since hardness and gumminess did not show significant difference between the samples, it was interesting that the sensorial tasting of the meatball showed big differences. As could be seen in Figure 7 and 15 in section 4.1.2 and 4.2.2, the cut surface of the different meatballs was different. The meatballs immersed in NaCl solution and the meatball with 0.5 % NaCl showed a crumblier and drier look, than the reference and the meatballs with 0.75 %, 1.0 % and 1.25 % added NaCl, which were smoother and easier to cut in. When tasting the meatballs, these meatballs that looked dry, were also less juicy and had a less pleasant mouthfeel since it did not hold together when chewing. This means that even though an instrument designed for analysing texture of food, the mouth and the tongues' sensibility will be able to notice a difference, which the instrument can not detect. Thereby, the sensorial experience will be of more importance when discussing combinations to be tried out.

The result of the pH showed significant difference with one-way ANOVA, but as could be seen in Figures 10 and 18 in section 4.1.5 and 4.2.5, there were very small differences between the results. The range of the pH indicated that the solubility of the myofibrillar proteins in the meatballs will increase with added NaCl as can be read in section 2.1.2. This is also shown when analysing the textural differences between the samples, as already mentioned. Since the measurement uncertainty for pH was 0.1, the results of every trial would have overlapped and can in theory be the same value. The reason for analysing pH was to see if there was a big difference between the samples and if this difference would be able to have an effect on the solubility of the product. Since pH now showed around 6 for all samples, it will probably not be pH that gives different result of the texture due to inhibit solubilization of meat proteins. It will rather be the reduction of NaCl that will affect this.

As a conclusion for these results, it can be said that NaCl content will affect the sensory attributes of the meatball, such as the taste and texture. NaCl will be a carrier of flavour and when tasting the meatball it will be noticed a difference in how well the meatball holds together, both when cutting and eating the meatball, and the perception of how juicy it is will also be affected.

4.4 Combinations

When analysing the different results, it was decided that the textural properties according to the opinion of the authors, the measured NaCl content, and how salty the meatballs immersed in NaCl solution were perceived, could be used as support to decide which combinations between NaCl concentration in batter and NaCl solution that should be tried. To be able to understand how much NaCl content different combinations would end up with after cooking, the equations retrieved from linear regression of the NaCl content, seen in Figure text of Figure 3 and 11 in section 4.1.1 and 4.2.1 were used. By putting them together, equations to find a desired NaCl content, by using both immersion and added NaCl as methods, could be found. However, it was known from the given recipe that the meat naturally contained 0.1 % NaCl, and to not double this effect, 0.1 % was removed from each result in the immersed meatball data, and a new equation was found, y = 0.04x + 0.167. This equation was put together with the equation for the added NaCl meatballs. The method for NaCl immersion was named x and the method for NaCl in batter y, and equalled to the desired NaCl content z, for example 1.7 %, as can be seen below.

$$0.04x + 0.167 + 1.28y + 0.206 = z = 1.7$$

$$-32y + 33.185 = x$$

The same was done for 1.8 % and 1.9 % NaCl content, and the equations were plotted in Figure 19, with NaCl content in the batter on the y-axis and NaCl content by immersion on the x-axis. By viewing the lines in the graph, combinations of the methods to give a desired NaCl content could be seen.

It was decided that lowering the NaCl content by more than 0.4 %-units, would not give an acceptable meatball in sensory aspect. Thus, with a desire to decrease the NaCl content by as much as possible, four combinations where the NaCl content was around 1.7 % were chosen. Here, two combinations where the NaCl content and the fact the that only a salty flavour of the meatballs immersed in 10 % and 15 % was considered, and texture was taken secondarily. The two other combinations considered that there was a better texture of the meatballs with a NaCl concentration above 0.75 %, and therefore two combinations close to this together with a lower concentration of NaCl solution were chosen. To possibly get a result where the meatballs were closer in sensory aspect to the reference, three combinations where the NaCl content was theoretically between 1.8-1.9 % in the cooked meatball, giving a NaCl decrease of 0.2-0.3 %-units were also chosen. All combinations can be seen in Figure 19, shown as black squares in the graph.

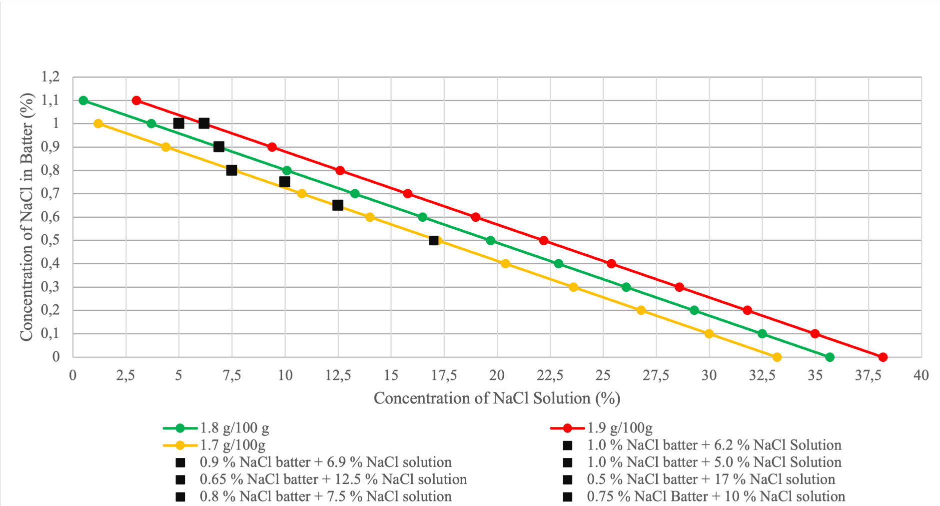

Figure 19: Graph showing lines with theoretical NaCl content of 1.7 %, 1.8 % and 1.9 %. The y-axis is the method of NaCl in batter, and the x-axis is the method of immersion in NaCl solutions. The black squares show the combinations that were chosen to make.

4.5 Result of the Different Combinations

Meatballs containing combinations of NaCl-in-batter and NaCl concentration in solution were analysed and compared to the reference meatball. The result of the different combinations can be seen in the following sections. A summary of these data is presented in Table C1 and C2, and the raw data and ANOVA together with Tukey-Kramer post-hoc test is presented in Table C3 -C18 in Appendix C. As discussed in section 4.3, the pH did not affect the solubilization of the meat proteins, and therefore this measurement was not included in this part of the results. Neither were any professional sensory evaluations with external participants made, but all meatballs were tasted and examined by the authors to give a sense of the sensory attributes.

To simplify, the different combinations were named sample 1-7, and the combination belonging to a certain number can be seen in Table 4 below.

Table 4: Table showing which sample number that refers to what combination.

Sample name	Combinations
1	0.5 % in meat batter + 17 % in NaCl solution
2	0.75 % in meat batter + 10 % in NaCl solution
3	0.8 % in meat batter + 7.5 % in NaCl solution
4	0.65 % in meat batter + 12.5 % in NaCl solution
5	1.0 % in meat batter + 5.0 % in NaCl solution
6	0.9 % in meat batter + 6.9 % in NaCl solution
7	1.0 % in meat batter + 6.2 % in NaCl solution

4.5.1 Salt Content

The average NaCl content calculated from all the samples was 1.5 %, which was lower than for the reference. Performing one-way ANOVA on the results, showed a significant difference (F=79.11 >Fcrit=2.66). More specifically, Tukey-Kramer post hoc, showed that the reference and sample 4 differed from all other samples, which can be seen in Figure 20. When tasting the meatballs, none were experienced as un-salty but perhaps somewhat less flavour intensive.

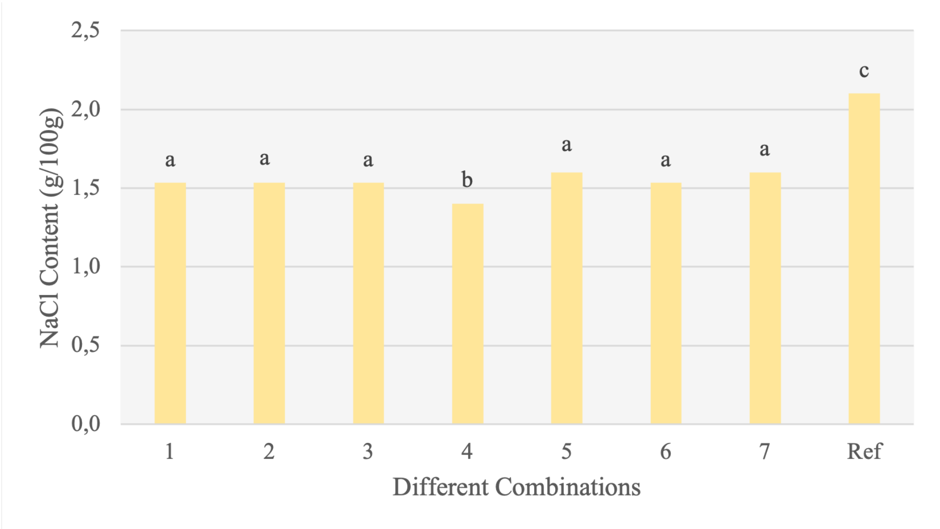

Figure 20: Graph showing the average NaCl Content for different combinations of added NaCl in the batter and NaCl concentration in solution, named from 1 to 7, as well as a reference, with added NaCl in the batter but not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. The combinations translated to sample numbers can be seen in Table 4.

4.5.2 Texture

The parameters cohesiveness, hardness and gumminess were examined. For cohesiveness, sample number 5 showed the highest result, but no big differences were noted between the samples and one-way ANOVA for cohesiveness gave no significant difference (F=1.82 < Fcrit =2.66). For hardness, the reference had the highest result, and sample 2 the lowest. Doing one-way ANOVA revealed significant differences (F=2.72 > Fcrit=2.66), and post-hoc Tukey-Kramer showed that these existed between the reference and sample 2. For gumminess, sample 2 had the lowest result and the reference, along with sample 5, had the highest result. One-way ANOVA showed significance (F=3.16 > Fcrit=2.66) and Tukey-Kramer post-hoc showed that these existed between the reference and sample 2, as well as sample 2 compared to sample 5. The results can be seen in Figures 21, 22 and 23 below.

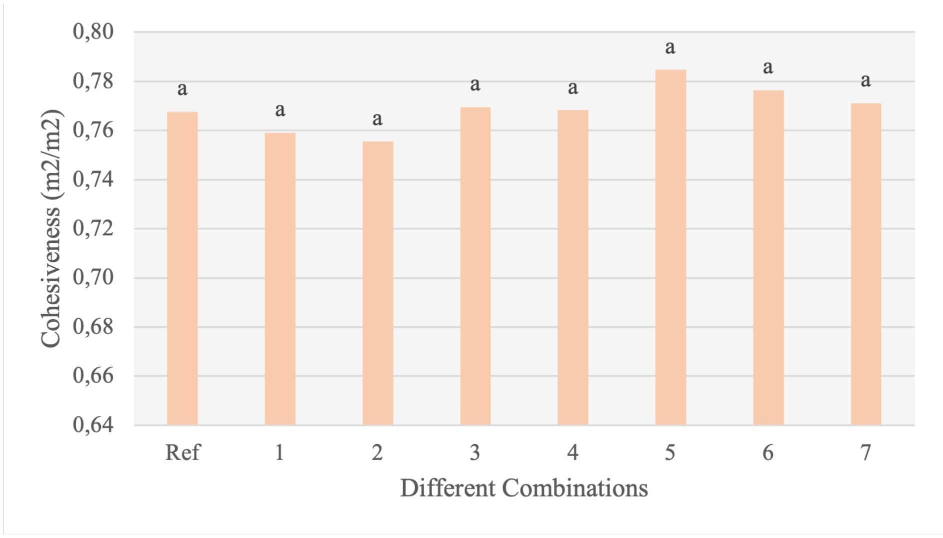

Figure 21: Graph showing the average Cohesiveness (m^2/m^2) *for different combinations of added NaCl in the batter and NaCl concentration in solution, named from 1 to 7, as well as a reference, with added NaCl in the batter but not immersed in a NaCl solution. No significant difference between the meatballs was seen when performing one-way ANOVA. The combinations translated to sample numbers can be seen in Table 4.*

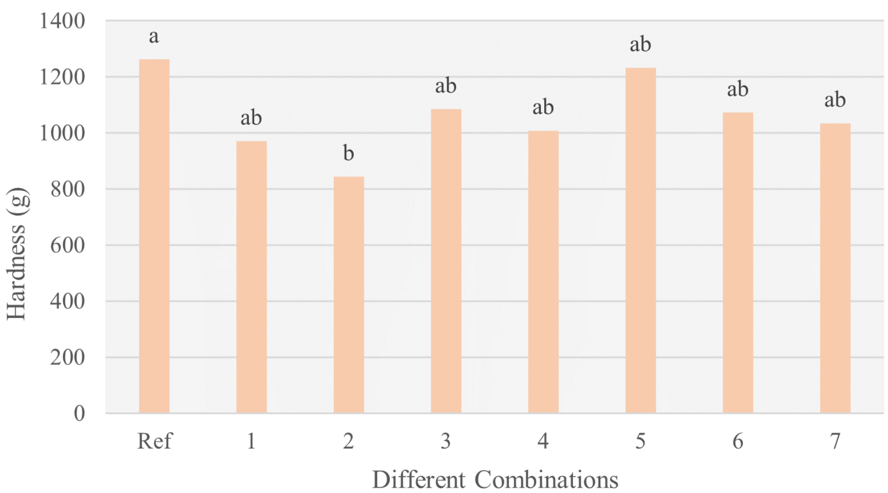

Figure 22: Graph showing the average Hardness (g) for different combinations of added NaCl in the batter and NaCl concentration in solution, named from 1 to 7, as well as a reference, with added NaCl in the batter but not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. The combinations translated to sample numbers can be seen in Table 4.

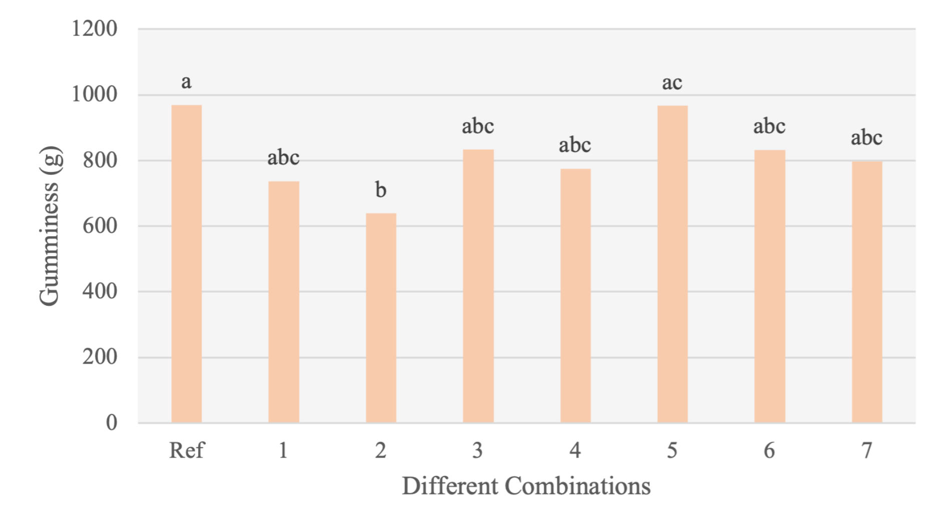

Figure 23: Graph showing the average Gumminess (g) for different combinations of added NaCl in the batter and NaCl concentration in solution, named from 1 to 7, as well as a reference, with added NaCl in the batter but not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. The combinations translated to sample numbers can be seen in Table 4.

The different samples were cut in half and tested, after having been heated. Some textural differences were observed visually and could also be perceived when tasted, such as being softer to chew due to being less cohesive in meat consistency when compared to the reference. Images of the meatballs can be seen in Figure 24.

Figure 24: Cross-section pictures of the combinations to observe textural differences. The combinations from right to left, up to down correspond to sample 1, 2, 3, 4, 5, 6, 7 and the reference, with added NaCl in the batter but not immersed in a NaCl solution. The translation from samples to combinations can be read in the image, or in Table 4.

4.5.3 Cooking Loss

The result of the cooking loss showed that the reference experienced the lowest cooking loss compared to the other samples. When performing one-way ANOVA, significant difference in cooking loss was found (F =5.11 > Fcrit= 2.25). From the Tukey-Kramer post-hoc test it was found that the reference differed significantly from sample 1, 2, 3, 4 and 7. Sample 1 also differed significantly from sample 4. All average results and where significant differences were found can be seen in Figure 25 below.

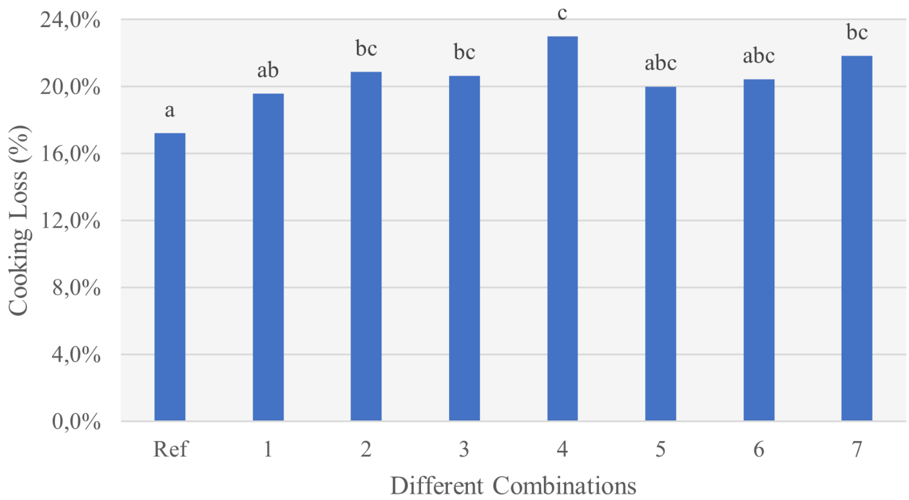

Figure 25: Graph showing the average Cooking Loss (%) for different combinations of added NaCl in the batter and NaCl concentration in solution, named from 1 to 7, as well as a reference, with added NaCl in the batter but not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. The combinations translated to sample numbers can be seen in Table 4.

4.5.4 Water Content

The result of the water content for the combinations can be seen in Figure 26. As can be seen, the reference got the lowest water content, and differed from the others between 1.1-2.7 g/100g. The one-way ANOVA result showed there it was a significant difference between the samples (F=11.7 > Fcrit=2.65). Tukey Kramer post-hoc test showed that there was significant difference between the reference and all the other combinations (except for sample 5), between sample 1 and 3, 4, 5 and 7 and between sample 2 and 5.

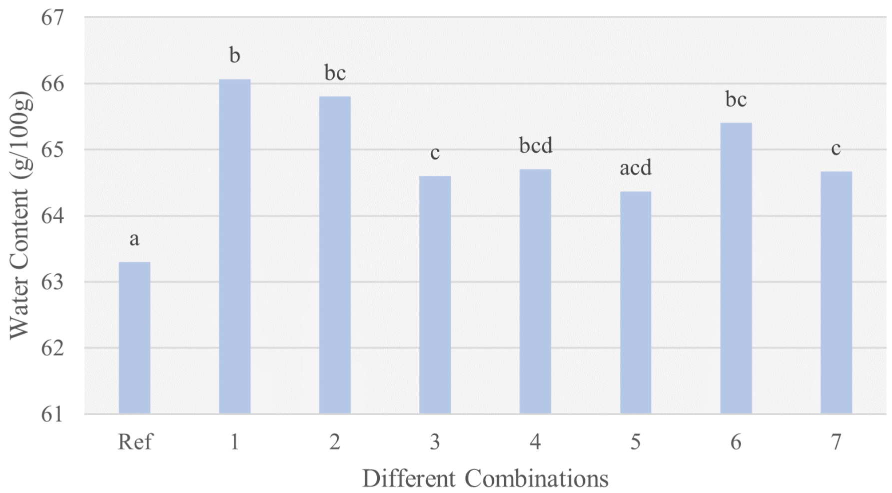

Figure 26: Graph showing the average Water Content (g/100g) for different combinations of added NaCl in the batter and NaCl concentration in solution, named from 1 to 7, as well as a reference, with added NaCl in the batter but not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. The combinations translated to sample numbers can be seen in Table 4.

4.6 Discussion of Results from Different Combinations

Regarding NaCl content, all the combinations significantly differed from the reference and sample number 4 differed from all other samples reaching the lowest NaCl content. In most samples, the NaCl content result was around 1.5 %, which is 0.2 %-units lower than the hypothesis for samples 1-4, around 0.3 %-units for samples 5-6, and as large as 0.4 %-units for sample 7. One explanation to the difference between expected NaCl content and actual result could be that the meatballs already contained some NaCl in the batter. This could give a smaller concentration gradient between the exterior and interior of the meatball, resulting in less mass diffusion of NaCl and with that, less possibility to absorb external NaCl during immersion. This theory could also explain why samples that contained less NaCl within the meatball but were immersed in higher concentration NaCl solutions had the same final NaCl content as those containing more NaCl within but were immersed in lower concentration solutions, as they were also exposed to lower concentration gradients.

The texture analysis resulted in a significant difference in hardness between the reference and sample 2 (0.75 % added NaCl, 10 % immersion), where sample 2 was lower than the reference. Regarding gumminess, significant differences were found between the reference and sample 2 and 5 (1.0 % added NaCl, 5 % immersion) respectively, where the reference and sample 5 were significantly larger than sample 2. For cohesion, no significance was found, but sample 2 had the smallest value, and sample 5 the highest one. With sample 5 containing 1 % added NaCl, it was, along with sample 7, the closest to the reference regarding added NaCl of all the samples, which could also explain the high results for all three parameters for sample 5. However, it does not explain why sample 7 did not get as high results. Neither does it explain why sample 2, that contained more added NaCl than both sample 1 and 4 got the lowest result. As mentioned in section 4.3, the texture analyser was not as sensitive in its measurements as actual human tasting and observations of the meatballs. Because, when tasting and cutting meatballs, the textural differences were more obvious, with lower amounts of added NaCl giving a less cohesive texture. It can also be noted that for the most, there were no actual significant differences between other samples from the texture analyser and perhaps the values from sample 2 could be seen as outliers. A supporting argument for this is that when comparing sample 2 to the meatball with only added NaCl of 0.75 %, sample 2 had much lower hardness and gumminess results, when it was expected that they should be similar. To conclude, the texture instrument was primarily used as a way to get actual values on the texture and enable a numerical comparison, but the usefulness of these values are questionable.

For cooking loss, all samples except 5 and 6 differed from the reference and combining these results with the water content, showed that sample number 5 stood out as the only one not differing from the reference. Samples 5, 6 and 7 contained the most NaCl in the batter of the combinations and according to literature, they should have the best water holding capacity and least cooking loss. Sample 1 with the least amount of added NaCl, should therefore have the smallest water holding capacity [14]. Interestingly, the results point inversely, which is however in line with previous results from different concentration batters. The reason for this is not understood, but some hypotheses have been discussed in section 4.3. It can also be added that when looking at the raw numbers, they do not fluctuate very much but vary between 63.3 g/100g and 66.1 g/100g.

With these results in mind, two meatballs were chosen for the sensory evaluation. First, sample number 5, because it had a high enough internal NaCl content to give an acceptable texture and in addition to this, its results were not significantly different from the reference in either gumminess, cooking loss or water content. However, the NaCl solution in which it was immersed, was of low concentration, and to evaluate whether the concentration gradient between the interior and exterior affects the perception of saltiness, the sample with the lowest amount of added NaCl, but highest amount of NaCl in solution was also chosen; sample number 1 with 5 % added NaCl and 17 % NaCl solution. To see if the method of heterogeneously distributing the NaCl had an effect at all, a meatball containing the same amount of NaCl as the chosen samples, but not immersed in anything, was also chosen for the sensory evaluation. The rest of the design of the sensory evaluation is found in section 3.4.

4.7 Result of the Sensory Evaluation

Meatballs presented in Table 3 in section 3.4 were analysed during the sensory evaluation. The answers from each panellist from the sensory evaluation was compiled, and the results are found in the sections below. The result are presented as the average value of the different parameters, though for better statistical analysis the data compiled was centered and standardised before performing one-way ANOVA. The data and performed one-way ANOVA together with Tukey-Kramer post-hoc test can be seen in Appendix D.

4.7.1 Overall Flavour

The result of the overall flavour of the different meatballs can be seen in Figure 27. As can be seen, the reference was graded the highest and the meatball with 0.5 % NaCl in the batter, and immersed in a 17 % NaCl Solution was graded the lowest. When performing one-way ANOVA, it was shown that there was a significant difference between the samples ($F=5.79 > Fcrit=2.68$), and the difference was seen between the meatball with highest grade and the meatball with the lowest grade, when performing Tukey-Kramer post-hoc test. The other samples were not significantly different.

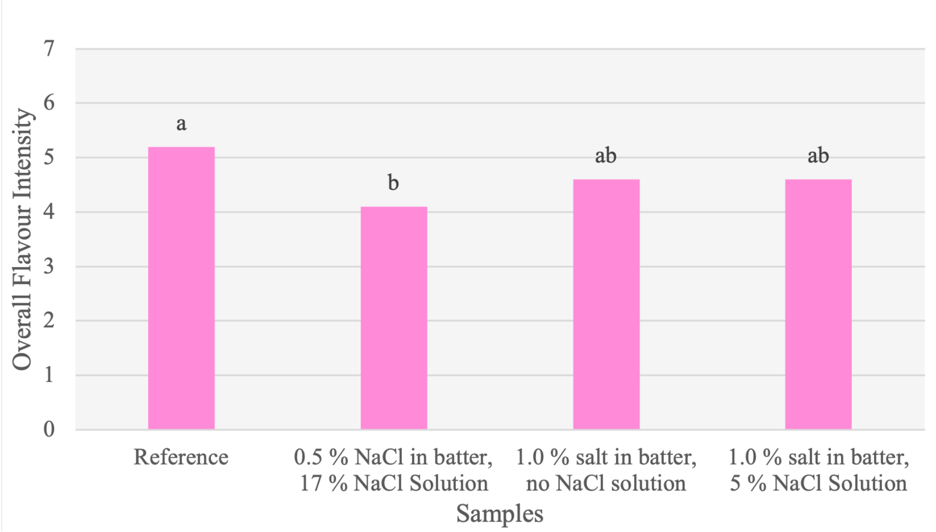

Figure 27: Graph showing the average grading of the Overall Flavour of the different samples graded during the sensory evaluation. The reference had a higher amount of added NaCl in the batter and was not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. Data used for the one-way ANOVA has been centered and standardised.

4.7.2 Salt Intensity

Results showed that participants rated the reference as giving the most salty flavour. After centering and standardising the data, one-way ANOVA showed a significant difference ($F=48.19 > Fcrit=2.68$). Tukey-Kramer post-hoc test showed that the reference significantly differed from all other meatballs evaluated. The remaining samples, did not significantly differ from each other in salt intensity. The results can be seen below, in Figure 28.

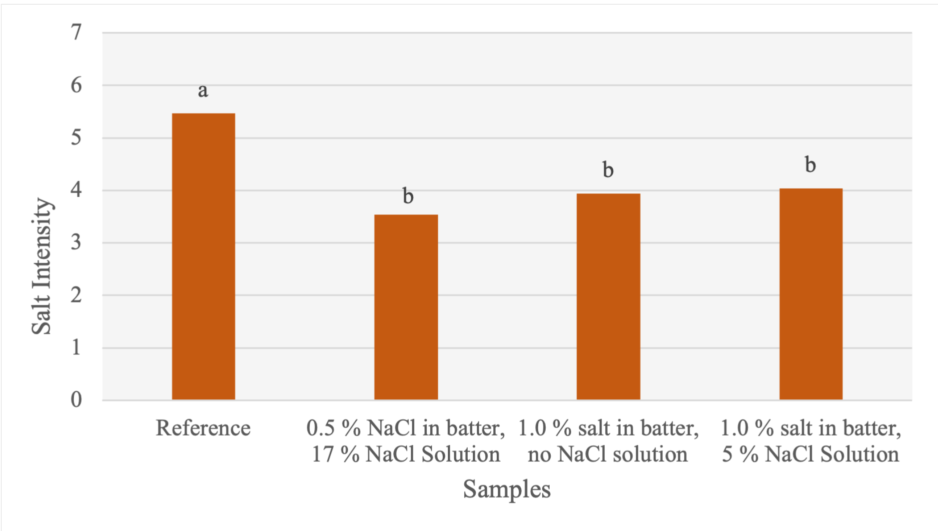

Figure 28: Graph showing the average grading of the Salt Intensity of the different samples graded during the sensory evaluation. The reference had a higher amount of added NaCl in the batter and was not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. Data used for the one-way ANOVA has been centered and standardised.

4.7.3 Juiciness

The average grading of the juiciness showed similar values for all the samples as they were all graded from 4 to 5. One-way ANOVA showed that the there was no significant difference between the samples (F=0.52 < Fcrit=2.58). Although, the juiciness was the highest for the sample with 0.5 % NaCl in the batter immersed in 17 % NaCl solution and lowest for the reference. The result can be seen in Figure 29.

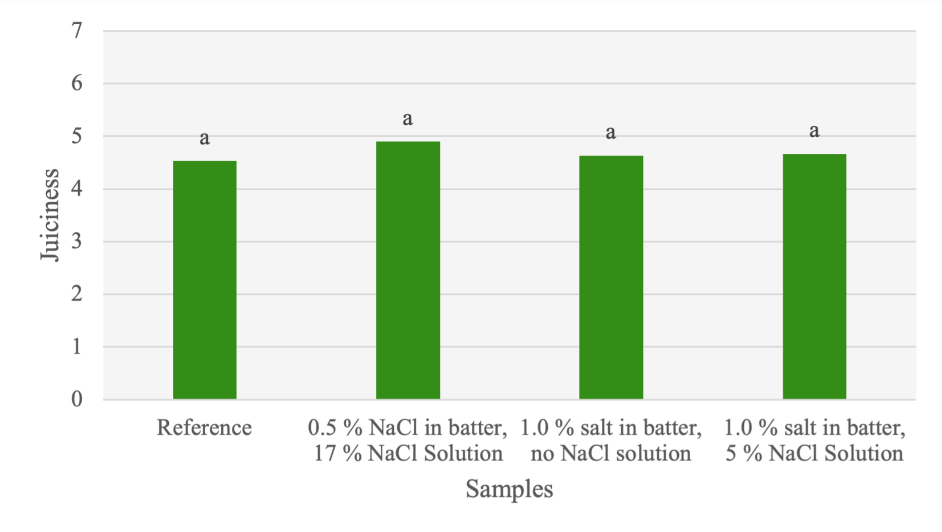

Figure 29: Graph showing the average grading of the Juiciness of the different samples graded during the sensory evaluation. The reference had a higher amount of added NaCl in the batter and was not immersed in a NaCl solution. No significant different could be found when performing one-way ANOVA. Data used for the one-way ANOVA has been centered and standardised.

4.7.4 Cohesion

Results showed that participants rated the reference as being the most cohesive, binding together the most. After centering and standardising the data, one-way ANOVA showed a significant difference (F=16.45 > Fcrit=2.68). Tukey-Kramer post-hoc test showed that the reference significantly differed from all other meatballs. Meatball with 0.5 % NaCl in the batter immersed in 17 % NaCl solution also significantly differed from meatball consisting of 1.0 % salt in batter and not immersed. The results can be seen below in Figure 30.

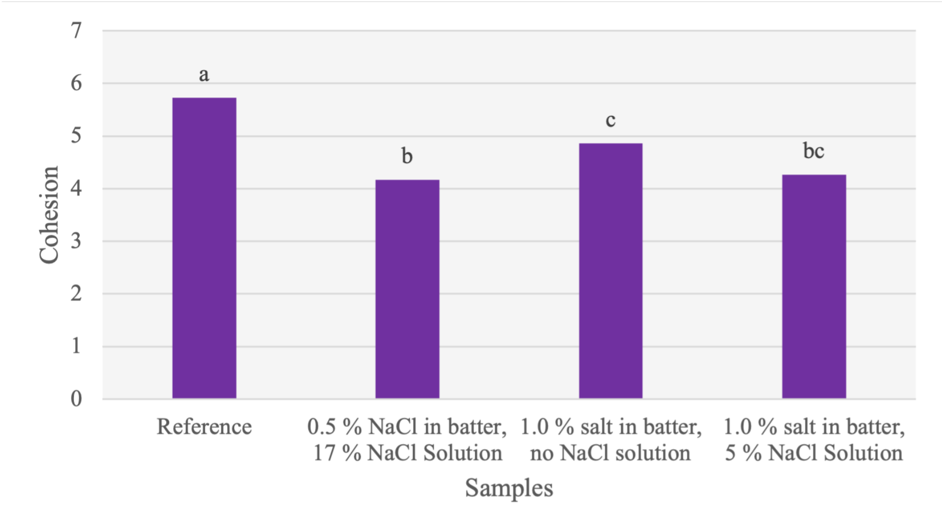

Figure 30: Graph showing the average grading of the Cohesion of the different samples graded during the sensory evaluation. The reference had a higher amount of added NaCl in the batter and was not immersed in a NaCl solution. Different letters above the staples means that the results are significantly different from each other according to Tukey-Kramer post-hoc test on significant one-way ANOVA results. Data used for the one-way ANOVA has been centered and standardised.

4.7.5 Liking

Results showed that participants liked the reference the most and meatball with 0.5 % NaCl in the batter immersed in 17 % NaCl solution the least. However, after centering and standardising the data, one-way ANOVA did not find any significant differences in liking of the different meatballs ($F=2.32 < Fcrit=2.68$). The results can be seen below in Figure 31.

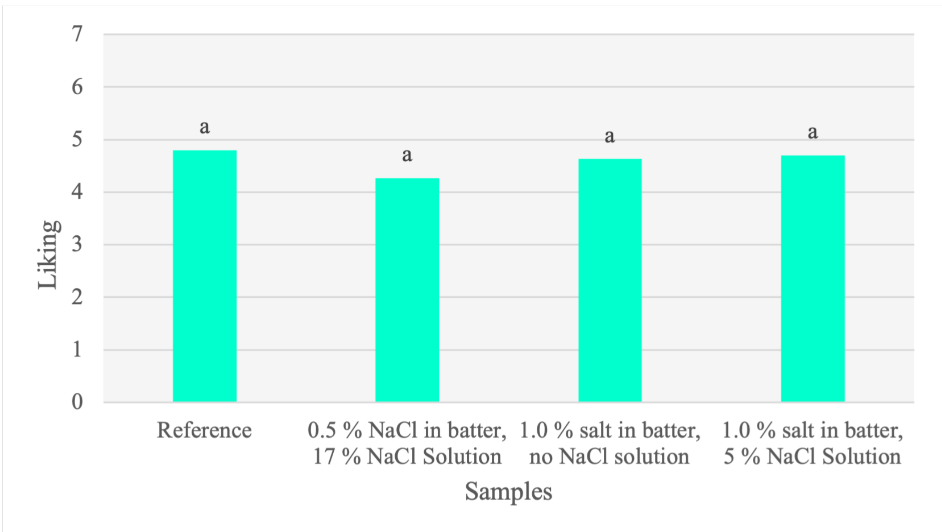

Figure 31: Graph showing the average grading of the Liking of the different samples graded during the sensory evaluation. The reference had a higher amount of added NaCl in the batter and was not immersed in a NaCl solution. No significant different could be found when performing one-way ANOVA. Data used for the one-way ANOVA has been centered and standardised.

4.8 Discussion from Sensory Evaluation

For overall flavour, a significant difference was found between the reference and meatball with 0.5 % added NaCl and 17 % NaCl solution (further called 0.5x17), with the reference being significantly higher. As meatball 0.5x17 had the lowest amount of added NaCl amongst the samples, and the reference had the highest, these results point towards literature, that mentions that NaCl is a carrier of taste [16]. However, the other samples were not significantly different from each other. This could indicate that distributing the NaCl mostly on the exterior will lower the flavour-carrier attribute of NaCl, as the total NaCl content of all samples, except for the reference, is approximately the same. The fact that meatball with 1.0 % added NaCl and not immersed (1.0x0) and meatball with 1.0 % added NaCl immersed in 5 % NaCl solution (1.0x5) does not significantly differ from the reference, could be an effect of the NaCl reduction method reducing by stealth, see section 2.2.3.1, where the reduction is too small for a difference to be noted. However, despite these results not being significant, they were still lower than for the reference sample, indicating that the difference might still have been felt somewhat.

For NaCl intensity, the reference significantly differed from all other samples. The other samples did not differ from each other. While this is in line with actual NaCl content, the aim of this thesis was to examine how a heterogeneous distribution of NaCl would affect the perception of the salt intensity. According to literature, meatball 0.5x17 and 1.0x5 should have been experienced as more salty than meatball 1.0x0 [26]–[30]. Some technical aspects could have affected these results. For example, NaCl might migrate towards the interior of the meatball when being reheated, resulting in a smaller concentration gradient, which would decrease the difference in NaCl distribution between the samples and make them more similar. It could also be discussed whether meatball 1.0x5 was immersed in a salty enough solution for it to make any difference in perception. Possibly, using a sample that had a larger concentration difference but still an acceptable texture would have been a better sample to use. To do this, a combination that resulted in a lower NaCl reduction would have had to be chosen, or methods to improve the texture despite the NaCl reduction would need to be examined.

For juiciness, no significant differences were found, but in raw numbers, meatball 0.5x17, containing the least amount of added NaCl, was found to be the juiciest. This is not in line with literature, stating that more added NaCl gives a higher water holding capacity and is therefore to be perceived as juicier [14]. However, considering earlier results in section 4.5.4, that show that sample 1, which is the same as meatball 0.5x17, has a high water content, the results could still be reasonable. Perhaps the combination of a high water content but a lower water holding capacity make existing juices easily release from the meatball, and they may be perceived as more juicy.

For cohesion, it could be seen that the reference obtained the highest value, around 5.7, while the others received values below five. The reference became significantly different from the other samples, meaning that the panellists evaluated the reference as the meatball which, when chewing, held together the best. Meatball 0.5x17 scored the lowest and was thereby the meatball that was experienced to fall apart most easily. However, it is possible that the panellists, when cutting the meatball in half, already notice a difference in cohesion, and were thereby indirectly affected by this when chewing the meatball and evaluating it. Nevertheless, sample 0.5x17 consisted of 0.5 % NaCl within the batter, much less than the other samples. This implies that the result of cohesion from this sensory evaluation corresponds to the theory that NaCl has a considerable role when creating the gel of the meat batter during cooking [7], which has been explained in earlier discussions. It also corresponds to the authors' personal experience of the cohesion of the meatball when trying them during the trials.

For liking, it could be seen that the reference scored the highest value, although it was not significant from the other samples with lower amount of NaCl. Thereafter, the meatballs with 1.0 % NaCl within the batter (meatball 1.0x0 and 1.0x5) got similar values and meatball 0.5x17 with the lowest amount of added NaCl within the batter scored the lowest. Due to this insignificant result, it can be discussed that meatballs, regardless of differences in perception of NaCl intensity and cohesion, will be perceived as good.

For all these results, it should be taken into consideration that the panel was untrained and therefore not as sensitive to small changes as a trained panel would be. The ratings on the different samples may for this reason be inconsistent. However, it can be discussed that it is regular people who will consume the meatballs in their everyday lives, and the choice of untrained panellists can therefore be argued for. Sensory evaluation design-wise, the panellists were asked to cut the meatball and eat one half at a time, as it was important to get a big enough bite of the meatball to sense flavour and texture, as it was not believed that people usually put a whole meatball in their mouths at once. In this sense, there was not actually a coating around the entire meatball during the consumption, and maybe this too could have affected the results. An improvement could be to make smaller size meatballs and make panellists consume them whole. However, the size of the meatballs made, was chosen because they were the same size as those from the production. Moreover, it should be taken in consideration that the evaluation was made with meatballs produced in a test kitchen. Meatballs produced in the industrial process would probably have lower NaCl content, which might have affected these results. This was however out of scope, and was thereby not considered when formulating a conclusion.

As a conclusion of this sensory evaluation, it seems that regardless of heterogeneous distribution of NaCl throughout the meatball, the NaCl perception will be similar. Thereby, the method of immersing the meatball in a NaCl solution will probably not be a method to use with the purpose of obtaining a meatball with lower NaCl content but the same salt intensity. However, despite the changed perception of texture and salt intensity, the liking of the meatballs will not be affected.

5. Conclusions

The objective of this thesis was to investigate if a heterogeneous distribution of NaCl would make the perception of the salt intensity increase, even though the total amount of added NaCl was lowered, compared to a reference. The heterogeneous distribution was received by immersing the meatballs in a NaCl solution during the process, to obtain an exterior of the meatball with a higher concentration of NaCl than within the meatball. The hypothesis was that this method would increase the perception of NaCl. Furthermore, it was investigated how the decrease in amount of NaCl would affect texture and overall flavour.

When investigating these objectives, two conclusions could be drawn. Firstly, an increased NaCl perception due to a heterogeneous NaCl distribution was not found, for either meatballs with high or low NaCl concentration differences between interior and exterior. Therefore, heterogeneous distribution could not be confirmed as a successful NaCl reduction method on meatballs. Neither could any answer to how the salt best could be distributed to receive a minimum salt-taste difference despite a lower concentration of added NaCl be found. Secondly, it could be concluded that textural properties, such as cohesion, will change when lowering the internal NaCl content. However, this result will not affect the perception of juiciness and probably not overall flavour, regarding NaCl content differences of 0.6 %-units and less.

Conclusion one, regarding the method of immersing meatballs in a NaCl solution to heterogeneously distribute the NaCl, was based on the sensory evaluation. Here, it was seen that when panellists evaluated the four different meatballs, the perception of salt intensity significantly differed between the reference (2.1 % NaCl) and the three other samples with similar concentration of NaCl (1.5-1.6 %). Between the other three different meatballs there was no significant difference, and because these meatballs consisted of two samples with different distribution of NaCl and one without, it could be concluded that immersion of meatballs would not increase the perception of NaCl. Because of this result, no conclusions could be drawn on the optimal distribution of NaCl to minimise the salt-taste difference from a reference meatball.

Conclusion two was drawn partly from personal observations, where meatballs containing lower amounts of NaCl were found to be less cohesive during both cutting and chewing. These observations were confirmed in the sensory evaluation, where all samples had a significantly lower cohesion result than the reference meatball. The sensory evaluation did not show any significant results in juiciness and for overall flavour, only the meatball with the lowest added NaCl in the batter significantly differed from the reference.

A suggestion for future work would be to examine ways to improve the texture of the meat, as this was a bottleneck in choosing acceptable meatballs for a sensory evaluation, and thus limited the choice of combinations to use for a sensory evaluation. Perhaps phosphates, hydrocolloids or other binding agents could be incorporated into the batter recipe. Another suggestion, is to minimise the mass diffusion between exterior and interior, which may give a saltier perception. This could be done by continuing the works of Xiong et al. [15] in making gel coatings, or in other ways increasing the viscosity of the saline solution, making the migration of NaCl slower.

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Appendix A

In this section, data compiled during experimental trials of immersing meatballs in different concentration of NaCl in the solution can be found.

Table A1: Summarized data for meatballs immersed in different concentration of NaCl in the solution. Values are presented as mean ± standard deviation. Different letters between the samples in the same row means that the result are significantly different.

Analysis	Reference	5 % NaCl solution	10 % NaCl solution	15 % NaCl solution
NaCl Content (g/100g)	2.1 +/- 0.0 [a]	0.47 +/- 0.058 [b]	0.67 +/- 0.058 [c]	0.87 +/- 0.058 [d]
Hardness (g)	1300 +/- 190 [a]	1400 +/- 220 [a]	1500 +/- 29 [a]	1500 +/- 170 [a]
Cohesiveness	0.77 +/- 0.010 [a]	0.71 +/- 0.028 [a]	0.71 +/- 0.037 [a]	0.71 +/- 0.0079 [a]
Gumminess (g)	970 +/- 140 [a]	980 +/- 140 [a]	1030 +/- 34 [a]	1030 +/- 110 [a]
Cooking Loss (%)	17 +/- 1.6 [a]	20. +/- 1.1 [b]	21 +/- 2.1 [b]	19 +/- 2.9 [ab]
Water Content (g/100g)	63 +/- 0.26 [a]	64 +/- 0.95 [a]	64 +/- 1.4 [a]	64 +/- 1.2 [a]
pH	6.0 +/- 0.0 [a]	5.9 +/- 1.1E-15 [b]	5.9 +/- 1.1E-15 [b]	5.9 +/- 1.1E-15 [b]

Table A2: Raw data on NaCl content for meatballs immersed in different concentration of NaCl in the solution.

NaCl Content (g/100g)	Ref	5 %	10 %	15 %
Sample 1	*2.1*	*0.4*	*0.6*	*0.8*
Sample 2	*2.1*	*0.5*	*0.7*	*0.9*
Sample 3	*2.1*	*0.5*	*0.7*	*0.9*
Mean value	*2.1*	*0.4667*	*0.6667*	*0.8667*
Stand. Dev.	*0.0*	*0.0577*	*0.0577*	*0.0577*

Table A3: One-way ANOVA on NaCl content for meatballs immersed in different concentration of NaCl in the solution.

Anova: Single factor, NaCl Content

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	6.3	2.1	0
5 %	3	1.4	0.466667	0.003333
10 %	3	2	0.666667	0.003333
15 %	3	2.6	0.866667	0.003333

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	4.8625	3	1.620833	648.3333	6.92E-10	4.066181
Within groups	0.02	8	0.0025			
Total	4.8825	11				

Table A4: Post-hoc Tukey-Kramer on NaCl content for meatballs immersed in different concentration of NaCl in the solution.

POST HOC: Tukey-Kramer on Salt Content			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 5 %	4.9	0.130769836	YES
Ref vs 10 %	4.3	0.130769836	YES
Ref vs 15 %	3.7	0.130769836	YES
5 % vs 10 %	0.6	0.130769836	YES
5 % vs 15 %	1.2	0.130769836	YES
10 % vs 15 %	0.6	0.130769836	YES

Table A5: Raw data of Hardness for meatballs immersed in different concentration of NaCl in the solution.

Hardness (g)	**Ref**	**5 %**	**10 %**	**15 %**
Sample 1	*1481.5*	*1194.9*	*1478.7*	*1359.9*
Sample 2	*1168.1*	*1331.5*	*1421.4*	*1372.9*
Sample 3	*1137.7*	*1627.9*	*1451.6*	*1652.9*
Mean value	*1262.433333*	*1384.76667*	*1450.566667*	*1461.9*
Stand. Dev.	*190.3252304*	*221.360008*	*28.66397274*	*165.5385152*

Table A6: One-way ANOVA on Hardness for meatballs immersed in different concentration of NaCl in the solution.

Anova: Single factor, Hardness						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Ref	3	3787.3	1262.43	36223.7		
5 %	3	4154.3	1384.77	49000.3		
10 %	3	4351.7	1450.57	821.623		
15 %	3	4385.7	1461.9	27403		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	75415.6	3	25138.5	0.88634	0.488299733	4.066180551
Within groups	226897	8	28362.1			
Total	302313	11				

Table A7: Raw data on Cohesiveness for meatballs immersed in different concentration of NaCl in the solution.

Cohesiveness	**Ref**	**5 %**	**10 %**	**15 %**
Sample 1	*0.764*	*0.702*	*0.687*	*0.716*
Sample 2	*0.76*	*0.74*	*0.755*	*0.704*
Sample 3	*0.779*	*0.686*	*0.698*	*0.701*
Mean value	*0.767666667*	*0.70933333*	*0.713333333*	*0.707*
Stand. Dev.	*0.010016653*	*0.02773686*	*0.036501142*	*0.007937254*

Table A8: One-way ANOVA on Cohesiveness for meatballs immersed in different concentration of NaCl in the solution.

Anova: Single factor, Cohesiveness						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Ref	3	2.303	0.76767	0.0001		
5 %	3	2.128	0.70933	0.00077		
10 %	3	2.14	0.71333	0.00133		
15 %	3	2.121	0.707	6.3E-05		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	0.00757	3	0.00252	4.45779	0.040391935	4.066180551
Within groups	0.00453	8	0.00057			
Totalt	0.0121	11				

Table A9: Tukey-Kramer post-hoc test on Cohesiveness for for meatballs immersed in different concentration of NaCl in the solution.

POST HOC: Tukey-Kramer on Cohesiveness			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 5 %	0.05833	0.06224	NO
Ref vs 10 %	0.05433	0.06224	NO
Ref vs 15 %	0.06067	0.06224	NO
5 % vs 10 %	0.004	0.06224	NO
5 % vs 15 %	0.00233	0.06224	NO
10 % vs 15 %	0.00633	0.06224	NO

Table A10: Raw data on Gumminess for meatballs immersed in different concentration of NaCl in the solution.

Gumminess (g)	**Ref**	**5 %**	**10 %**	**15 %**
Sample 1	*1131.2*	*838.456*	*1016.48*	*973.718*
Sample 2	*888.141*	*984.901*	*1073.48*	*966.47*
Sample 3	*886.346*	*1116.37*	*1014.47*	*1158.41*
Mean value	*968.5623*	*979.909*	*1034.81*	*1032.866*
Stand. Dev.	*140.8512*	*139.0242*	*33.50428*	*108.78467*

Table A11: One-way ANOVA on Gumminess for meatballs immersed in different concentration of NaCl in the solution.

Anova: Single factor, Gumminess

SUMMARY

Groups	Count	Sum	Average	Variance		
Ref	3	2905.687	968.5623333	19839.06347		
5 %	3	2939.727	979.909	19327.7379		
10 %	3	3104.43	1034.81	1122.5367		
15 %	3	3098.598	1032.866	11834.10533		

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	10856.10339	3	3618.701129	0.277702384	0.840063847	4.066180551
Within groups	104246.8868	8	13030.86085			
Total	115102.9902	11				

Table A12: Raw data on Cooking loss for meatballs immersed in different concentration of NaCl in the solution.

Cooking Loss	**Ref**	**5%**	**10 %**	**15 %**
Sample 1	*15.48 %*	*21.94 %*	*21.94 %*	*18.71 %*
Sample 2	*16.13 %*	*20.00 %*	*20.00 %*	*23.23 %*
Sample 3	*17.42 %*	*18.71 %*	*17.42 %*	*14.19 %*
Sample 4	*18.71 %*	*20.00 %*	*19.35 %*	*17.42 %*
Sample 5	*16.13 %*	20.00 %	*21.94 %*	*19.35 %*
Sample 6	*19.35 %*	*19.35 %*	*23.23 %*	*19.35 %*
Mean value	*17.20 %*	*20.00 %*	*20.65 %*	*18.71 %*
Stand. Dev.	*1.56 %*	*1.08 %*	*2.12 %*	*2.94 %*

Table A13: One-way ANOVA Cooking loss for meatballs immersed in different concentration of NaCl in the solution.

Anova: Single factor, Cooking Loss

SUMMARY

Groups	Count	Sum	Average	Variance		
Ref	6	77	12.83333	0-058667		
5 %	6	74.4	12.4	0.028		
10 %	6	73.8	12.3	0.108		
15 %	6	75.6	12.6	0.208		

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	1	3	0.333333	3.311258	0.041009054	3.098391
Within groups	2.013333333	20	0.100667			
Total	3.013333333	23				

Table A14: Post-hoc Tukey-Kramer on Cooking loss for meatballs immersed in different concentration of NaCl in the solution.

POST HOC: Tukey-Kramer on Cooking Loss			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 5 %	0.533333333	0.512935	YES
Ref vs 10 %	0.533333333	0.512935	YES
Ref vs 15 %	0.233333333	0.512935	NO
5 % vs 10 %	0.1	0.512935	NO
5 % vs 15 %	0.2	0.512935	NO
10 % vs 15 %	0.3	0.512935	NO

Table A15: Raw data on Water content for meatballs immersed in different concentration of NaCl in the solution.

Water Content (g/100g)	**Ref**	**5 %**	**10 %**	**15 %**
Sample 1	*63.4*	*65.1*	*65.2*	*65.2*
Sample 2	*63.0*	*64.3*	*63.0*	*62.9*
Sample 3	*63.5*	*63.2*	*62.5*	*63.3*
Mean value	*63.3*	*64.2*	*63.56667*	*63.8*
Stand. Dev.	*0.26457513*	*0.9539392*	*1.436431*	*1.228821*

Table A16: One-way ANOVA on Water content for meatballs immersed in different concentration of NaCl in the solution.

Anova: Single factor, Water Content						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Ref	3	110.1	36.7	0.07		
5 %	3	107.4	35.8	0.91		
10 %	3	109.3	36.4333	2.06333		
15 %	3	108.6	36.2	1.51		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	1.31	3	0.43667	0.3836	0.76782	4.06618
Within groups	9.10666667	8	1.13833			
Total	10.4166667	11				

Table A17: pH for meatballs immersed in different concentration of NaCl in the solution.

pH	**Ref**	**5 %**	**10 %**	**15 %**
Sample 1	*6.0*	*5.9*	*5.9*	*5.9*
Sample 2	*6.0*	*5.9*	*5.9*	*5.9*
Sample 3	*6.0*	*5.9*	*5.9*	*5.9*
Mean value	*6.0*	*5.9*	*5.9*	*5.9*
Stand. Dev.	*0*	*1.08779E-15*	*1.08779E-15*	*1.08779E-15*

Table A18: One-way ANOVA on pH for meatballs immersed in different concentration of NaCl in the solution.

Anova: Single factor, pH						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Ref	3	18	6	0		
5 %	3	17.7	5.9	1.18329E-30		
10 %	3	17.7	5.9	1.18329E-30		
15 %	3	17.7	5.9	1.18329E-30		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	0.0225	3	0.0075	8.451E+27	2.4397E-110	4.066180551
Within groups	7.09975E-30	8	8.87469E-31			
Total	0.0225	11				

Table A19: Post-hoc Tukey-Kramer on pH for meatballs immersed in different concentration of NaCl in the solution.

POST HOC: Tukey-Kramer on pH			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 5 %	0.1	2.46385E-15	YES
Ref vs 10 %	0.1	2.46385E-15	YES
Ref vs 15 %	0.1	2.46385E-15	YES
5 % vs 10 %	0	2.46385E-15	NO
5 % vs 15 %	0	2.46385E-15	NO
10 % vs 15 %	0	2.46385E-15	NO

Appendix B

In this section, data compiled during experimental trials of meatballs with different concentration of added NaCl within the batter can be found.

Table B1: Summarized data for meatballs with different concentration of NaCl in the batter. Values are presented as mean ± standard deviation.

Analysis	**Reference**	**0.5 %**	**0.75 %**
NaCl Content (g/100g)	2.1 +/- 0.0 ^{a}	0.84 +/- 0.058 ^{b}	1.2 +/ 0.058 ^{c}
Hardness (g)	1300 +/- 190 ^{a}	1500 +/- 150 ^{a}	1400 +/- 100 ^{a}
Cohesiveness	0.77 +/- 0.010 ^{ab}	0.74 +/- 0.016 ^{a}	0.74 +/- 0.021 ^{a}
Gumminess (g)	970 +/- 140 ^{a}	1100 +/- 97 ^{a}	1000 +/- 90 ^{a}
Cooking Loss (%)	17 +/- 1.6 ^{a}	20. +/- 1.5 ^{b}	21 +/- 1.5 ^{b}
Water Content (g/100g)	63 +/- 0.26 ^{a}	64 +/- 0.53 ^{b}	65 +/- 0.23 ^{bc}
pH	6.0 +/ 0.0 ^{a}	6.0 +/- 0.058 ^{ab}	5.9 +/- 0.058 ^{ab}

Table B2: Summarized data for meatballs with different concentration of NaCl in the batter. Values are presented as mean ± standard deviation.

Analysis	**1.0 %**	**1.25 %**
NaCl Content (g/100g)	1.5 +/- 0 [d]	1.83 +/- 0.058 [e]
Hardness (g)	1300 +/- 220 [a]	1100 +/- 180 [a]
Cohesiveness	0.75 +/- 0.022 [a]	0.80 +/- 0.013 [b]
Gumminess (g)	950 +/- 190 [a]	880 +/- 130 [a]
Cooking Loss (%)	21 +/- 1.5 [b]	21 +/- 1.8 [b]
Water Content (g/100g)	65 +/- 0.12 [c]	65 +/- 0.058 [bc]
pH	5.9 +/ 1.1E-15 [b]	5.9 +/- 1.1E-15 [b]

Table B3: Raw data on the NaCl content for meatballs with different concentrations of NaCl in the batter.

Salt Content (g/100g)	**Ref**	**0.5 %**	**0.75 %**	**1.0 %**	**1.25%**
Sample 1	*2.1*	*0.8*	*1.2*	*1.5*	*1.8*
Sample 2	*2.1*	*0.8*	*1.2*	*1.5*	*1.9*
Sample 3	*2.1*	*0.9*	*1.1*	*1.5*	*1.8*
Mean value	*2.1*	*0.833333*	*1.166666667*	*1.5*	*1.833333*
Stand. Dev.	*0*	*0.057735*	*0.057735027*	*0*	*0.057735*

Table B4: One-way ANOVA on NaCl content for meatballs with different concentrations of NaCl in the batter.

Anova: Single factor, NaCl Content

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	6.3	2.1	0
0.5 %	3	2.5	0.833333	0.003333333
0.75 %	3	3.5	1.166667	0.003333333
1.0 %	3	4.5	1.5	0
1.25 %	3	5.5	1.833333	0.003333333

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	3.077333	4	0.769333	384.6666667	6.69913E-11	3.47805
Within groups	0.02	10	0.002			
Total	3.097333	14				

Table B5: Tukey-Kramer post-hoc on NaCl content for meatballs with different concentrations of NaCl in the batter.

POST HOC: Tukey-Kramer on Salt Content			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 0.5 %	1.2666667	0.120166	YES
Ref vs 0.75 %	0.9333333	0.120166	YES
Ref vs 1.0 %	0.6000000	0.120166	YES
Ref vs 1.25 %	0.2666667	0.120166	YES
0.5 % vs 0.75 %	0.3333333	0.120166	YES
0.5 % vs 1.0 %	0.6666667	0.120166	YES
0.5 % vs 1.25 %	1.0000000	0.120166	YES
0.75 % vs 1.0 %	0.3333333	0.120166	YES
0.75 % vs 1.25 %	0.6666667	0.120166	YES
1.0 % vs 1.25 %	0.3333333	0.120166	YES

Table B6: Raw data on Hardness for meatballs with different concentration of NaCl in the batter.

Hardness (g)	**Ref**	**0.5 %**	**0.75 %**	**1.0 %**	**1.25 %**
Sample 1	*1481.5*	*1450.8*	*1345.5*	*1501.1*	*1297*
Sample 2	*1168.1*	*1710.2*	*1529.5*	*1242.8*	*1013.9*
Sample 3	*1137.7*	*1450.9*	*1370.6*	*1057.2*	*967.5*
Mean value	*1262.433333*	*1537.3*	*1415.2*	*1267.033*	*1092.8*
Stand. Dev.	*190.3252304*	*149.7358007*	*99.77910603*	*222.94*	*178.3577*

Table B7: One-way ANOVA on Hardness for meatballs with different concentrations of NaCl in the batter.

Anova: Single factor, Hardness						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Ref	3	3787.3	1262.433	36223.69		
0.5 %	3	4611.9	1537.3	22420.81		
0.75 %	3	4245.6	1415.2	9955.87		
1.0 %	3	3801.1	1267.033	49702.24		
1.25 %	3	3278.4	1092.8	31811.47		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	341682.6	4	85420.66	2.845191	0.081948	3.47805
Within groups	300228.2	10	30022.82			
Total	641910.8	14				

Table B8: Raw data on Cohesiveness for meatballs with different concentrations of NaCl in the batter.

Cohesiveness	**Ref**	**0.5 %**	**0.75 %**	**1.0 %**	**1.25 %**
Sample 1	*0.764*	*0.728*	*0.712*	*0.759*	*0.789*
Sample 2	*0.76*	*0.724*	*0.752*	*0.768*	*0.803*
Sample 3	*0.779*	*0.753*	*0.743*	*0.725*	*0.814*
Mean value	*0.76767*	*0.735*	*0.73567*	*0.75067*	*0.802*
Stand. Dev.	*0.01002*	*0.01572*	*0.02098*	*0.022679*	*0.01253*

Table B9: One-way ANOVA on Cohesiveness for meatballs with different concentrations of NaCl in the batter.

Anova: Single factor, Cohesiveness

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	2.303	0.767666667	0.000100333
0.5 %	3	2.205	0.735	0.000247
0.75 %	3	2.207	0.735666667	0.000440333
1.0 %	3	2.252	0.750666667	0.000514333
1.25 %	3	2.406	0.802	0.000157

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	0.009332	4	0.0023331	7.995544894	0.003687496	3.478049691
Within groups	0.002918	10	0.0002918			
Total	0.01225	14				

Table B10: Tukey-Kramer post-hoc on Cohesiveness for meatballs with different concentrations of NaCl in the batter.

POST HOC: Tukey-Kramer on Cohesiveness

Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 0.5 %	0.032667	0.0459	NO
Ref vs 0.75 %	0.032	0.0459	NO
Ref vs 1.0 %	0.017	0.0459	NO
Ref vs 1.25 %	0.034333	0.0459	NO
0.5 % vs 0.75 %	0.000667	0.0459	NO
0.5 % vs 1.0 %	0.015667	0.0459	NO
0.5 % vs 1.25 %	0.067	0.0459	YES
0.75 % vs 1.0 %	0.015	0.0459	NO
0.75 % vs 1.25 %	0.066333	0.0459	YES
1.0 % vs 1.25 %	0.051333	0.0459	YES

Table B11: Raw data on Gumminess for meatballs with different concentrations of NaCl in the batter.

Gumminess (g)	**Ref**	**0.5 %**	**0.75 %**	**1.0 %**	**1.25 %**
Sample 1	*1131.2*	*1055.79*	*958.1*	*1139.6*	1023,9
Sample 2	*888.141*	*1238.75*	*1135.74*	*954.186*	*814.35*
Sample 3	*886.346*	*1091.2*	*1017.4*	*766.645*	*787.7*
Mean value	*968.5623*	*1128.58*	*1037.08*	*953.477*	*875.3167*
Stand. Dev.	*140.8512*	*97.0389*	*90.4404*	*186.4785*	*129.365*

Table B12: ANOVA on Gumminess for meatballs with different concentrations of NaCl in the batter.

Anova: Single factor, Gumminess

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	2905.687	968.5623	19839.06
0.5 %	3	3385.74	1128.58	9416.539
0.75 %	3	3111.24	1037.08	8179.469
1.0 %	3	2860.431	953.477	34774.24
1.25 %	3	2625.95	875.3167	16735.31

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	108998.5	4	27249.62	1.531831	0.265789	3.47805
Within groups	177889.2	10	17788.92			
Total	286887.7	14				

Table B13: Raw data on Cooking loss for meatballs with different concentrations of NaCl in the batter.

Cooking Loss	**Ref**	**0.5 %**	**0.75 %**	**1.0 %**	**1.25 %**
Sample 1	*15.48 %*	*20.00 %*	*19.35 %*	*20.00 %*	*19.35 %*
Sample 2	*16.13 %*	*18.71 %*	*21.94 %*	*18.71 %*	*19.35 %*
Sample 3	*17.42 %*	*21.94 %*	*21.29 %*	*20.65 %*	*21.94 %*
Sample 4	*18.71 %*	*19.35 %*	*19.35 %*	*20.00 %*	*19.35 %*
Sample 5	*16.13 %*	*18.71 %*	*23.23 %*	*21.29 %*	*22.58 %*
Sample 6	*19.35 %*	*21.94 %*	*20.65 %*	*23.23 %*	*23.23 %*
Mean value	*17.20 %*	*20.11 %*	*20.97 %*	*20.65 %*	*20.97 %*
Stand. Dev.	*1.56 %*	*1.49 %*	*1.51 %*	*1.53 %*	*1.81 %*

Table B14: One-way ANOVA on Cooking loss for meatballs with different concentrations of NaCl in the batter.

Anova: Single factor, Cooking Loss

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	6	1.032258065	0.172043011	0.00024419
0.5 %	6	1.206451613	0.201075269	0.000223378
0.75 %	6	1.258064516	0.209677419	0.000228928
1.0 %	6	1.238709677	0.206451613	0.000233091
1.25 %	6	1.258064516	0.209677419	0.000328824

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	0.006068678	4	0.00151717	6.028114664	0.00154125	2.75871047
Within groups	0.006292057	25	0.000251682			
Total	0.012360735	29				

Table B15: Tukey-Kramer post-hoc on Cooking loss for meatballs with different concentrations of NaCl in the batter.

POST HOC: Tukey-Kramer on Cooking Loss			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 0.5 %	0.029032258	0.026897544	YES
Ref vs 0.75 %	0.037634409	0.026897544	YES
Ref vs 1.0 %	0.034408602	0.026897544	YES
Ref vs 1.25 %	0.037634409	0.026897544	YES
0.5 % vs 0.75 %	0.008602151	0.026897544	NO
0.5 % vs 1.0 %	0.005376344	0.026897544	NO
0.5 % vs 1.25 %	0.008602151	0.026897544	NO
0.75 % vs 1.0 %	0.003225806	0.026897544	NO
0.75 % vs 1.25 %	0	0.026897544	NO
1.0 % vs 1.25 %	0.003225806	0.026897544	NO

Table B16: Raw data on Water content for meatballs with different concentrations of NaCl in the batter.

Water Content (g/100g)	**Ref**	**0.5 %**	**0.75 %**	**1.0 %**	**1.25 %**
Sample 1	*63.4*	*64.7*	*64.7*	*65.2*	*64.7*
Sample 2	*63.0*	*63.7*	*65.1*	*65.00*	*64.8*
Sample 3	*63.5*	*63.9*	*64.7*	*65.00*	*64.8*
Mean value	*63.3*	*64.1*	*64.833*	*65.067*	*64.767*
Stand. Dev.	*0.265*	*0.529*	*0.231*	*0.115*	*0.0577*

Table B17: One-way ANOVA on Water content for meatballs with different concentrations of NaCl in the batter.

Anova: Single factor, Water Content						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Ref	3	110.1	36.7	0.07		
0.5 %	3	107.7	35.9	0.28		
0.75 %	3	105.5	35.16667	0.053333		
1.0 %	3	104.8	34.93333	0.013333		
1.25 %	3	105.7	35.23333	0.003333		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	6.197333	4	1.549333	18.44444	0.000131	3.47805
Within groups	0.84	10	0.084			
Total	7.037333	14				

Table B18: Tukey-Kramer on Water content for meatballs with different concentrations of NaCl in the batter.

POST HOC: Tukey-Kramer on Water Content			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 0.5 %	0.8	0.778094	YES
Ref vs 0.75 %	1.533333333	0.778094	YES
Ref vs 1.0 %	1.766666667	0.778094	YES
Ref vs 1.25 %	1.466666667	0.778094	YES
0.5 % vs 0.75 %	0.733333333	0.778094	NO
0.5 % vs 1.0 %	0.966666667	0.778094	YES
0.5 % vs 1.25 %	0.666666667	0.778094	NO
0.75 % vs 1.0 %	0.233333333	0.778094	NO
0.75 % vs 1.25 %	0.066666667	0.778094	NO
1.0 % vs 1.25 %	0.3	0.778094	NO

Table B19: Raw data for pH for meatballs with different concentrations of NaCl in the batter.

pH	**Ref**	**0.5 %**	**0.75 %**	**1.0 %**	**1.25 %**
Sample 1	*6.0*	*6.0*	*5.9*	*5.9*	*5.9*
Sample 2	*6.0*	*5.9*	*5.9*	*5.9*	*5.9*
Sample 3	*6.0*	*6.0*	*6.0*	*5.9*	*5.9*
Mean value	*6.0*	*5.966667*	*5.933*	*5.9*	*5.9*
Stand. Dev.	*0.00*	*0.0577*	*0.0577*	*1.09E-15*	*1.09E-15*

Table B20: One-way ANOVA on pH for meatballs with different concentrations of NaCl in the batter.

Anova: Single factor, pH						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Ref	3	18	6	0		
0.5 %	3	17.9	5.966667	0.003333		
0.75 %	3	17.8	5.933333	0.003333		
1.0 %	3	17.7	5.9	1.18E-30		
1.25 %	3	17.7	5.9	1.18E-30		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	0.022666667	4	0.005667	4.25	0.028909	3.47805
Within groups	0.013333333	10	0.001333			
Total	0.036	14				

Table B21: Tukey-Kramer post-hoc on pH for meatballs with different concentrations of NaCl in the batter.

POST HOC: Tukey-Kramer on pH			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 0.5 %	0.0333333	0.098115	NO
Ref vs 0.75 %	0.0666667	0.098115	NO
Ref vs 1.0 %	0.1	0.098115	YES
Ref vs 1.25 %	0.1	0.098115	YES
0.5 % vs 0.75 %	0.0333333	0.098115	NO
0.5 % vs 1.0 %	0.0666667	0.098115	NO
0.5 % vs 1.25 %	0.0666667	0.098115	NO
0.75 % vs 1.0 %	0.0333333	0.098115	NO
0.75 % vs 1.25 %	0.0333333	0.098115	NO
1.0 % vs 1.25 %	0	0.098115	NO

Appendix C

In this section, data compiled during experimental trials of the meatballs with different combinations of added NaCl in batter and NaCl solutions can be found.

Table C1: Summarized data for meatballs with different concentration of NaCl in the batter and immersed in different NaCl solutions. This table shows the reference and sample 1-3. Values are presented as mean ± standard deviation.

Analysis	**Reference**	**1**	**2**	**3**
NaCl Content (g/100g)	2.1 +/- 0.0 ^{c}	1.5 +/- 0.058 ^{a}	1.5 +/- 0.058 ^{a}	1.5 +/- 0.058 ^{a}
Hardness (g)	1300 +/- 190 ^{a}	970 +/- 160 ^{ab}	840 +/- 190 ^{b}	1100 +/- 130 ^{ab}
Cohesiveness	0.77 +/- 0.010 ^{a}	0.76 +/- 0.0051 ^{a}	0.76 +/ 0.017 ^{a}	0.77 +/- 0.014 ^{a}
Gumminess (g)	970 +/- 140 ^{a}	740 +/- 120 ^{abc}	640 +/- 150 ^{b}	830 +/- 90. ^{abc}
Cooking Loss (%)	17 +/- 1.6 ^{a}	20. +/- 2.5 ^{ab}	21 +/- 2.0 ^{bc}	21 +/- 1.2 ^{bc}
Water Content(g/100g)	63 +/- 0.26 ^{a}	66 +/- 0.40 ^{b}	66 +/- 0.26 ^{bc}	65 +/- 0.10 ^{c}
pH	6.0 +/ 0.0 ^{abcde}	5.9 +/ 0.0 ^{a}	5.9 +/ 0.0 ^{b}	5.9 +/ 0.0 ^{c}

Table C2: Summarized data for meatballs with different concentration of NaCl in the batter and immersed in different NaCl solutions. This table shows the samples 4-7. Values are presented as mean ± standard deviation.

Analysis	**4**	**5**	**6**	**7**
NaCl Content (g/100g)	1.4 +/ 0.0 ^{b}	1.6 +/- 0.0 ^{a}	1.5 +/- 0.058 ^{a}	1.6 +/- 0.0 ^{a}
Hardness (g)	1000 +/- 23 ^{ab}	1200 +/- 57 ^{ab}	1000 +/- 150 ^{ab}	1000 +/- 140 ^{ab}
Cohesiveness	0.77 +/- 0.012 ^{a}	0.78 +/- 0.0050 ^{a}	0.78 +/- 0.0072 ^{a}	0.77 +/- 0.017 ^{a}
Gumminess (g)	770 +/- 29 ^{abc}	970 +/- 40. ^{ac}	830 +/-110 ^{abc}	800 +/- 120 ^{abc}
Cooking Loss (%)	23 +/- 2.3 ^{c}	20. +/- 1.3 ^{abc}	20. +/- 1.7 ^{abc}	22 +/- 1.8 ^{bc}
Water Content(g/100g)	65 +/- 0.98 ^{bcd}	64 +/- 0.47 ^{acd}	65 +/- 0.17 ^{bc}	65 +/- 0.25 ^{c}
pH	5.9 +/- 0.058	6.0 +/- 0.058	5.9 +/- 0.0 ^{d}	5.9 +/- 0.0 ^{a}

Table C3: Raw data of the Salt content for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

NaCl Content (g/100g)	**Ref**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sample 1	*2.1*	*1.6*	*1.5*	*1.6*	*1.4*	*1.6*	*1.6*	*1.6*
Sample 2	*2.1*	*1.5*	*1.6*	*1.5*	*1.4*	*1.6*	*1.5*	*1.6*
Sample 3	*2.1*	*1.5*	*1.5*	*1.5*	*1.4*	*1.6*	*1.5*	*1.6*
Mean value	*2.1*	*1.533*	*1.533*	*1.533*	*1.400*	*1.600*	*1.533*	*1.600*
Stand. Dev.	*0.0*	*0.1*	*0.0577*	*0.0577*	*0.000*	*0.000*	*0.058*	*0.000*

Table C4: One-way ANOVA on NaCl content for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Anova: Single factor, NaCl Content

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	6.3	2.1	0
1	3	4.6	1.5333333	0.003333333
2	3	4.6	1.5333333	0.003333333
3	3	4.6	1.5333333	0.003333333
4	3	4.2	1.4	7.39557E-32
5	3	4.8	1.6	7.39557E-32
6	3	4.6	1.53333333	0.003333333
7	3	4.8	1.6	7.39557E-32

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	0.922916667	7	0.131845238	79.10714286	3.22459E-11	2.6571966
Within groups	0.026666667	16	0.001666667			
Total	0.949583333	23				

Table C5: Tukey-Kramer post-hoc on NaCl content for meatballs for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

POST HOC: Tukey-Kramer on NaCl Content			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 1	0.566666667	0.115399827	YES
Ref vs 2	0.566666667	0.115399827	YES
Ref vs 3	0.566666667	0.115399827	YES
Ref vs 4	0.7	0.115399827	YES
Ref vs 5	0.5	0.115399827	YES
Ref vs 6	0.566666667	0.115399827	YES
Ref vs 7	0.5	0.115399827	YES
1 vs 2	0	0.115399827	NO
1 vs 3	0	0.115399827	NO
1 vs 4	0.133333333	0.115399827	YES
1 vs 5	0.066666667	0.115399827	NO
1 vs 6	0	0.115399827	NO
1 vs 7	0.066666667	0.115399827	NO
2 vs 3	0	0.115399827	NO
2 vs 4	0.133333333	0.115399827	YES
2 vs 5	0.066666667	0.115399827	NO
2 vs 6	0	0.115399827	NO
2 vs 7	0.066666667	0.115399827	NO
3 vs 4	0.133333333	0.115399827	YES
3 vs 5	0.066666667	0.115399827	NO
3 vs 6	0	0.115399827	NO
3 vs 7	0.066666667	0.115399827	NO
4 vs 5	0.2	0.115399827	YES
4 vs 6	0.133333333	0.115399827	YES
4 vs 7	0.2	0.115399827	YES
5 vs 6	0.066666667	0.115399827	NO
5 vs 7	0	0.115399827	NO
6 vs 7	0.066666667	0.115399827	NO

Table C6: Raw data on Hardness for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Hardness (g)	**Ref**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sample 1	*1481.5*	*903.7*	*990.6*	*1165.9*	*1034.0*	*1297.2*	*1239.3*	*991.5*
Sample 2	*1168.1*	*851.8*	*630.7*	*929.9*	*992.0*	*1205.9*	*947.2*	*916.6*
Sample 3	*1137.7*	*1154.6*	*908.1*	*1156.7*	*997.6*	*1192.7*	*1029.5*	*1194.2*
Mean value	*1262.433*	*970.033*	*843.133*	*1084.167*	*1007.867*	*1231.933*	*1072.00*	*1034.1*
Stand. Dev.	*190.325*	*161.932*	*188.540*	*133.678*	*22.805*	*56.907*	*150.616*	*143.619*

Table C7: One-way ANOVA on Hardness for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Anova: Single factor, Hardness

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	3787.3	1262.433333	36223,69333
1	3	2910.1	970.0333333	26222,04333
2	3	2529.4	843.1333333	35547,50333
3	3	3252.5	1084.166667	17869,81333
4	3	3023.6	1007.866667	520,0533333
5	3	3695.8	1231.933333	3238,363333
6	3	3216	1072	22685,29
7	3	3102.3	1034.1	20626,51

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	389099.5583	7	55585.65119	2.729247437	0.045633	2.657197
Within groups	325866.54	16	20366.65875			
Total	714966.0983	23				

Table C8: Tukey-Kramer post-hoc on Hardness for meatballs for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

POST HOC: Tukey-Kramer on Hardness			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 1	292.4	403.4044	NO
Ref vs 2	419.3	403.4044	YES
Ref vs 3	178.26667	403.4044	NO
Ref vs 4	254.56667	403.4044	NO
Ref vs 5	30.5	403.4044	NO
Ref vs 6	190.43333	403.4044	NO
Ref vs 7	228.33333	403.4044	NO
1 vs 2	126.9	403.4044	NO
1 vs 3	114.13333	403.4044	NO
1 vs 4	37.83333	403.4044	NO
1 vs 5	261.9	403.4044	NO
1 vs 6	101.96667	403.4044	NO
1 vs 7	64.06667	403.4044	NO
2 vs 3	241.03333	403.4044	NO
2 vs 4	164.73333	403.4044	NO
2 vs 5	388.8	403.4044	NO
2 vs 6	228.86667	403.4044	NO
2 vs 7	190.96667	403.4044	NO
3 vs 4	76.3000000	403.4044	NO
3 vs 5	147.7666667	403.4044	NO
3 vs 6	12.1666667	403.4044	NO
3 vs 7	50.0666667	403.4044	NO
4 vs 5	224.0666667	403.4044	NO
4 vs 6	64.1333333	403.4044	NO
4 vs 7	26.2333333	403.4044	NO
5 vs 6	159.9333333	403.4044	NO
5 vs 7	197.8333333	403.4044	NO
6 vs 7	37.9	403.4044	NO

Table C9: Raw data on Cohesiveness for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Cohesiveness	**Ref**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sample 1	*0.764*	*0.7642*	*0.7577*	*0.7666*	*0.7808*	*0.7805*	*0.7681*	*0.7519*
Sample 2	*0.760*	*0.7541*	*0.7374*	*0.7849*	*0.7659*	*0,7832*	*0.7801*	*0.826*
Sample 3	*0.779*	*0.759*	*0.7712*	*0.7570*	*0.7578*	*0.7902*	*0.7811*	*0.7786*
Mean value	*0.7677*	*0.7591*	*0.7554*	*0.7695*	*0.7682*	*0,7846*	*0.7764*	*0.7710*
Stand.Dev.	*0.0100*	*0.0051*	*0.0170*	*0.0142*	*0.0117*	*0.0050*	*0.0072*	*0.0167*

Table C10: One-way ANOVA on Cohesiveness for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Anova: Single factor, Cohesiveness

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	2.303	0.767666667	0.000100333
1	3	2.2773	0.7591	0.00002551
2	3	2.2663	0.755433333	0.000289463
3	3	2.3085	0.7695	0.00020091
4	3	2.3045	0.768166667	0.000136103
5	3	2.3539	0.784633333	2.50633E-05
6	3	2.3293	0.776433333	5.23333E-05
7	3	2.3131	0.771033333	0.000278563

ANOVA

Source of variation	SS	df	MS	F	p-value	F-crit
Between groups	0.00176573	7	0.000252247	1.820818445	0.151858	2.657197
Within groups	0.00221656	16	0.000138535			
Total	0.00398229	23				

Table C11: Raw data on Gumminess for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Gumminess	**Ref**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sample 1	*1131.2*	*690,596*	*750.5*	*893.8*	*807.4*	*1012.5*	*951.9*	*745.5*
Sample 2	*888.141*	*642.3*	*465.03*	*729.8*	*759.7*	*944.4*	*739.0*	*717.3*
Sample 3	*886.346*	*876.3*	*700.3*	*875.7*	*756*	*942.4*	*804.1*	*929.8*
Mean value	*968.562*	*736.399*	*638.610*	*833.100*	*774.367*	*966.433*	*831.667*	*797.533*
Stand. Dev.	*140.851*	*123.541*	*152.406*	*89.917*	*28.667*	*39.907*	*109.094*	*115.411*

Table C12: One-way ANOVA on Gumminess for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Anova: Single factor, Gumminess

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	2905.687	968.5623333	19839.06
1	3	2209.196	736.3986667	15262.41
2	3	1915.83	638.61	23227.52
3	3	2499.3	833.1	8085.07
4	3	2323.1	774.3666667	821.8233
5	3	2899.3	966.4333333	1592.603
6	3	2495	831.6666667	11901.54
7	3	2392.6	797.5333333	13319.66

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	258833.0058	7	36976.14368	3.145243	0.027323	2.657197
Within groups	188099.4046	16	11756.21279			
Total	446932.4104	23				

Table C13: Tukey-Kramer post-hoc on Gumminess for meatballs for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

POST HOC: Tukey-Kramer on Gumminess			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 1	232.16367	306.4887	NO
Ref vs 2	329.95233	306.4887	YES
Ref vs 3	135.46233	306.4887	NO
Ref vs 4	194.19567	306.4887	NO
Ref vs 5	2.12900	306.4887	NO
Ref vs 6	136.89567	306.4887	NO
Ref vs 7	171.02900	306.4887	NO
1 vs 2	97.78867	306.4887	NO
1 vs 3	96.70133	306.4887	NO
1 vs 4	37.96800	306.4887	NO
1 vs 5	230.03467	306.4887	NO
1 vs 6	95.26800	306.4887	NO
1 vs 7	61.13467	306.4887	NO
2 vs 3	194.49000	306.4887	NO
2 vs 4	135.75667	306.4887	NO
2 vs 5	327.82333	306.4887	YES
2 vs 6	193.05667	306.4887	NO
2 vs 7	158.92333	306.4887	NO
3 vs 4	58.73333	306.4887	NO
3 vs 5	133.33333	306.4887	NO
3 vs 6	1.43333	306.4887	NO
3 vs 7	35.56667	306.4887	NO
4 vs 5	192.06667	306.4887	NO
4 vs 6	57.30000	306.4887	NO
4 vs 7	23.16667	306.4887	NO
5 vs 6	134.76667	306.4887	NO
5 vs 7	168.90000	306.4887	NO
6 vs 7	34.13333	306.4887	NO

Table C14: Raw data on Cooking loss for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Cooking Loss	**Ref**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sample 1	*15.48 %*	*16.13 %*	*17.42 %*	*20.00 %*	*19.35 %*	*19.35%*	*18.06 %*	*23.23 %*
Sample 2	*16.13 %*	*22.58 %*	*21.94 %*	*21.94 %*	*21.94 %*	*18.71 %*	*21.94 %*	*19.35 %*
Sample 3	*17.42 %*	*21.29 %*	*22.58 %*	*21.29 %*	*24.52 %*	*21.29 %*	*22.58 %*	*21.94 %*
Sample 4	*18.71 %*	*21.29 %*	*20.00 %*	*20.65 %*	*25.81 %*	*19.35 %*	*20.00 %*	*20.65 %*
Sample 5	*16.13 %*	*18.71 %*	*20.65 %*	*18.71 %*	*23.87 %*	*21.94 %*	*19.35 %*	*21.29 %*
Sample 6	*19.35 %*	*17.42 %*	*22.58 %*	*21.29 %*	*22.58 %*	*19.35 %*	*20.65 %*	*24.52 %*
Mean value	*17.20 %*	*19.57 %*	*20.86 %*	*20.65 %*	*23.01 %*	*20.00 %*	*20.43 %*	*21.83 %*
Stand. Dev.	*1.56 %*	*2.54 %*	*1.99 %*	*1.15 %*	*2.26 %*	*1.29 %*	*1.67 %*	*1.84 %*

Table C15: One-way ANOVA on Cooking loss for meatballs for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Anova: Single factor, Cooking Loss

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	6	1.032258065	0.172043011	0.00024419
1	6	1.174193548	0.195698925	0.00064377
2	6	1.251612903	0.208602151	0.00039403
3	6	1.238709677	0.206451613	0.000133195
4	6	1.380645161	0.230107527	0.000510579
5	6	1.2	0.2	0.000166493
6	6	1.225806452	0.204301075	0.000277489
7	6	1.309677419	0.21827957	0.000339924

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	0.012104579	7	0.001729226	5.105332	0.000331	2.249024
Within groups	0.013548387	40	0.00033871			
Total	0.025652966	47				

Table C16: Tukey-Kramer post-hoc on Cooking loss for meatballs for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

POST HOC: Tukey-Kramer on Cooking Loss			
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 1	0.0236559	0.0339682	NO
Ref vs 2	0.0365591	0.0339682	YES
Ref vs 3	0.0344086	0.0339682	YES
Ref vs 4	0.0580645	0.0339682	YES
Ref vs 5	0.0279570	0.0339682	NO
Ref vs 6	0.0322581	0.0339682	NO
Ref vs 7	0.0462366	0.0339682	YES
1 vs 2	0.0129032	0.0339682	NO
1 vs 3	0.0107527	0.0339682	NO
1 vs 4	0.0344086	0.0339682	YES
1 vs 5	0.0043011	0.0339682	NO
1 vs 6	0.0086022	0.0339682	NO
1 vs 7	0.0225806	0.0339682	NO
2 vs 3	0.0021505	0.0339682	NO
2 vs 4	0.0215054	0.0339682	NO
2 vs 5	0.0086022	0.0339682	NO
2 vs 6	0.0043011	0.0339682	NO
2 vs 7	0.0096774	0.0339682	NO
3 vs 4	0.0236559	0.0339682	NO
3 vs 5	0.0064516	0.0339682	NO
3 vs 6	0.0021505	0.0339682	NO
3 vs 7	0.0118280	0.0339682	NO
4 vs 5	0.0301075	0.0339682	NO
4 vs 6	0.0258065	0.0339682	NO
4 vs 7	0.0118280	0.0339682	NO
5 vs 6	0.0043011	0.0339682	NO
5 vs 7	0.0182796	0.0339682	NO
6 vs 7	0.0139785	0.0339682	NO

Table C17: Raw data for Water content for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solutions.

Water Content (g/100g)	**Ref**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sample 1	*63.4*	*65.6*	*66.1*	*64.7*	*65.5*	*64.9*	*65.6*	*64.7*
Sample 2	*63.0*	*66.3*	*65.6*	*64.6*	*63.6*	*64.0*	*65.3*	*64.9*
Sample 3	*63.5*	*66.3*	*65.7*	*64.5*	*65.0*	*64.2*	*65.3*	*64.4*
Mean value	*63.3*	*66.07*	*65.8*	*64.6*	*64.7*	*64.3667*	*65.4*	*64.6667*
Stand. Dev.	*0.26458*	*0.40415*	*0.26458*	*0.100*	*0.98489*	*0.47258*	*0.17321*	*0.25166*

Table C18: One-way ANOVA on Water content for meatballs for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solution.

Anova: Single factor, Water Content

SUMMARY

Groups	Count	Sum	Average	Variance
Ref	3	189.9	63.3	0.07
1	3	198.2	66.06666667	0.163333333
2	3	197.4	65.8	0.07
3	3	193.8	64.6	0.01
4	3	194.1	64.7	0.97
5	3	193.1	64.36666667	0.223333333
6	3	196.2	65.4	0.03
7	3	194	64.66666667	0.063333333

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	16.31625	7	2.330892857	11.65446429	3.13127E-05	2.6571966
Within groups	3.2	16	0.2			
Total	19.51625	23				

Table C19: Tukey-Kramer post-hoc on Water content for meatballs for meatballs with different combinations of NaCl in the batter and immersed in different NaCl solutions.

POST HOC:	Tukey-Kramer on Water Content		
Comparison	Absolute Average Mean	Q crit	Significance
Ref vs 1	2.766667	1.264142	YES
Ref vs 2	2.5	1.264142	YES
Ref vs 3	1.3	1.264142	YES
Ref vs 4	1.4	1.264142	YES
Ref vs 5	1.066667	1.264142	NO
Ref vs 6	2.1	1.264142	YES
Ref vs 7	1.366667	1.264142	YES
1 vs 2	0.266667	1.264142	NO
1 vs 3	1.466667	1.264142	YES
1 vs 4	1.366667	1.264142	YES
1 vs 5	1.7	1.264142	YES
1 vs 6	0.666667	1.264142	NO
1 vs 7	1.4	1.264142	YES
2 vs 3	1.2	1.264142	NO
2 vs 4	1.1	1.264142	NO
2 vs 5	1.433333	1.264142	YES
2 vs 6	0.4	1.264142	NO
2 vs 7	1.133333	1.264142	NO
3 vs 4	0.1	1.264142	NO
3 vs 5	0.233333	1.264142	NO
3 vs 6	0.8	1.264142	NO
3 vs 7	0.0666667	1.264142	NO
4 vs 5	0.3333333	1.264142	NO
4 vs 6	0.7	1.264142	NO
4 vs 7	0.0333333	1.264142	NO
5 vs 6	1.0333333	1.264142	NO
5 vs 7	0.3	1.264142	NO
6 vs 7	0.7333333	1.264142	NO

Appendix D

In this section, the hand-out form to the panellists during the sensory evaluation and the results from this session can be found. To understand which three-digit code which refer to which meatball can be seen in table D1 below.

Table D1: The three-digit code used during the sensory evaluation and which meatball it refers to.

Code	**Type of meatball**
#892	Reference meatball
#458	Meatball with 0.5 % NaCl in batter, immersed in 17 % NaCl solution
#167	Meatball with 1.0 % NaCl in batter
#906	Meatball with 1.0 % NaCl in batter, immersed in 5 % NaCl solution

Sensory Evaluation Form

Before starting the evaluation, please carefully read through the entire form and make sure you have understood everything. Raise your hand if you have any questions.

You will be presented with four meatballs: Sample 458, Sample 892, Sample 167 and Sample 906. For all these four, the parameters *overall flavour, saltiness, juiciness, cohesion* and *liking* will be evaluated according to 7-point scales. These parameters are described below, and the descriptions can also be found on every subsequent page.

The course of action will be the following:

- Cut a meatball in half and place the half in your mouth. Chew, taste and swallow the same way you usually consume your meatballs.
- Answer the evaluation form for the sample by making a check in the boxes. If you feel the need to taste again, use the remaining half of the meatball.
- Rinse your palate with water and a piece of cracker.
- Repeat the procedure for the remaining samples.
- When you are done, you are free to hand in this form and leave. There may be people outside waiting to do the same evaluation, please do not discuss your opinion of the samples with them.

Description of parameters

Overall flavour intensity - The intensity of the meatball flavor, including all perceived flavors such as spices and general meat-taste.

Salt intensity - The perceived saltiness of the sample.

Juiciness -The perceived juiciness of the sample, for example explained as the amount of juices released during chewing.

Cohesion **-** How well the mass of the samples holds together during chewing (first few chews).

Liking - Your general liking of the samples.

Age: ______

Gender: _______

Figure D1: The front page of the sensory evaluation form handed out to all panellists.

Sample 458

Overall Flavour Intensity

Very low 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ *Very high*

Salt intensity

Very low 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ *Very high*

Juiciness

Very dry 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ *Very juicy*

Cohesion

Easily decomposes 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ *Holds together very well*

Liking

Dislike very much 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ *Like very much*

Description of parameters

Overall flavour intensity - The intensity of the meatball flavor, including all perceived flavors such as spices and general meat-taste.

Salt intensity - The perceived saltiness of the sample.

Juiciness -The perceived juiciness of the sample, for example explained as the amount of juices released during chewing.

Cohesion - How well the mass of the samples holds together during chewing (first few chews).

Liking - Your general liking of the samples.

Figure D2: The ranking questionnaire in the sensory evaluation form for one of the samples. The design was the same for all other samples.

Table D2: Raw data of the parameters evaluated during the sensory evaluation. The data is presented as mean value ± standard deviation. Which three-digit code that refers to which meatball can be seen in Table D1.

Parameter	#458	#892	#167	#906
Overall Flavour	4.1 +/- 1.2 ^{b}	5.2 +/- 1.0 ^{a}	4.6 +/- 1.2 ^{ab}	4.6 +/- 1.4 ^{ab}
Salt Intensity	3.5 +/- 1.2 ^{b}	5.5 +/- 0.8 ^{a}	3.9 +/- 1.2 ^{b}	4.0 +/- 1.2 ^{b}
Juiciness	4.9 +/- 1.1 ^{a}	4.5 +/- 1.4 ^{a}	4.6 +/- 1.2 ^{a}	4.7 +/- 1.3 ^{a}
Cohesion	4.2 +/- 1.4 ^{b}	5.7 +/- 1.4 ^{a}	4.9 +/- 1.6 ^{c}	4.3 +/- 1.4 ^{bc}
Liking	4.3 +/- 1.2 ^{a}	4.8 +/- 1.1 ^{a}	4.6 +/- 1.2 ^{a}	4.7 +/- 1.4^{a}

Overall Flavour, Raw data

Panellists \ Sample	#458	#892	#167	#906	Average	SD
1	6	5	4	4	4,75	0,957
2	2	4	3	4	3,25	0,957
3	4	7	6	6	5,75	1,258
4	3	5	5	5	4,50	1,000
5	3	6	5	6	5,00	1,414
6	4	7	6	4	5,25	1,500
7	5	6	7	7	6,25	0,957
8	2	5	3	2	3,0	1,414
9	4	5	7	6	5,5	1,291
10	3	5	5	4	4,25	0,957
11	3	4	2	4	3,25	0,957
12	5	5	4	4	4,5	0,577
13	4	5	5	6	5	0,816
14	5	6	4	3	4,5	1,291
15	4	6	5	5	5	0,816
16	5	5	4	4	4,5	0,577
17	4	3	3	4	3,5	0,577
18	6	5	6	6	5,75	0,500
19	3	4	3	4	3,5	0,577
20	4	3	4	1	3	1,414
21	4	7	5	7	5,75	1,500
22	6	6	4	5	5,25	0,957
23	4	6	3	6	4,75	1,500
24	5	5	5	5	5	0,000
25	4	4	5	5	4,5	0,577
26	2	6	5	3	4	1,826
27	3	5	4	5	4,25	0,957
28	5	5	6	5	5,25	0,500
29	5	6	6	4	5,25	0,957
30	6	5	4	4	4,75	0,957
Average	4,1	5,2	4,6	4,6		
Stand. Dev.	1,1847	1,0306	1,2484	1,3544		

Overall Flavour, Centered data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	1,25	0,25	-0,75	-0,75	0	0,957
2	-1,25	0,75	-0,25	0,75	0	0,957
3	-1,75	1,25	0,25	0,25	0	1,258
4	-1,5	0,5	0,5	0,5	0	1
5	-2	1	0	1	0	1,414
6	-1,25	1,75	0,75	-1,25	0	1,5
7	-1,25	-0,25	0,75	0,75	0	0,957
8	-1	2	0	-1	0	1,414
9	-1,5	-0,5	1,5	0,5	0	1,291
10	-1,25	0,75	0,75	-0,25	0	0,957
11	-0,25	0,75	-1,25	0,75	0	0,957
12	0,5	0,5	-0,5	-0,5	0	0,577
13	-1	0	0	1	0	0,816
14	0,5	1,5	-0,5	-1,5	0	1,291
15	-1	1	0	0	0	0,816
16	0,5	0,5	-0,5	-0,5	0	0,577
17	0,5	-0,5	-0,5	0,5	0	0,577
18	0,25	-0,75	0,25	0,25	0	0,5
19	-0,5	0,5	-0,5	0,5	0	0,577
20	1	0	1	-2	0	1,414
21	-1,75	1,25	-0,75	1,25	0	1,5
22	0,75	0,75	-1,25	-0,25	0	0,957
23	-0,75	1,25	-1,75	1,25	0	1,5
24	0	0	0	0	0	0
25	-0,5	-0,5	0,5	0,5	0	0,577
26	-2	2	1	-1	0	1,826
27	-1,25	0,75	-0,25	0,75	0	0,957
28	-0,25	-0,25	0,75	-0,25	0	0,5
29	-0,25	0,75	0,75	-1,25	0	0,9574
30	1,25	0,25	-0,75	-0,75	0	0,9574
Average	-0,525	0,575	-0,025	-0,025	-2E-17	0,45
Stand. Dev.	0,98556	0,74322	0,76381	0,86938		

Overall Flavour, Standardized data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	1,306	0,261	-0,783	-0,783	0	1
2	-1,306	0,783	-0,261	0,783	0	1
3	-1,391	0,993	0,199	0,199	0	1
4	-1,5	0,5	0,5	0,5	0	1
5	-1,414	0,707	0	0,707	0	1
6	-0,833	1,167	0,5	-0,833	0	1
7	-1,306	-0,261	0,783	0,783	0	1
8	-0,707	1,414	0	-0,707	0	1
9	-1,162	-0,387	1,162	0,387	0	1
10	-1,306	0,783	0,783	-0,261	0	1
11	-0,261	0,783	-1,306	0,783	0	1
12	0,866	0,866	-0,866	-0,866	0	1
13	-1,2247	0	0	1,225	0	1
14	0,387	1,162	-0,387	-1,162	0	1
15	-1,225	1,225	0	0	0	1
16	0,866	0,866	-0,866	-0,866	0	1
17	0,866	-0,866	-0,866	0,866	0	1
18	0,5	-1,5	0,5	0,5	0	1
19	-0,866	0,866	-0,866	0,8660	0	1
20	0,707	0	0,707	-1,414	0	1
21	-1,167	0,833	-0,500	0,833	0	1
22	0,783	0,783	-1,306	-0,261	0	1
23	-0,500	0,833	-1,167	0,833	0	1
24	0	0	0,000	0,000	0	0
25	-0,866	-0,866	0,866	0,866	0	1
26	-1,095	1,095	0,548	-0,548	0	1
27	-1,306	0,783	-0,261	0,783	0	1
28	-0,5	-0,5	1,500	-0,500	0	1
29	-0,261	0,783	0,783	-1,306	0	1
30	1,306	0,261	-0,783	-0,783	0	1
Average	-0,420	0,446	-0,046	0,021		
Stand. Dev.	0,931	0,716	0,771	0,797		

Figure D3: Tables showing the raw, centered and standardized data on answers on overall flavour of four different meatballs. Which three-digit code that refers to which meatball can be seen in Table D1.

Table D3: One-way ANOVA on overall flavour for four different meatballs. Standardized data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

Anova: Single factor, Overall Flavour

SUMMARY

Groups	Count	Sum	Average	Variance
#458	30	-12.6085	-0.4202842	0.866134
#892	30	13.37008	0.44566927	0.512571
#167	30	-1.38669	-0.0462228	0.594832
#906	30	0.625134	0.02083781	0.635604

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	11.33492112	3	3.77830704	5.792416	0.001002	2.682809
Within groups	75.66507888	116	0.65228516			
Total	87	119				

Table D4: Tukey-Kramer post-hoc on overall flavour for four different meatballs. Centered and standardised data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

POST-HOC: Tukey-Kramer on Overall Flavour

Comparison	Absolute Average Mean	Q crit	Significance
458 vs 892	0.865953507	0.54337	YES
458 vs 167	0.374061388	0.54337	NO
458 vs 906	0.44112204	0.54337	NO
892 vs 167	0.491892119	0.54337	NO
892 vs 906	0.424831467	0.54337	NO
167 vs 906	0.067060652	0.54337	NO

Saltiness, Raw Data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	5	5	4	4	4,5	0,577
2	2	5	3	4	3,5	1,291
3	4	7	5	4	5	1,414
4	1	5	2	5	3,25	2,062
5	3	6	5	6	5	1,414
6	5	6	5	4	5	0,816
7	3	6	4	5	4,5	1,291
8	3	6	2	2	3,25	1,893
9	4	5	5	3	4,25	0,957
10	4	6	4	4	4,5	1,000
11	1	5	1	4	2,75	2,062
12	3	4	3	3	3,25	0,500
13	4	5	4	6	4,75	0,957
14	3	6	3	3	3,75	1,500
15	3	5	6	3	4,25	1,500
16	4	6	5	4	4,75	0,957
17	4	5	3	3	3,75	0,957
18	4	7	6	6	5,75	1,258
19	3	4	3	3	3,25	0,500
20	5	6	5	4	5	0,816
21	3	6	4	5	4,5	1,291
22	3	5	3	3	3,5	1,000
23	4	5	4	5	4,5	0,577
24	4	5	4	5	4,5	0,577
25	6	6	5	5	5,5	0,577
26	3	6	4	2	3,75	1,708
27	3	4	3	3	3,25	0,500
28	3	6	6	6	5,25	1,500
29	3	5	4	3	3,75	0,957
30	6	6	3	4	4,75	1,500
Average	3,533	5,467	3,933	4,033		
Stand. Dev.	1,167	0,776	1,230	1,159		

Saltiness, Centered data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	0,5	0,5	-0,5	-0,5	0	0,5774
2	-1,5	1,5	-0,5	0,5	0	1,2910
3	-1	2	0	-1	0	1,4142
4	-2,25	1,75	-1,25	1,75	0	2,0616
5	-2	1	0	1	0	1,4142
6	0	1	0	-1	0	0,8165
7	-1,5	1,5	-0,5	0,5	0	1,2910
8	-0,25	2,75	-1,25	-1,25	0	1,8930
9	-0,25	0,75	0,75	-1,25	0	0,9574
10	-0,5	1,5	-0,5	-0,5	0	1,0000
11	-1,75	2,25	-1,75	1,25	0	2,0616
12	-0,25	0,75	-0,25	-0,25	0	0,5000
13	-0,75	0,25	-0,75	1,25	0	0,9574
14	-0,75	2,25	-0,75	-0,75	0	1,5000
15	-1,25	0,75	1,75	-1,25	0	1,5000
16	-0,75	1,25	0,25	-0,75	0	0,9574
17	0,25	1,25	-0,75	-0,75	0	0,9574
18	-1,75	1,25	0,25	0,25	0	1,2583
19	-0,25	0,75	-0,25	-0,25	0	0,5000
20	0	1	0	-1	0	0,8165
21	-1,5	1,5	-0,5	0,5	0	1,2910
22	-0,5	1,5	-0,5	-0,5	0	1,0000
23	-0,5	0,5	-0,5	0,5	0	0,5774
24	-0,5	0,5	-0,5	0,5	0	0,5774
25	0,5	0,5	-0,5	-0,5	0	0,5774
26	-0,75	2,25	0,25	-1,75	0	1,7078
27	-0,25	0,75	-0,25	-0,25	0	0,5000
28	-2,25	0,75	0,75	0,75	0	1,5000
29	-0,75	1,25	0,25	-0,75	0	0,9574
30	1,25	1,25	-1,75	-0,75	0	1,5000
Average	-0,7083	1,225	-0,3083	-0,2083		
Stand. Dev.	0,84609	0,62405	0,71825	0,88103		

Saltiness, Standardized data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	0,866	0,866	-0,866	-0,866	0	1
2	-1,162	1,162	-0,387	0,387	0	1
3	-0,707	1,414	0,000	-0,707	0	1
4	-1,091	0,849	-0,606	0,849	0	1
5	-1,414	0,707	0,000	0,707	0	1
6	0,000	1,225	0,000	-1,225	0	1
7	-1,162	1,162	-0,387	0,387	0	1
8	-0,132	1,453	-0,660	-0,660	0	1
9	-0,261	0,783	0,783	-1,306	0	1
10	-0,500	1,500	-0,500	-0,500	0	1
11	-0,849	1,091	-0,849	0,606	0	1
12	-0,500	1,500	-0,500	-0,500	0	1
13	-0,783	0,261	-0,783	1,306	0	1
14	-0,500	1,500	-0,500	-0,500	0	1
15	-0,833	0,500	1,167	-0,833	0	1
16	-0,783	1,306	0,261	-0,783	0	1
17	0,261	1,306	-0,783	-0,783	0	1
18	-1,391	0,993	0,199	0,199	0	1
19	-0,500	1,500	-0,500	-0,500	0	1
20	0,000	1,225	0,000	-1,225	0	1
21	-1,162	1,162	-0,387	0,387	0	1
22	-0,500	1,500	-0,500	-0,500	0	1
23	-0,866	0,866	-0,866	0,866	0	1
24	-0,866	0,866	-0,866	0,866	0	1
25	0,866	0,866	-0,866	-0,866	0	1
26	-0,439	1,317	0,146	-1,025	0	1
27	-0,500	1,500	-0,500	-0,500	0	1
28	-1,500	0,500	0,500	0,500	0	1
29	-0,783	1,306	0,261	-0,783	0	1
30	0,833	0,833	-1,167	-0,500	0	1
Average	-0,545	1,101	-0,305	-0,250		
Stand. Dev.	0,638	0,345	0,547	0,746		

Figure D4: Tables showing the raw, centered and standardised data on answers on salt intensity of four different meatballs. Which three-digit code which refer to which meatball can be seen in table D1.

Table D5: One-way ANOVA on salt intensity for four different meatballs. Centered and standardised data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

Anova: Single factor, Salt Intensity

SUMMARY

Groups	Count	Sum	Average	Variance
#458	30	-16.35932	-0.5453107	0.4069491
#892	30	33.0190366	1.1006346	0.11871699
#167	30	-9.1576002	-0.3052533	0.29963072
#906	30	-7.5021161	-0.2500705	0.55628075

ANOVA

Source of variation	SS	df	MS	F	p-value	F-crit
Between groups	49.9342509	3	16.64475	48.1905637	2.671E-20	2.68281
Within groups	40.0657491	116	0.3453944			
Total	90	119				

Table D6: Tukey-Kramer post-hoc on salt intensity for four different meatballs. Centered and standardised data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

POST HOC: Tukey Cramer on Salt Intensity

Comparison	Absolute Average Mean	Q crit	Significance
458 vs 892	1.645945	0.395398	YES
458 vs 167	0.240057	0.395398	NO
458 vs 906	0.29524	0.395398	NO
892 vs 167	1.405888	0.395398	YES
892 vs 906	1.350705	0.395398	YES
167 vs 906	0.055183	0.395398	NO

Juciness, Raw data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	6	4	4	3	4,25	1,258
2	6	3	4	3	4	1,414
3	5	6	6	5	5,5	0,577
4	5	3	3	4	3,75	0,957
5	5	5	6	5	5,25	0,500
6	6	3	3	4	4	1,414
7	4	4	3	6	4,25	1,258
8	3	5	5	4	4,25	0,957
9	4	3	4	5	4	0,816
10	5	7	6	6	6	0,816
11	6	4	2	6	4,5	1,915
12	5	4	6	4	4,75	0,957
13	3	6	5	6	5	1,414
14	6	6	6	2	5	2,000
15	4	6	5	6	5,25	0,957
16	5	5	4	5	4,75	0,500
17	5	3	5	5	4,5	1,000
18	5	6	5	6	5,5	0,577
19	4	5	6	3	4,5	1,291
20	6	4	6	3	4,75	1,500
21	6	6	6	7	6,25	0,500
22	4	4	4	5	4,25	0,500
23	6	6	5	6	5,75	0,500
24	6	4	4	5	4,75	0,957
25	4	5	6	5	5	0,816
26	5	5	5	5	5	0,000
27	5	4	3	5	4,25	0,957
28	5	1	3	2	2,75	1,708
29	2	6	5	4	4,25	1,708
30	6	3	4	5	4,5	1,291
Average	4,9	4,53333	4,63333	4,66667		
Stand. Dev.	1,061879	1,35782	1,18855	1,26854		

Juciness, Centered data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	1,75	-0,25	-0,25	-1,25	0	1,258
2	2	-1	0	-1	0	1,414
3	-0,5	0,5	0,5	-0,5	0	0,577
4	1,25	-0,75	-0,75	0,25	0	0,957
5	-0,25	-0,25	0,75	-0,25	0	0,5
6	2	-1	-1	0	0	1,414
7	-0,25	-0,25	-1,25	1,75	0	1,258
8	-1,25	0,75	0,75	-0,25	0	0,957
9	0	-1	0	1	0	0,816
10	-1	1	0	0	0	0,816
11	1,5	-0,5	-2,5	1,5	0	1,915
12	0,25	-0,75	1,25	-0,75	0	0,957
13	-2	1	0	1	0	1,414
14	1	1	1	-3	0	2
15	-1,25	0,75	-0,25	0,75	0	0,957
16	0,25	0,25	-0,75	0,25	0	0,5
17	0,5	-1,5	0,5	0,5	0	1
18	-0,5	0,5	-0,5	0,5	0	0,577
19	-0,5	0,5	1,5	-1,5	0	1,291
20	1,25	-0,75	1,25	-1,75	0	1,5
21	-0,25	-0,25	-0,25	0,75	0	0,5
22	-0,25	-0,25	-0,25	0,75	0	0,5
23	0,25	0,25	-0,75	0,25	0	0,5
24	1,25	-0,75	-0,75	0,25	0	0,957
25	-1	0	1	0	0	0,816
26	0	0	0	0	0	0
27	0,75	-0,25	-1,25	0,75	0	0,957
28	2,25	-1,75	0,25	-0,75	0	1,708
29	-2,25	1,75	0,75	-0,25	0	1,708
30	1,5	-1,5	-0,5	0,5	0	1,291
Average	0,21667	-0,15	-0,05	-0,0167		
Stand. Dev.	1,19036	0,84741	0,88911	0,99986		

Juciness, Standardized data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	1,391	-0,199	-0,199	-0,993	0	1
2	1,414	-0,707	0,000	-0,707	0	1
3	-0,866	0,866	0,866	-0,866	0	1
4	1,306	-0,783	-0,783	0,261	0	1
5	-0,5	-0,5	1,5	-0,5	0	1
6	1,414	-0,707	-0,707	0,000	0	1
7	-0,199	-0,199	-0,993	1,391	0	1
8	-1,306	0,783	0,783	-0,261	0	1
9	0	-1,2247	0	1,22474	0	1
10	-1,225	1,225	0	0	0	1
11	0,783	-0,261	-1,306	0,783	0	1
12	0,261	-0,783	1,306	-0,783	0	1
13	-1,414	0,707	0,000	0,707	0	1
14	0,5	0,5	0,500	-1,500	0	1
15	-1,306	0,783	-0,261	0,783	0	1
16	0,5	0,5	-1,5	0,5	0	1
17	0,5	-1,5	0,5	0,5	0	1
18	-0,87	0,87	-0,87	0,87	0	1
19	-0,39	0,39	1,16	-1,16	0	1
20	0,83333	-0,5	0,83333	-1,1667	0	1
21	-0,5	-0,5	-0,5	1,5	0	1
22	-0,5	-0,5	-0,5	1,5	0	1
23	0,5	0,5	-1,5	0,5	0	1
24	1,30558	-0,7833	-0,7833	0,26112	0	1
25	-1,2247	0	1,22474	0	0	1
26	0	0	0	0	0	0
27	0,783	-0,261	-1,306	0,783	0	1
28	1,317	-1,025	0,146	-0,439	0	1
29	-1,317	1,025	0,439	-0,146	0	1
30	1,162	-1,162	-0,387	0,387	0	1
Average	0,07868	-0,1151	-0,0777	0,1141		
Stand. Dev.	0,9794	0,75398	0,86157	0,83077		

Figure D5: Tables showing the raw, centered and standardised data on answers on juiciness of four different meatballs. Which three-digit code that refer to which meatball can be seen in Table D1.

Table D7: One-way ANOVA on juiciness for four different meatballs. Centered and standardised data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

Anova: Single factor, Juiciness

SUMMARY

Groups	Count	Sum	Average	Variance
#458	30	2.360498	0.078683	0.959223
#892	30	-3.45259	-0.11509	0.568488
#167	30	-2.33102	-0.0777	0.742298
#906	30	3.423117	0.114104	0.690171

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	1.154791251	3	0.38493	0.520145	0.669251	2.682809
Within groups	85.84520875	116	0.740045			
Total	87	119				

Cohesion, Raw data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	6	6	6	3	5,25	1,500
2	2	6	5	4	4,25	1,708
3	4	6	7	4	5,25	1,500
4	5	6	6	6	5,75	0,500
5	4	7	6	6	5,75	1,258
6	3	7	6	5	5,25	1,708
7	3	6	5	6	5	1,414
8	2	3	2	2	2,25	0,500
9	5	6	6	4	5,25	0,957
10	7	7	6	5	6,25	0,957
11	4	3	6	3	4	1,414
12	3	6	6	3	4,5	1,732
13	3	5	4	3	3,75	0,957
14	4	7	6	4	5,25	1,500
15	5	6	6	6	5,75	0,500
16	3	4	2	3	3	0,816
17	2	6	4	5	4,25	1,708
18	4	7	5	5	5,25	1,258
19	3	4	2	3	3	0,816
20	6	7	7	3	5,75	1,893
21	2	3	2	5	3	1,414
22	6	6	5	3	5	1,414
23	6	3	3	5	4,25	1,500
24	5	7	6	5	5,75	0,957
25	5	7	5	6	5,75	0,957
26	5	7	2	3	4,25	2,217
27	6	6	6	3	5,25	1,500
28	4	4	4	6	4,5	1,000
29	3	7	6	2	4,5	2,380
30	5	7	4	7	5,75	1,500
Average	4,1667	5,733	4,8667	4,26667		
Stand. Dev.	1,4162	1,413	1,5916	1,38796		

Cohesion, Centered data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	0,75	0,75	0,75	-2,25	0	1,5
2	-2,25	1,75	0,75	-0,25	0	1,708
3	-1,25	0,75	1,75	-1,25	0	1,5
4	-0,75	0,25	0,25	0,25	0	0,5
5	-1,75	1,25	0,25	0,25	0	1,258
6	-2,25	1,75	0,75	-0,25	0	1,708
7	-2	1	0	1	0	1,414
8	-0,25	0,75	-0,25	-0,25	0	0,5
9	-0,25	0,75	0,75	-1,25	0	0,957
10	0,75	0,75	-0,25	-1,25	0	0,957
11	0	-1	2	-1	0	1,414
12	-1,5	1,5	1,5	-1,5	0	1,732
13	-0,75	1,25	0,25	-0,75	0	0,957
14	-1,25	1,75	0,75	-1,25	0	1,5
15	-0,75	0,25	0,25	0,25	0	0,5
16	0	1	-1	0	0	0,816
17	-2,25	1,75	-0,25	0,75	0	1,708
18	-1,25	1,75	-0,25	-0,25	0	1,258
19	0	1	-1	0	0	0,816
20	0,25	1,25	1,25	-2,75	0	1,893
21	-1	0	-1	2	0	1,414
22	1	1	0	-2	0	1,414
23	1,75	-1,25	-1,25	0,75	0	1,5
24	-0,75	1,25	0,25	-0,75	0	0,957
25	-0,75	1,25	-0,75	0,25	0	0,957
26	0,75	2,75	-2,25	-1,25	0	2,217
27	0,75	0,75	0,75	-2,25	0	1,5
28	-0,5	-0,5	-0,5	1,5	0	1
29	-1,5	2,5	1,5	-2,5	0	2,380
30	-0,75	1,25	-1,75	1,25	0	1,5
Average	-0,5917	0,975	0,1083	-0,4917		
Stand. Dev.	1,0514	0,882	1,0207	1,2221		

Cohesion, Standardized data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	0,5	0,5	0,5	-1,5	0	1
2	-1,317	1,025	0,439	-0,146	0	1
3	-0,833	0,500	1,167	-0,833	0	1
4	-1,5	0,5	0,5	0,5	0	1
5	-1,391	0,993	0,199	0,199	0	1
6	-1,317	1,025	0,439	-0,146	0	1
7	-1,414	0,707	0	0,707	0	1
8	-0,5	1,5	-0,5	-0,5	0	1
9	-0,261	0,783	0,783	-1,306	0	1
10	0,783	0,783	-0,261	-1,306	0	1
11	0	-0,71	1,414	-0,707	0	1
12	-0,87	0,866	0,866	-0,866	0	1
13	-0,78	1,306	0,261	-0,783	0	1
14	-0,83	1,167	0,5	-0,833	0	1
15	-1,5	0,5	0,5	0,5	0	1
16	0	1,225	-1,225	0	0	1
17	-1,32	1,025	-0,146	0,439	0	1
18	-0,99	1,391	-0,199	-0,199	0	1
19	0	1,225	-1,225	0	0	1
20	0,132	0,66	0,660	-1,453	0	1
21	-0,71	0	-0,707	1,414	0	1
22	0,707	0,707	0	-1,414	0	1
23	1,167	-0,833	-0,833	0,5	0	1
24	-0,783	1,306	0,261	-0,783	0	1
25	-0,783	1,306	-0,783	0,261	0	1
26	0,338	1,240	-1,015	-0,564	0	1
27	0,5	0,5	0,5	-1,5	0	1
28	-0,5	-0,5	-0,5	1,5	0	1
29	-0,63	1,050	0,630	-1,050	0	1
30	-0,5	0,833	-1,167	0,833	0	1
Average	-0,49	0,753	0,035	-0,301		
Stand. Dev.	0,75	0,594	0,723	0,859		

Figure D6: Tables showing the raw, centered and standardised data on answers on cohesion of four different meatballs. Which three-digit code that refers to which meatball can be seen in Table D1.

Table D8: One-way ANOVA on cohesion for four different meatballs. Centered and standardised data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

Anova: Single factor, Cohesion						
Summary						
Groups	Count	Sum	Average	Variance		
#458	30	-14.60443	-0.486814	0.562765		
#892	30	22.58174	0.752725	0.353147		
#167	30	1.059093	0.035303	0.522757		
#906	30	-9.03641	-0.301214	0.73834		
ANOVA						
Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	26.86675708	3	8.955586	16.45485	5.64622E-09	2.682809
Within groups	63.13324292	116	0.544252			
Total	90	119				

Table D9: Tukey-Kramer post-hoc on cohesion for four different meatballs. Centered and standardised data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

POST-HOC: Tukey-Kramer on Cohesion			
Comparison	Absolute Average Mean	Q crit	Significance
458 vs 892	1.239538933	0.496337	YES
458 vs 167	0.522117277	0.496337	YES
458 vs 906	0.185600534	0.496337	NO
892 vs 167	0.717421656	0.496337	YES
892 vs 906	1.053938399	0.496337	YES
167 vs 906	0.336516743	0.496337	NO

Liking, Raw data

Panellists \ Sample	#458	#892	#167	#906	Average	SD
1	6	5	4	4	4,75	0,957
2	3	5	5	4	4,25	0,957
3	5	6	6	6	5,75	0,500
4	3	4	5	5	4,25	0,957
5	5	6	6	6	5,75	0,500
6	5	3	5	5	4,5	1,000
7	3	4	4	7	4,5	1,732
8	2	5	3	2	3	1,414
9	5	6	6	7	6	0,816
10	4	6	6	5	5,25	0,957
11	3	4	2	4	3,25	0,957
12	5	3	4	5	4,25	0,957
13	4	5	6	5	5	0,816
14	4	6	5	3	4,5	1,291
15	4	6	5	5	5	0,816
16	6	4	4	5	4,75	0,957
17	5	4	3	4	4	0,816
18	6	4	6	6	5,5	1,000
19	3	5	4	4	4	0,816
20	3	3	4	1	2,75	1,258
21	4	5	7	7	5,75	1,500
22	5	4	4	5	4,5	0,577
23	6	6	3	6	5,25	1,500
24	6	6	5	4	5,25	0,957
25	3	3	5	5	4	1,155
26	5	7	4	2	4,5	2,082
27	4	5	4	5	4,5	0,577
28	3	4	6	5	4,5	1,291
29	3	6	5	4	4,5	1,291
30	5	4	3	5	4,25	0,957
Average	4,267	4,8	4,633	4,7		
Stand. Dev.	1,172	1,126	1,189	1,418		

Liking, Centered data

Panellists \ Sample	#458	#892	#167	#906	Average	SD
1	1,25	0,25	-0,75	-0,75	0	0,9574
2	-1,25	0,75	0,75	-0,25	0	0,9574
3	-0,75	0,25	0,25	0,25	0	0,5
4	-1,25	-0,25	0,75	0,75	0	0,957
5	-0,75	0,25	0,25	0,25	0	0,5
6	0,5	-1,5	0,5	0,5	0	1
7	-1,5	-0,5	-0,5	2,5	0	1,732
8	-1	2	0	-1	0	1,414
9	-1	0	0	1	0	0,816
10	-1,25	0,75	0,75	-0,25	0	0,957
11	-0,25	0,75	-1,25	0,75	0	0,957
12	0,75	-1,25	-0,25	0,75	0	0,957
13	-1	0	1	0	0	0,816
14	-0,5	1,5	0,5	-1,5	0	1,291
15	-1	1	0	0	0	0,816
16	1,25	-0,75	-0,75	0,25	0	0,957
17	1	0	-1	0	0	0,816
18	0,5	-1,5	0,5	0,5	0	1
19	-1	1	0	0	0	0,816
20	0,25	0,25	1,25	-1,75	0	1,258
21	-1,75	-0,75	1,25	1,25	0	1,5
22	0,5	-0,5	-0,5	0,5	0	0,577
23	0,75	0,75	-2,25	0,75	0	1,5
24	0,75	0,75	-0,25	-1,25	0	0,957
25	-1	-1	1	1	0	1,155
26	0,5	2,5	-0,5	-2,5	0	2,082
27	-0,5	0,5	-0,5	0,5	0	0,577
28	-1,5	-0,5	1,5	0,5	0	1,291
29	-1,5	1,5	0,5	-0,5	0	1,291
30	0,75	-0,25	-1,25	0,75	0	0,957
Average	-0,333	0,2	0,0333	0,1		
Stand. Dev.	0,9522	0,981	0,8629	0,997		

Liking, Standardized data

Panellist \ Sample	#458	#892	#167	#906	Average	SD
1	1,306	0,261	-0,783	-0,78	0	1
2	-1,306	0,783	0,783	-0,26	0	1
3	-1,5	0,5	0,5	0,5	0	1
4	-1,306	-0,26	0,7833	0,78	0	1
5	-1,5	0,5	0,5	0,5	0	1
6	0,5	-1,5	0,5	0,5	0	1
7	-0,866	-0,289	-0,289	1,44	0	1
8	-0,707	1,414	0	-0,71	0	1
9	-1,225	0	0	1,22	0	1
10	-1,306	0,783	0,783	-0,26	0	1
11	-0,261	0,783	-1,306	0,78	0	1
12	0,783	-1,306	-0,261	0,78	0	1
13	-1,225	0	1,225	0	0	1
14	-0,387	1,162	0,3873	-1,16	0	1
15	-1,225	1,225	0	0	0	1
16	1,306	-0,783	-0,783	0,26	0	1
17	1,225	0	-1,225	0	0	1
18	0,5	-1,5	0,5	0,5	0	1
19	-1,225	1,225	0	0	0	1
20	0,199	0,199	0,993	-1,39	0	1
21	-1,167	-0,5	0,833	0,83	0	1
22	0,866	-0,87	-0,866	0,87	0	1
23	0,5	0,5	-1,5	0,5	0	1
24	0,783	0,783	-0,261	####	0	1
25	-0,866	-0,866	0,866	0,866	0	1
26	0,240	1,201	-0,240	####	0	1
27	-0,866	0,866	-0,866	0,866	0	1
28	-1,162	-0,387	1,162	0,387	0	1
29	-1,162	1,162	0,387	####	0	1
30	0,783	-0,261	-1,306	0,783	0	1
Average	-0,342	0,161	0,017	0,164		
Stand. Dev.	0,973	0,858	0,800	0,776		

Figure D7: Tables showing the raw, centered and standardized data on answers on liking of four different meatballs. Which three-digit code that refers to which meatball can be seen in Table D1.

Table D10: One-way ANOVA on liking for four different meatballs. Centered and standardised data is used. Which three-digit code that refers to which meatball can be seen in Table D1.

Anova: Single factor, Liking

Summary

Groups	Count	Sum	Average	Variance
458	30	-10.2689	-0.3423	0.947416
892	30	4.828485	0.160949	0.736733
167	30	0.518283	0.017276	0.640586
906	30	4.922158	0.164072	0.602551

ANOVA

Source of Variation	SS	df	MS	F	p-value	F-crit
Between groups	5.108712	3	1.702904	2.326939	0.078283	2.682809
Within groups	84.89129	116	0.731821			
Total	90	119				