**Salt and Meat**

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| **Abstract**  Meat and meat products with their high nutritional value are important food group in order to have a sufficient and balanced diet. Salt, on the other hand, is an ingredient used in foods as it has protective properties as well as flavoring foods. Sodium in the salt structure plays an important role in maintaining the body's electrolyte balance and regulating blood pressure. Excessive consumption of salt or sodium causes hypertension and cardiovascular diseases. Salt consumption is considerably above the maximum daily amount that individuals can consume in the world and Turkey. A significant portion of the salt taken in the diet is taken into the body as a result of the consumption of processed foods. Since meat products contain relatively high amounts of salt, various strategies have been developed for salt reduction in meat products. While reducing the salt content of meat and meat products, it is aimed to produce the desired products without the loss of quality characteristics of meat and flavor defects. This article reviews the human health effects of salt and the methods that can be applied to reduce salt in processed meat products. |
| Keywords: Reduced Salt in Meat Products, Salt Reduction, Health |

1. **Introduction**

Adequate and balanced nutrition is needed for growth, development and healthy survival. In order to have adequate and balanced nutrition; Proteins, vitamins, carbohydrates, fats, mineral substances and water must be taken into the body in sufficient quantities. One of the most important parameters required for individuals to have an adequate and balanced diet is the consumption of foods of animal origin. Meat products, which are among the foods of animal origin, are among the irreplaceable foods with the different tastes they offer to consumers in addition to providing a balanced diet [1]. Meat and meat products; It is a food product rich in protein, essential fatty acids, mineral substances and vitamins with high biological value. It contains amino acids and fat-soluble vitamins (A, D, E, K) necessary for adequate and balanced nutrition. Meat products contain B group vitamins and vitamins B1, B2, B6, B12 and niacin, which are essential for nutrition. In addition, it is an indispensable food item for adequate and balanced nutrition because it contains minerals such as potassium, calcium, phosphorus, iron, zinc and chlorine [2]. Salt should be consumed to maintain health. In the human body, it contains ions such as sodium, calcium, magnesium, chloride, potassium, as well as fat, carbohydrates, proteins and water. Thanks to these ions, the body's electrolyte balance is maintained. Too little or too much of these ions in the human body disrupts the electrolyte balance and various health problems occur. Approximately 40% of the salt consists of sodium (Na) and 60% is chlorine (Cl) ions. In addition to being a mineral substance found in the structure of foods, sodium is also the most important cation of the extracellular fluid. 60% of the sodium in the body is located in extracellular fluid. 30-40% of sodium is found on the surface of bone crystals and quickly dissolves into the blood when needed. The remaining 20% of sodium is located in plasma, muscle and nerve tissues [3]. Salt is one of the indispensable food ingredients of traditional cuisines. Salt has preservative, flavor enhancing and bad taste masking properties in foods. In addition, salt is preferred to be used in foods because it is easily accessible and low cost [4]. The most common raw material and/or additive used in meat products is salt. The first use of salt in meat products was for the preservation of the products. Another use of salt in meat products is to provide the desired taste and flavor to the product. Additionally, salt has a crispening function in meat products. Salt used in meat and meat products increases the water retention capacity of proteins by causing them to bind more water. On the other hand, salt increases the osmotic pressure of food and limits bacterial growth with the toxic effect created by chloride ions. It also prevents the development of undesirable microorganisms in foods by reducing the water activity value in meat and meat products. However, it has been reported that excessive salt consumption causes cardiovascular diseases, hypertension, stroke, stomach cancer, kidney diseases and indirectly obesity in individuals. The amount of salt taken into the body from food in the world and in our country is over 5g/day. On the other hand, the dietary guide prepared in the USA and the Canadian Health Authority have determined the tolerable upper sodium intake limit as 2300 mg/day. Recent data show that reducing daily salt intake to 1200 mg/day reduces cardiovascular risk and blood pressure [5]. In most developed countries, 80% of sodium intake comes from processed foods. In Asian and African countries, approximately 70% of the salt taken into the body comes from salt added while preparing food. According to the report prepared by the European Commission and the data obtained from the American diet, 77% of sodium intake comes from processed foods, 12% from unprocessed foods, 6% from salt used during meals at the table, and 5% from salt added during cooking [5]. In a study, 55.5% of the daily sodium consumed in Turkey comes from foods, 31.9% comes from bread, and 12.6% comes from table salt. The effects of sodium found naturally in foods and those obtained as a result of consumption of processed foods differ. Consuming breakfast products results in a salt intake of 58%, followed by pickles with 17%, meat and meat products with 12%, nuts with 5%, biscuits and crackers with 2%, and other foods with 6% [6]. Consumers' desire to consume healthy products has led manufacturers to produce meat products with reduced sodium. Salt reduction in meat products occurs by directly reducing some or all of NaCl, using different chloride salts (KCl, CaCl2, MgCl2) and flavor enhancers instead of NaCl, or using new processing techniques. This article provides information about the effects of sodium reduction on sensory perception and product properties by applying various methods to meat and meat products[3,4,7].

1. **Purposes of Using Salt in Meat Products**
   1. **Taste**

The sense of taste arises as a result of the presence of chemical stimuli. Taste buds located in the mouth, throat and tongue enable the perception of taste. As individuals begin to age, they begin to perceive the taste of foods less [8]. Although taste buds appear to be the same, their responses to sour, bitter, sweet and salty tastes are different for each taste receptor cell. It has been determined that each taste bud contains 50-100 specialized receptor cells responsible for the perception of different tastes. It is possible to group these receptor cells into 4 groups. These; Type I cells are the most abundant taste cells in the taste buds and the receptors responsible for the perception of salt taste. It is perceived on the right and left edges of the tongue. Type II cells have receptor proteins on the cells' surfaces. These receptors enable the perception of bitter, sweet and general tastes. It is perceived in the front and back parts of the tongue. Type III are the receptors responsible for the perception of sour taste. It is perceived in the middle parts of the tongue. (H+) ions formed by acids in foods cause the sour taste to occur. The perception of sour taste is also different for each different receptor. The function of type IV is not fully known [9].

Ionic stimuli such as sodium and salt react with ion channels in the cell membrane of the taste receptor. Ion channels are permeable for salt cations (Na+) and the electrical potential across the membrane changes and depolarization occurs. This situation provides a transition to Ca+2 ions and releases neurotransmitters. When sodium channels are activated by sodium, the taste of salt is perceived and sent to the taste center in the brain [10]. Anions have an impact on the taste properties of different salt types. The taste perceptions created by sodium chloride, bromide and iodide salts vary among individuals [11]. In addition, the decrease in salinity depends on the type of anion present in the chloride ion. Sodium chloride has a significant effect on the perception of salt taste [12]. This is due to the presence of the Cl - anion and its effect on receptor cells. The diffusion of large anions through cell channels in taste receptors is limited. Therefore, this situation becomes a less effective stimulant for bromide and iodide salts with large anions [13].

* 1. **Flavor**

Salt is a widely used food ingredient in our country, which has a rich culinary culture, due to its flavor-enhancing properties. Products in which salt is not used at sufficient levels are perceived as tasteless by the consumer. While salt increases the intensity of the taste in foods, it masks undesirable bad taste [14].

The food component with the highest salinity is sodium chloride. Sodium chloride is taken as a reference when measuring the salinity of a substance. It is Na+ cations that determine the salinity rate. However, K+, Li+, NH4, Ca+2 cations also contribute to the taste in the form of salinity. The reason why NaCl salt is used more frequently in foods compared to mineral salts such as CaCl2, KCl, MgSO4 is due to the low cost of this component, its easy accessibility and its contribution to the formation of the desired taste in foods. Another advantage that salt provides to foods is that it regulates the enzyme activity of foods and enables the development of organisms that are effective in the formation of aroma compounds [15]. Products such as calcium chloride, potassium chloride and phosphate, which are used to reduce the salt content of foods, cause bitter, metallic and astringent tastes in foods, and also cause undesirable color and structural changes in the product. Reducing the amount of sodium chloride in meat products creates a proteolysis enzyme as a result of the activity of the endopeptidase enzyme, causing unwanted softness in the meat, while the exopeptidase enzyme causes the formation of an undesirable taste and odor in the meat [16].

* 1. **Protective Properties of Salt and Its Effect on Microbial Stability**

Sodium chloride is one of the most important additives used in meat and meat products. The most important function of sodium chloride in meat products is that it helps reduce water activity. Salting of meat products aims to add flavor to the meat and prevents the development of microorganisms in foods to a large extent [17]. High salt concentration used in foods creates changes in cellular metabolism due to the osmotic pressure effect, causing the loss of water-soluble components such as vitamins and minerals in the natural structure of meat products and causing a serious decrease in the nutritional value of foods. Additionally, the salt in processed foods alone is insufficient to preserve foods. Salt needs to be applied to foods in combination with other preservation processes (drying, osmatic dehydration, etc.) [18]. Salt prevents spoilage by reducing the water activity value of microorganisms and pathogens that cause spoilage in food below the level required for their growth in food. The aw value in a food is an expression of the availability of water in the food for enzymatic reactions, metabolic activities and microbial growth. Each microorganism has an aw value at which it can grow. The aw value of meat and meat products is in the range of 0.99-0.70. While the aw values of salami and sausages vary between 0.857-0.993, this value for sausage is 0.72-0.90. These values are the most important factor in the formation of bacteria that cause food spoilage and cause food poisoning. As a result of spoilage of meat products, bacteria such as Bacillus, Clostridium, Pseudomonas and Escherichia may develop in meat [19]. If the aw value of foods decreases, the shelf life decreases accordingly. By reducing the salt level in the products, other parameters need to be changed to increase the antimicrobial effect and keep the shelf life constant. It has been stated that reducing NaCl levels below the standard amount required without any other protective measures reduces the shelf life of the product [20].

* 1. **Salt and Health**

In recent years, the demand for healthy foods has been increasing as a result of consumers' sensitivity to nutrition. Consumers prefer products with reduced salt content in their diets. It has been determined by research that excessive salt consumption causes health problems such as cardiovascular diseases, kidney disease, increase in blood pressure, hypertension and cardiovascular diseases [21,22,23]. The amount of salt consumed by people varies between 9-12 grams/day in the world and in our country. The amount of salt consumed in the world is determined as 12 grams/day [21]. In our country, the amount of salt consumed in studies conducted by SALTurk (who are they) (date should be 2011) varies as 18 grams/day [24]. Salt intake should be 5 grams/day for a normal human body. However, salt consumption, which was 1.5 grams/day in ancient times, has increased to 9-18 grams/day today. This amount, which is approximately three times the amount of salt that should be consumed, has revealed the necessity of the "Excessive Salt Reduction Program" in Turkey by the Ministry of Health [25].

* 1. **Effect of Salt Consumption on Hypertension**

Hypertension is seen in individuals who consume excessive amounts of salt. Hypertension disease is defined as diastolic blood pressure ≥90mmHg and systolic blood pressure ≥140mmHg. Hypertension disease is seen in societies where the daily sodium intake is more than 5.75 grams per day. This shows that a certain level of salt intake is required for the development of hypertension. It has been reported that in addition to the sodium contained in salt, the chloride ion also causes hypertension. Abnormalities related to the function of sodium and chloride ions in the body cause volume expansion and increase in blood pressure. Blood pressure does not increase when sodium citrate or ammonium chloride is used alone [26].

* 1. **Effect of Salt Consumption on Cardiovascular Disease**

High blood pressure accounts for 50% of deaths from coronary heart disease and 60% of deaths from stroke, and is a cause of death and disability in adults. The risk of cardiovascular disease increases with increasing blood pressure, and when blood pressure decreases, the risk of this disease decreases significantly [27]. There are not many controlled studies investigating the effect of salt reduction on cardiovascular disease. In one study, salt intake higher than 5g per day was associated with more than 17% risk of cardiovascular disease and more than 23% risk of stroke. Various countries have aimed to reduce the amount of salt in foods. As a result of the studies , it was concluded that salt reduction reduces cystological blood pressure below 10 mm Hg, reduces the mortality rate from stroke and coronary heart disease by 75-80%, and an increase of 5-6 years in life expectancy has been observed [28].

* 1. **Effect of Salt Consumption on Kidney Disease**

Sodium is effective in regulating blood pressure and maintaining fluid balance in our body. However, excessive amounts of salt taken with food cause increased calcium excretion in the urine and a decrease in calcium in the bones. Calcium loss in bones also increases the risk of kidney stone formation and osteoporosis. Excessive salt consumption negatively affects kidney health. Excessive salt consumption accelerates the excretion of albumin and proteins from the body in kidney patients [29,30]. Studies have also found that there is a relationship between kidney failure and hypertension. Kidney disease and hypertension manifest themselves when uncontrolled blood pressure damages other organs. Atherosclerotic disease, which occurs as a result of the accumulation of various substances on the inner walls of the vessels feeding the heart, can cause long-term hypertension and deterioration in kidney functions along with uncontrolled blood pressure. Hypertension is observed in 80-85% of chronic kidney patients [31].

* 1. **Effect of Salt Consumption on Stomach Cancer**

High salt intake causes infections by causing hypergastrinemia and proliferation of Helicobacter pylori bacteria in the gastric mucosa shows that there is an increasing correlation between salt consumption and stomach cancer. As a result of individuals' consumption of processed meat products, canned foods, and fast food, the salt contained in foods has a destructive effect on the stomach [32].

1. **Meat and Salt**

Meat and meat products; It is a very valuable food item due to its deliciousness, rich in essential nutrients, easy to digest and satisfying the senses. At the same time, meat products are foods that can spoil very quickly if adequate storage conditions are not provided. This has caused meat to be transformed into different products. Meat products began to be produced by adding various seasonings of different taste, flavor and appearance. Foods such as sausage, pastrami and roasted meat, which are among the traditional products of our country, are products that arise from the need to preserve meat for a longer period of time [33]. The quality of meat is very important in terms of gaining the appreciation of consumers. Quality of meat; The nutritional value varies depending on many parameters such as meat composition, crispness, water retention capacity, taste and smell, as well as meat spoilage and contamination [34]. One of the most important factors affecting consumer appreciation of meat products is the crispness of the meat. While the tenderness of meat occurs as a result of the age, gender, species of the animal, the amount of connective tissue in the meat, the nutritional status of the animal, pre-slaughter factors and enzymatic reactions that occur during the ripening of the meat, this is the most important factor that determines the quality of the meat [35]. Salting meat products is a method as old as drying. The salting process is one of the most important stages in dried meat products. The salt used in the production of meat products increases the water retention capacity of the meat and prevents the development of microorganisms by reducing the water activity [36]. With the salting process before drying, the water activity of the meat drops below the value of 0.95 and by providing drying before drying, the meat becomes safer against bacteria. [37]. The salt concentration of a salted and dried meat product with a water activity of 0.95 is in the range of 4.3-4.5% [38]. In addition, salt affects chemical and biochemical reactions such as lipolysis, proteolysis and lipid oxidation, thus affecting color, flavor and textural changes in the product. It improves the properties [39,40]. Salting of meat products is done in two different ways: wet salting and dry salting. Dry salting is a method applied to dried and cured meat products such as "pastrami", "ham" and "bacon". In dry salting, the salting process is applied in a way that the salt is distributed homogeneously over the surface of the piece of meat and affects the entire surface. It is recommended to use refined fine salt for fast salting and coarse salt for slow absorption. In wet salting, the meat is kept in salt solution (brine) for a while to ensure that the salt penetrates the entire surface of the meat. The ideal temperature here is 4-8 ˚ C and the time the meat should be kept in brine can vary between 48-72 hours [40-42]. The main factor that allows salt to penetrate the entire surface of the meat is the dissolution of salt on the meat surface and the concentration of this solution. The penetration rate of salt may vary depending on muscle type. Salt inhibits proteolytic enzymes, causing the meat to soften. The textural properties of the muscles where the salting process is done differently are also different. Low salt addition to meat products provides a soft textural structure as a result of excessive proteolysis [43,44]. Curing process in meat and meat products; By adding additives such as salt, nitrite and nitrate to meat and seasoning it with various spices depending on the product type, it improves the properties such as aroma, flavour, texture, taste and color in the products and makes the foods more durable [45].

The curing process is the most commonly used method to add juiciness, crispness and consistency to the final meat. In the curing process, many compounds such as sodium chloride, sodium lactate, sodium phosphate, polysaccharides and gums are preferred due to their functional functions. Sodium chloride, which is widely used in foods, ensures that the water contained in the curing solution and in the natural structure of the meat remains in the structure of the meat [46]. In the first stage of bacon production, in addition to salt, nitrite or nitrate must be used in the meat for curing purposes [47,48]. It is undesirable to use salt alone during the salting process. Because the use of salt alone gives the meat a hard structure and causes the meat to acquire a dark and undesirable color. Due to this negative feature of the salting process, substances such as nitrite or nitrate are added to the meat along with the salt. The use of nitrite and nitrate along with salt helps to provide the desired color and aroma in meat. In addition, the preservation period of meat is prolonged and the occurrence of oxidative rancidity is thus limited [49].

The use of excessive salt in meat products for preservation purposes and the health problems experienced as a result of consuming these products have directed consumers to meat products with reduced salt. More than 70% of the salt taken in the diet is obtained from processed foods. More than 20% of this value comes from meat products [3]. Efforts to reduce salt consumption in Turkey include reducing the salt content of processed foods through legal means and reporting the salt content of foods on their labels. The maximum salt amounts allowed by the Food Codex in Turkey are as in Table 1 below [50].

Table 1. Maximum salt amounts allowed by the Food Codex in Turkey [50].

|  |  |
| --- | --- |
| MEAT TYPE | SALT CONTENT |
| Bacon | Dry matter maximum 10% by mass |
| roasting | Maximum 3% by mass |
| in ham | Maximum 3% by mass |
| Chicken Doner | Maximum 2% by mass |
| Mince | Maximum 2% by mass |

WHO recommends consuming less than 2g of sodium (5g of salt) per person per day. For this purpose, efforts are being made to reduce the amount of salt contained in meat products [51]. The amount of salt contained in meat products is not at a level that would cause harm to the human body. As a result of the processing of meat products, the amount of salt in meat increases. For example, fresh beef tenderloin meat typically contains 50 mg sodium/100 g, but beef burger meat contains 396 mg sodium/100 g. Table 2 shows the sodium and sodium chloride amounts contained in meat and meat products in the National Food Composition data system [52].

Table 2. Amount of sodium and sodium chloride contained in meat and meat products

[g/100 g edible part] [52].

|  |  |  |
| --- | --- | --- |
| MEAT TYPE(100g) | Sodium (mg) | Salt (mg) |
| raw products |  |  |
| Beef tenderloin meat | 50mg | 124mg |
| sheep loin meat | 65 mg | 163mg |
| Beef tenderloin meat | 49 mg | 123mg |
| chicken leg meat | 82 mg | 205mg |
| Offal beef kidney | 192 mg | 481 mg |
| turkey leg meat | 72 mg | 179 mg |
| Trout | 120mg | 299 mg |
| Processed Products |  |  |
| beef burger meat | 396 mg | 800 mg |
| sausage veal | 889 mg | 2223 mg |
| Bacon | 2799mg | 6996 mg |
| salami turkey | 938 mg | 2345 mg |
| Doner Chicken meat raw | 653 mg | 1631 mg |
| doner minced meat | 800 mg | 2001 mg |
| Sausage | 971 mg | 2428 mg |

* 1. **Use of Salt in Meat Products**

Salt has an important function in adding flavor to meat products, increasing the existing flavor and providing the desired textural properties. Salt contributes to the development of textural properties in meat products by causing the proteins to swell, increasing their binding properties and water retention capacity. 2% salt is used in meat products [53]. Using less than 1.4% salt in meat products reduces the cooking efficiency of meat products, and this requires the addition of extra protein to the products. 79% of the total sodium amount in meat products with 2% salt content comes from the salt added to the products. [54].

* 1. **Use of Salt in Emulsion Products**

Meat products such as salami and sausage are among the most important food products produced using emulsion technology. While preparing salami and sausage products, it is based on the principle of creating a continuous phase by chopping some meat in the dough cutter with salt and knives rotating at high speeds with the help of blades rotating at high speeds, adding ice or water to the environment and extracting the proteins dissolved in salt water. Oil is slowly added to this phase to form an oil/water emulsion [55]. A stable product is obtained by placing the emulsion in natural or artificial casings and smoking and cooking [56]. Salt is an ingredient used as an additive in emulsion type products. Salt increases the viscosity in emulsion products such as salami and sausage. In addition, it has a bacteriostatic effect on products [57]. By increasing the water retention capacity of emulsion products, loss of juiciness during cooking is prevented. Chlorine (Cl-) ions in the salt formulation penetrate into the myofilaments and swell, and sodium ions (Na+1) form. It increases water retention capacity by clustering in filaments. Salt added during the making of salami dough ensures emulsion formation by extracting myofibrillar proteins dissolved in salt water [58,59]. The solubility of actin and myosin, which are the determining factors affecting the formation of emission; It varies depending on factors such as pH, salt solubility and temperature. The rate of use of dissolved proteins in emulsion products are parameters that highly affect the stability, viscosity, absorption capacity and product yield of salami [60,61].

* 1. **Use of Salt in Bacon Production**

Pastrami is a cured meat product obtained by salting, pressing, drying and curing the meat removed in whole pieces from certain parts of the beef carcass. [62,63]. One of the most important stages of pastrami production is the process of curing the meat. During the curing process, meat is treated with salt, nitrite, nitrate and sugar. The cured meat is then dried by pressing once or twice at a certain weight. After the moisture content of the meat is reduced to a certain level, the necessary curing and drying process is carried out to provide the taste, flavor and texture characteristics specific to pastrami [64]. The salt used in the curing process has an effect on the changes that occur in pastrami production. Salt has many positive effects in ensuring the desired product development in meat products. The presence of high salt concentration in products such as pastrami produced in pieces helps maintain microbial stability by affecting the intracellular and extracellular osmotic pressure, causing the removal of intracellular water and reducing water activity. Salt affects flavor by increasing the solubility in meat proteins. At high salt concentrations, the bacteriostatic effect of salt increases. In addition, as the amount of salt used in pastrami production increases, the dry matter content of the products also increases. The salt content of the product obtained from pastrami production is around 5-6%. In bacon production, salt content can be reduced to less than 3% due to consumer preference [64,65].

* 1. **Use of Salt in Roasting Production**

The meat of bovine and ovine butchered animals is chopped into small pieces not exceeding 7cm, salt and internal fat are added, roasted in special cauldrons at dry temperature, and then packaged in their own oil or with the internal fat obtained from butchered animals in artificial or natural packaging materials to be completely covered with a layer of fat. It is a meat product [66]. Kavurma is the only meat product that is cooked in pieces. It is a processed food product obtained by roasting meat, making it more durable and preserving it in oil, since the times when refrigeration technology was unknown. In the meat industry, roasting is among the limited products preserved in fat, and the production of these products is quite limited [67]. One of the most important additives used in roasting production is salt. In addition to its antimicrobial contribution, salt contributes to the taste and flavor of the roasted product [56].

* 1. **Use of Salt in Sucuk Production**

The meat pieces taken from the breast, leg and shoulder parts of the beef carcasses are separated from the coarse fat and connective tissues and sausage dough is obtained together with tail fat and meat fat (10% tail fat, 10% meat fat, 80% beef). The sausage dough is kept at -20˚C for a day to rest. Salt, garlic and spices are added to sausage dough. Additionally, sodium nitrite is added to the sausage to give color. The resulting sausage dough is filled into artificial intestines with a diameter of 38 mm [68,69]. Salt (NaCl), used as an additive in sausage production, affects water retention capacity, color, fat binding properties and flavor. Another advantage that salt provides to the sausage product is its contribution to product safety and shelf life by reducing water activity [70].

* 1. **Use of Salt in Minced Meat and Meatballs**

Sodium chloride used in ground meat or meatballs is an important factor in determining the sensory properties of meat. Transglutaminases used in the preparation of meatball dough are used to increase gel formation and meat yield in meatballs [71]. Sodium chloride is used to reduce cooking loss and improve texture in products such as ground meat and meatballs. Sodium chloride increases the stickiness of the dough, thus ensuring the balance of moisture and fat in the meatballs [72]. In addition, components such as soy protein, caseinates, etc. are used in meat products to improve the technological properties of meatballs. NaCl is used to increase binding, hardness, cooking efficiency and flavor intensity in products such as ground meat and meatballs. Sensory effects such as perceived saltiness in meatballs are affected by the taste of other ingredients and spices used in the product [3].

* 1. **Salt Reduction Strategies in Meat Products**

The salt content of meat and meat products can be gradually reduced so that the consumer does not notice it. In a study on gradual salt reduction, it was determined that the taste of the mouth adapted to the salt reduction and consumers perceived the salt of the products as normal salinity [73]. It has been observed that the UK, which implemented this strategy, reduced the salt content of processed food products sold in markets by 20-30% over a 3-year period [74]. This strategy for sodium reduction brings with it some limitations. Considering that 25% of individuals are sensitive to taste, it becomes difficult to reduce the amount of salt in the product without the consumers noticing [15]. In addition, in order for this time-consuming strategy to be successful, it must be applicable on an industrial scale and to all products. On the other hand, even if consumers find the reduced sodium product acceptable, it is very difficult to reduce the amount of salt without damaging the taste of the product. As a result of reducing salt in foods, undesirable bitter tastes occur. Additionally, reducing salt in foods causes the shelf life to shorten [75,76]. By reducing the salinity in meat and meat products, both the perceived saltiness and the intensity of the product taste decrease. There are different approaches to reducing sodium content in meat and meat products, especially processed meats. These approaches;

1. Reducing the amount of sodium chloride used in meat products,

2.Reducing the amount of sodium chloride and replacing it with different chloride salts (KCl, CaCl2, MgCl2).

3. Flavor enhancing and masking agents used to eliminate saltiness that occurs when saltiness is reduced in foods.

4. Optimizing the physical structure of salt

5. It is realized as the use of new processing techniques [16,3].

* 1. **Salt Substitutes Used Instead of Salt**

One of the salt substitutes commonly used to reduce or lower the sodium content of foods is potassium chloride (KCl). However, it has been stated that the use of 50:50 sodium chloride/potassium chloride in foods causes bitterness and a decrease in salty taste. It has been concluded that patients with heart failure, chronic renal failure and type I diabetes increase their existing health problems with high potassium intake [77]. By partially replacing salt with KCl, the amount of sodium in meat products can be reduced. Mixing and using chloride salts in meat products is one of the methods used to reduce the amount of sodium. The most well-known and commercially produced mixture Pansalt® \_ truck. Pansalt ® is a patented product prepared by removing almost half of the sodium chloride and replacing it with magnesium sulfate, potassium chloride and L-lysine hydrochloride from essential amino acids. The reason for using lysine hydrochloride in this mixture is to ensure easy excretion of sodium from the body, to increase the salinity of the product and to mask the taste perception of magnesium and potassium. Other commercially produced potassium chloride and sodium chloride mixtures are Morton Lite Salt ®, Losalt and Saxa So – Low salt. In a study, a mixture of 40% potassium chloride, 60% sodium chloride and Morton Lite Salt ® It was determined that turkey ham, veal ham, and bacon produced with meat were scored the same as the control groups [3]. A study was conducted on the effects of producing beef patties using low sodium salts. In the study, low-sodium and commercially used meatballs containing 12% magnesium sulfate, 28% KCl and 57% NaCl, Pansalt ®, NaCl , salt and without any added salt were used. Pansalt ® in the study It was observed that meatballs containing meatballs had a higher water retention capacity compared to other groups. This situation is thought to be caused by magnesium sulfate and potassium chloride in the formulation of Pansalt ® commercial salt [78]. Research has shown that the change in taste is not noticed when sodium chloride is replaced with other salts at a rate of 25-40%]. As the amount of potassium chloride in meat products increases to an acceptable level, there is an increase in acidic, spicy and salty taste [79]. Studies have shown that the addition of 50% potassium chloride, used instead of the salt component in cooked hams, helps to achieve high binding and quality sensory properties in the product. In a different study, no difference in sensory taste, crispness, flavor, and acceptability was found between hams prepared using 100% sodium chloride and hams prepared from 70% sodium chloride + 30% magnesium chloride and 70% sodium chloride + 30% potassium chloride [80] . In a study conducted to reduce the salt content of bacon, it was concluded that adding KCL instead of 15% salt was acceptable in terms of textural properties, but it was not possible to use it in terms of texture because the use of KCl instead of 30% salt in the salt content of bacon gave negative results in terms of chewiness and hardness in the product [81]. Phosphates are used to reduce the amount of sodium chloride in meat and meat products. In a study, the use of phosphates in cooked meat products was investigated. Phosphates are generally used in foods for purposes such as increasing cooking efficiency and improving water retention capacity. Phosphates release negatively charged parts of meat proteins in fresh and cured meat products, thus increasing the ionic strength and causing an increase in water retention capacity. With the addition of salt, the functionality of phosphates increases [82]. Salt and phosphates create a synergistic effect in meat products. The phosphate rate used to reduce the amount of sodium in meat products is much lower than sodium chloride. While sodium chloride is used at a rate of 2-4% in meat products, sodium polyphosphate is used at a rate of 0.5%. The NaCl content of cooked salami and sausages made by adding phosphates can be reduced to 1.4% without losing taste. It is possible to reduce the salt content in cooked hams to 1.7% NaCl [83].

* 1. **Flavor Enhancers and Enhancers**

Taste masking and flavor enhancing agents are among the methods used to reduce the amount of sodium consumed in foods. Some of these products; monosodium glutamate, lactate, edible seaweed, yeast extracts and nucleotides. Taste enhancers used in foods activate receptors by showing various activities in the throat and mouth, and the loss of flavor caused by reducing the amount of salt in foods is prevented [84]. In a study, monosodium glutamate (MSG) or Ajiplus was used instead of some of the table salt to reduce sodium levels in the Singaporean dish mee soto and chicken rice. When the salt level of these dishes was reduced by 40%, it was observed that the spice aroma, umami and sweet taste, chicken flavor and saltiness decreased. On the other hand, it was determined that chicken aroma, umami taste and saltiness increased with the addition of flavor enhancers. There was no difference in salinity between the products in which the NaCl level was reduced by 40% and the same amount of monosodium glutamate was added. It was concluded that the addition of monosodium glutamate to the products had positive effects on the product in terms of umami taste, flavor intensity and mouth taste [85]. In a study on chicken nuggets, a salt mixture was created using potassium chloride, tartaric acid, citric acid and sucrose instead of 40% sodium chloride. Quality characteristics were examined on 3 samples by adding 12%, 10% and 8% apple pulp to the product. It has been determined that adding apple pulp to the products and reducing the salt significantly reduces the emulsion stability and cooking ability of the products. It has been concluded that the moisture content of nuggets containing 12g/100g of apple pulp with reduced salt content is high. Adding apple pulp to the products increased the dietary fiber content. Addition of apple pulp and reducing the amount of salt reduced the textural quality. It was concluded that products with inadequate properties in terms of sensory quality were obtained [86]. In a study conducted under naturally controlled conditions and using 3 different salts (70% NaCl-30% KCl, 85% NaCl-15% KCl, 100% NaCl) pastrami was produced with 2 different production techniques and the effects of these practices on quality characteristics were investigated. In the research, it was noted that the amount of sodium determined in the raw material increased during the production process depending on the sodium ratio in the salt mixture, and decreased with the fenugreek process. After sensory evaluation, pastrami produced under natural conditions with 100% NaCl was appreciated in terms of taste, while pastrami produced under controlled conditions with 85% NaCl-15% KCl was appreciated in terms of color [87]. In a study conducted on fermented sausages considering taste and textural properties, the amount of potassium chloride used as a substitute for sodium chloride was determined as 40%, the amount of potassium lactate was 30% and the amount of glycine was 20%. As a result of the evaluations, it was concluded that the 40% substitution for these three substances inhibited pathogenic microorganisms in terms of food safety [88]. Lysine and succinic acid are among the substances used instead of salt to reduce sodium in meat and meat products. Lysine and succinic acid are substances that have antimicrobial and antioxidative properties. These substances can be used instead of 75% NaCl in dry curing of meat and meat products, ensuring that products with the same taste and flavor are obtained. Water binders such as phosphates, gums and starch must be used to preserve the water binding function lost by reducing the salt content in meat and meat products. Phosphates, gums and starch used for this purpose are used to improve the water retention capacity of meat products. The use of sodium and potassium lactate in meat products reduces the amount of sodium in the products [79,89]. In the study conducted to investigate the quality characteristics of low-sodium meatballs prepared using red meat, products with different contents were prepared using phosphate, sodium and fat. Analyzes were made on products with 10%, 15%, 20% fat and 0.8%, 0.42%, 0.04% salt content. Meatballs with 50% and 60% meat content were prepared. Meat and oils used in meatballs have different effects on the product. If the amount of meat used in the products increases, the perceived salty taste decreases, while if the amount of fat increases, the perceived saltiness increases. Although the use of phosphate does not have any effect on the perception of salinity, it has been found that it reduces cooking losses [3].

In a study conducted to reduce the amount of sodium chloride, potassium lactate was added to "Ham" with bones during the production stage. The purpose of using meat with bones here is to distribute the salts in the meat and apply an accelerated curing process. It was produced using 39.7 g/kg potassium lactate and 15 g/kg sodium chloride while preparing meats with bones. It has been determined that the addition of potassium lactate to meat with bones provides a positive improvement in sensory and physicochemical properties and positively affects microbial stability. [90]. A research was conducted on the sensory properties of fermented small sausages prepared by substituting sodium chloride with potassium chloride and potassium lactate at rates ranging from 0% to 50%. By increasing the amount of potassium lactate, an increase in sweetness, pH, doughy structure and the amount of disintegration of the product was observed, while a decrease in hardness, acidic taste, salty taste, ripe taste and sharpness in taste was observed. In addition, it was determined that products prepared by adding high amounts of potassium chloride were similar to the control group in terms of sensory properties [91].

* 1. **Optimizing the Physical Structure of Salt**

Among the methods used to reduce the amount of salt in meat and meat products, salt reduction in foods can be achieved by making changes in the physical structure of salt. One of the important parameters affecting the perception of salt is the size and shape of salt particles. Salt molecules with large surface areas and small ones dissolve quickly on the surface of the food, thus increasing the perception of saltiness [92]. In addition, applying salt to different layers of the food in varying concentrations can reduce the salt level without negatively affecting the perception of saltiness felt in the product. The salt used in meat and meat products must have a granular structure and the characteristics of refined salt. However, coarse salt is used in processed foods produced using traditional methods, such as pastrami. It has been determined that changes in the shape and crystal structure of the salt increase water binding in emulsion products more quickly, increase pH, increase protein solubility and positively affect cooking efficiency [93].

* 1. **Using New Alternative Technologies**

High pressure (HPP) and ultrasound applications, which are non-thermal food processing technologies, are used to reduce the salt level of meat products. High pressure (HPP) is applied to products with a value of 400-600 MPa at not very high temperatures (<45˚C) [94]. High pressure process is used in meat and meat products to prevent the development of pathogenic microorganisms in the products. In addition, this technology is used to preserve various features of meat products as a result of reducing salt levels. The interaction between sodium ions and proteins changes with the application of pressure, allowing sodium to enter the taste receptors on the tongue [95]. Proper distribution of salt on the meat is ensured by the ultra sound technique used in the salting process. In this way, although the NaCl level of the product is reduced, the salinity perceived by the consumer increases [96]. The sodium in meat does not only come from sodium chloride. Sodium nitrate (preservative, colorant), sodium citrate (sweetener), sodium phosphate, sodium bicarbonate (leaving agent) and monosodium glutamate (flavoring) additives can also be used in the formulation of meat . In the study, the effects of high pressure application and changing the NaCl and phosphate content in different process steps on some quality criteria were examined. It was concluded that the application of high pressure treatment to raw meat negatively affected the structure and water retention capacity of reduced-salt ham. It was concluded that a 45% salt reduction in ham would be possible when KCl was used together with high pressure application [97].

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