

## CONTENTS OF SODIUM-CHLORIDE IN VARIOUS GROUPS OF LOCALLY MANUFACTURED MEAT

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**Abstract:** Sodium chloride (NaCl) is one of the most important food additives and it has a significant impact on the sensory and microbiological properties of meat products. According to the Regulation on the quality of ground meat, meat preparations and meat products (*Official Gazette of RS 50/2019*), the salt content in meat products is not defined. The average NaCl values in these products can be concluded by comparison with available experimental and literature data. The aim of this study was to examine the content of sodium chloride in different meat products from 3 different production batches locally produced. A total of 42 samples were tested: Kulen and Čajna sausage (fermented sausages), dry tenderloin (cured meat products), smoked tenderloin (smoked products), hot dog (finely chopped boiled sausage), Serbian sausage (coarsely chopped boiled sausage) and pancetta (bacon). The highest average sodium chloride content was found in dry tenderloin (4.49g/100 g) while the lowest content was measured in hot dogs (1.88g/100 g). Comparing the obtained values of sodium chloride content with the values obtained by other authors for fermented products (Kulen and Čajna sausage), the tested products had significantly higher values of salt content, while the lowest average content of sodium chloride was found in smoked tenderloin samples. For other products, the content of the tested parameter was similar to the values reported in the literature. After the analysis of available samples, it was determined that the manufacturer adhered to the prescribed amounts of NaCl, according to the recipe, in every product. There weren't any notable deviations in the preparation of monitored meat products.

**Key words:** sodium chloride, meat products

## Introduction

Sodium chloride (NaCl) is one of the most commonly used additives in the meat industry because of its low cost and its functionality (*Ruusunen and Puolanne, 2005*). Cured meat products exist since ancient times as a result of the need to preserve meat for a longer period of time. Salting and drying prolong the shelf life of this perishable food. This process also provides microbiological stability and improves organoleptic properties such as texture. It is, additionally, used for flavouring, as a flavour enhancer, and is also responsible for water binding capacity and giving desired textural properties to processed meat. Cured meat products are foods highly valued by consumers as they are one of the most consumed groceries in people's nutrition. The properties that make these food stuffs particularly appealing are the result of the transformation of proteins and lipids that give these products their characteristic aroma and taste (*Balestra and Petracci, 2019; Domínguez et al., 2017*). In addition, the salinity caused by sodium chloride improves the perception of meat taste, which is an significant factor in the overall acceptability of meat products. Therefore, the reduction of sodium in processed meat can negatively affect the overall quality of the final product (*Ruusunen and Puolanne, 2005; Pietrasik and Gaudette, 2015*).

Sodium chloride is an excellent preservative, which inhibits the growth and development of unwanted microorganisms, prevents rapid spoilage, and increases the shelf life of cured meat products (*Inguglia et al., 2017*). Exposure to NaCl causes osmotic shock to microorganisms by binding water molecules with a consequent decrease in water activity ( $a_w$ ) below optimal growth conditions, resulting in water loss from the cell causing microbial cell death or slowing their growth (*Taylor and Davidson, 2007; Yotsuyanagi et al., 2016*). However, salt accelerates the oxidation of lipids and consequently generates unwanted changes in the colour and taste of meat and meat products, reducing their shelf life. In some cases, lipid oxidation is desirable, such as the development of the typical aroma of some meat products such as ham and sausages (*Mariutti and Bragagnolo, 2017*).

One of the main functions of salt in processed meat is the solubilization of functional myofibrillar proteins and improving water-holding capacity of meat products. As the salt penetrates the meat, the osmotic pressure around the muscle cells becomes higher than the one inside the cells, which consequently leads to the so-called process of so called osmotic dehydration. This process leads to an increase in the ability of proteins to bind water, resulting in a change or improvement in the texture of meat products. Increasing the water-binding capacity of meat reduces water loss during heat treatment, which improves the softness and juiciness of meat products (*Desmond, 2006; Domínguez et al., 2017; Morales et al., 2013*).

Meat and meat products are one of the components of the diet that contribute the most to sodium intake in the diet, with approximately 18-21% of daily sodium intake. The sodium content of meat products shows large variations in the degree of meat processing (fresh, dried, and processed meat), with unprocessed meat containing less than 0.1 g of sodium per 100 g of meat (*Aaslyng et al., 2014; De Marchi et al., 2017*).

The results of the DASH study (Dietary Approaches to Stopping Hypertension) show a linear correlation between salt intake and blood pressure. The link between excessive sodium intake and the development of hypertension has prompted public health and regulatory authorities to issue recommendations to reduce dietary salt intake (*Desmond et al., 2019*). *Kloss et al. (2015)*, according to the data of the European Commission, state that the countries of Eastern and Southern Europe show the highest rates of salt consumption. According to these data, salt consumption in adults in most European countries ranges from 7 to 13 g per day. Germany, Cyprus, Bulgaria and Latvia report the lowest salt intake (6.3 - 7.3 g/day), while the Czech Republic, Slovenia, Hungary and Portugal report the highest salt intake (12.3 - 13.6 g/day). *Powles et al. (2013)* report significantly different levels of salt intake with the lowest intake values observed in Denmark, the Netherlands and Belgium (8.3 - 8.8 g/day), and the highest in Hungary, Slovenia, Slovakia, Portugal and Italy (10.7 - 11, 2 g/day).

With increasing economic, health and consumer awareness, countries such as Finland, the UK, the EU, the US, and many other countries have formed national strategies to reduce salt consumption (*Aaslyng et al., 2014*). According to data gathered from previous research on sodium intake, populations from around the world are consuming much more sodium than is physiologically necessary. The current recommendations of the World Health Organization (*WHO, 2012*) are 5 g/day salt of salt, but there is a tendency to further reduce sodium intake to <2 g/day sodium (less than 5 g/day salt) in adults (strong recommendation), with a new goal of reducing dietary sodium intake by 30% before 2025. Changing consumer lifestyles and the easy availability of highly processed and fast foods have led to increased salt consumption. There is currently a great deal of consumer concern regarding salt intake and its prevalence in the diet worldwide. However, even with the development of modern canning practices, NaCl is still necessary for processed meat products. For the industry to actively involve in the salt reduction process, it is essential that products must be acceptable in terms of all quality parameters: shelf life, food safety, product texture, production yield, taste, and consumer acceptability throughout the shelf life (*Aaslyng et al., 2014*).

Although great progress has been made in the development of ingredients to replace salt and flavour enhancers in recent decades, there is a persisting problem of negative sensory effects that correlates with the use of these substances. The challenges that remain are the result of a need to use other ionic compounds to replace the functions of water retention, protein binding, and fat binding in foods in

which sodium chloride has been reduced while maintaining adequate microbiological safety (*Balestra and Petracci, 2019*). The author *Lilić (2016)* shows in his research that the reduction of sodium chloride content by replacement with potassium chloride and ammonium chloride has no significant effect on the sensory characteristics and colour of dried meat if these substances are added in an appropriate ratio.

Traditional practice in small meat processing plants leads to great variability in product properties (heterogeneous quality) because there is no strict uniformity in production. As sensory characteristics are one of the most important components of the quality of cured meat products, it is important to create a product with such attributes that would be attractive to the consumer, but it is also important to ensure continuous product quality, i.e. low variability of product characteristics. However, so far little has been done in the field of assessing the repeatability of the quality of traditionally cured meat products manufactured at low-capacity plants (*Jokanović et al., 2020*). On the other hand, the study conducted by *Rason et al. (2006)* shows that the internal composition of traditional dry sausages from 6 smaller production plants was homogeneous despite the apparent heterogeneous matrix.

The aim of the study was to examine the content of sodium chloride in meat products originating from 3 different production batches produced by a local manufacturer in order to gain insight into the uniformity of product quality and compliance with the manufacturer's specification.

## Material and Methods

Contents of NaCl were determined from the meat products that were sampled from a local producer from a small-capacity production plant. Five groups of meat products were examined, as follows: fermented dry sausages (Kulen and Čajna sausage), cured meat products (dry tenderloin), smoked products (smoked tenderloin), cooked products (hot dogs and Serbian sausage), and bacon (pancetta). Each product (originating from 3 different batches) was tested in duplicate, to determine how standardized the salting process was.

The NaCl content was determined volumetrically, by the Volhard method (SRPS ISO 1841-1: 1999).

The results of our research were statistically processed (Statsoft Inc. Statistics for Windows, Version 5.0.) and presented in tables as the arithmetic mean ( $\bar{X}$ ), the standard error of the arithmetic mean ( $S\bar{X}$ ), the standard deviation (SD), the variation interval (minimum – maximum) and coefficient of variation (CV).

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## Results and Discussion

The role of salt in meat products is multiple (inhibition of microorganism growth, ability to bind water, taste enhancer...). According to the Regulation on the quality of ground meat, meat preparations, and meat products (*Official Gazette of RS 50/2019*), the salt content in meat products is not defined, even though sodium chloride is one of the essential ingredients of dry fermented products. Based on experimental and literature data, the amount and method of adding table salt are specific to each group of meat products (*Prica et al., 2013*).

Table 1. shows the contents of sodium chloride in various meat products displayed as a percentage (%). Table 2. shows the average sodium chloride content in all 6 measurements (two measurements, three production batches).

The lowest coefficient of variation (CV), shown in Table 2, was recorded for following products: smoked tenderloin (2.92%) and fermented sausages - Čajna sausage (3.91%) and Kulen (4.87%). Such a low CV (CV <5%) may be the result of a relatively small number of samples (a total of 6 samples per product). The highest coefficient of variation was recorded in the samples of hot dogs (8.70%), pancetta (8.69%) and dry tenderloin (8.34%). Low coefficients of variation (CV <10%) indicate that, although there were variations in the preparation of meat products, they were not notable, i.e. the manufacturer adhered to the prescribed amount of NaCl added to each product, according to the recipe.

The average NaCl content in fermented sausages ranged from 3.98% to 4.49%. In a study by *Prica et al. (2013)* the average reported NaCl content in fermented sausages was 3.77%, while *Vuković et al. (2011)* state that the NaCl content in Kulen varied from 3.40 - 3.80%. According to the data reported by *Kurčubić et al. (2011)*, the mean value of NaCl content in Kulen in the three tested production batches was 3.45 g/100 g. The data provided by *Pećanac et al. (2017)* shows the NaCl content in Čajna sausage of 3.98%. *Branković Lazić et al. (2019)* in their research state that the NaCl content in fermented sausages ranged from 2.81% to 3.37%, depending on the applied manufacturing process. All mentioned values of salt content in the literature were lower than the values obtained in our research.

**Table 1. NaCl content (g/100g) in different meat products**

Product group	Product	Production batch	NaCl content	$\bar{X}$	$S\bar{X}$	SD	Interval of variation	
							Min	Max
Fermented meat products	Kulen sausage	1	4.44	4.38	0.06	0.08	4.32	4.44
		1	4.32					
		2	4.00	3.99	0.01	0.01	3.98	4.00
		2	3.98					
		3	4.44	4.36	0.08	0.11	4.28	4.44
	3	4.28						
	Čajna sausage	1	4.19	4.14	0.05	0.07	4.09	4.19
		1	4.09					
		2	4.45	4.47	0.02	0.03	4.45	4.49
		2	4.49					
3		4.22	4.34	0.12	0.16	4.22	4.45	
3	4.45							
Dry meat products	Dry tenderloin	1	4.95	4.92	0.04	0.05	4.88	4.95
		1	4.88					
		2	4.20	4.10	0.11	0.15	3.99	4.20
		2	3.99					
		3	4.49	4.46	0.03	0.04	4.43	4.49
		3	4.43					
Smoked meat products	Smoked tenderloin	1	3.00	2.98	0.02	0.03	2.96	3.00
		1	2.96					
		2	2.83	2.80	0.02	0.03	2.77	2.83
		2	2.77					
		3	2.87	2.89	0.01	0.02	2.87	2.90
		3	2.90					
Finely chopped boiled sausages	Hot dog	1	1.77	1.81	0.04	0.06	1.77	1.85
		1	1.85					
		2	2.12	2.08	0.05	0.06	2.03	2.12
		2	2.03					
		3	1.76	1.74	0.02	0.03	1.72	1.76
		3	1.72					
Coarsely chopped boiled sausages	Serbian sausage	1	2.54	2.56	0.02	0.03	2.54	2.58
		1	2.58					
		2	2.46	2.41	0.05	0.07	2.36	2.46
		2	2.36					
		3	2.78	2.77	0.01	0.01	2.76	2.78
		3	2.76					
Bacon	Pancetta	1	2.69	2.72	0.03	0.04	2.69	2.75
		1	2.75					
		2	2.82	2.84	0.02	0.02	2.82	2.85
		2	2.85					
		3	3.26	3.26	0.00	0.00	3.26	3.26
		3	3.26					

**Table 2. Average NaCl content (g / 100g) in different meat products in all 6 measurements**

Product	Production batch	$\bar{X}$	$S\bar{X}$	SD	Interval of variation		CV (%)
					Min	Max	
Kulen sausage	6	4.24	0.21	0.08	3.98	4.44	4.87
Čajna sausage	6	4.32	0.17	0.07	4.09	4.49	3.91
Dry tenderloin	6	4.49	0.37	0.15	3.99	4.95	8.34
Smoked tenderloin	6	2.89	0.08	0.03	2.77	3.00	2.92
Hot dog	6	1.88	0.16	0.07	1.72	2.12	8.70
Serbian sausage	6	2.58	0.17	0.07	2.36	2.78	6.41
Pancetta	6	2.94	0.26	0.10	2.69	3.26	8.69

The average NaCl content in dry tenderloin was 4.49% (Table 2). *Marchi et al. (2017)* report a value of 3.63% for NaCl content for this group of products. *Ganić et al. (2012)* examined the chemical composition of samples of high-quality tenderloin and tenderloin from industrial production, and obtained average values for NaCl content of 7.70% for tenderloin produced by artisanal production, or 4.96% for samples of origin from industrial production. The results obtained in the research of *Tomljanović (2015)* show that the share of salt in cured meat sausages was 4.39%. According to *Kurčubić et al. (2011)*, the salt content in dry pork ham in the three tested production batches was constant, and the mean value of sodium chloride content was 5.72 g/100 g. In study by *Pleadin et al. (2015)* the salt content was analyzed in different meat product categories and the results differed from 6.34% (prosciutto) to 6.52% (dry ham). The NaCl content in smoked tenderloin (Table 1), displayed as a percentage. The NaCl content in this product ranged from 2.80% to 2.98% between batches, in contrast to the study by *Pleadin et al. (2015)* who reported a value of 5.34% for the same product. In their research, *Stamenković (2004)*, stated that before preparing meat for smoking process, amount of up to 3.76% of NaCl is added, which correlates with the obtained result of NaCl content in the finished product in the amount of 3.44%, which are slightly higher than those obtained in analyzed products. The results in our study show that the NaCl content in boiled meat products ranged from 1.95% (average value for hot dogs) to 2.50% (average value for Serbian sausage), as shown in Table 2. In the production of boiled sausages (finely chopped boiled sausages, coarsely chopped boiled sausages, boiled sausages with pieces of meat), kitchen salt is usually added in the amount of 1.8% to 2.2% (this is considered the "normal salting") (*Vuković, 1998*). Average values for the same product group are 2.19%, according to research by *Aaslyng et al. (2014)*; values stated by *Peulić et al. (2019)* are 1.57 - 2.26 g/100g of product. Authors *Prica et al. (2013)* measured 3.06% sodium chloride on average in finely chopped boiled sausages from the Novi Sad market. Results of the study by *Dorđević et al. (2017)* conducted on Serbian sausage, sampled from 11 different producers from the territory of the Republic of Serbia, show the range of NaCl with a range of 1.60% to 2.50%. All mentioned studies indicate that the NaCl content in products that we tested was very similar to the experimental results

presented in the literature. The obtained NaCl content for dry bacon (bacon category) with a mean value of 2.94%, was lower than the one obtained in the study of *Guofeng et al.*, (2010), with an average salt content of 5.07%, as well as the values obtained by *Pleadin et al.* (2015), who reported the salt content in bacon of 5.52% and semi-durable bacon of 5.09%, as well as in pancetta - 5.57% (durable bacon). Previous research by this author on two different pancetta samples shows an even higher salt content in the range of 8.56% - 9.08% (*Pleadin et al.*, 2013) compared to our samples. On the other hand, *Marchi et al.*, (2017) state a value of 2.66% for the NaCl content in this product group, which is slightly lower result compared to the values from our study.

## Conclusion

Kitchen salt is one of the most important and widespread food additives that has not only a preservative effect, but also has a significant impact on the sensory and microbiological properties of meat products.

The highest average sodium chloride content was found in dry tenderloin (4.49 g/100 g) while the lowest content was measured in hot dogs (1.88 g/100 g). Comparing the obtained values of sodium chloride content with the values measured by other authors for fermented products (Kulen and Čajna sausage), the examined products had significantly higher values of salt concentration. The lowest content of sodium chloride was found in smoked tenderloin samples. For other products, the content of the tested parameter was similar to the values reported in the literature. The World Health Organization recommends that the daily intake of salt for adults, healthy people should not exceed 5 g/day. Since the obtained results indicate that in some tested samples the measured amount of sodium chloride was very close to the upper limit of the recommended value of daily salt intake, measured per 100 g of meat product, it is necessary to continuously and systematically control and reduce sodium chloride in meat products. Also, there is a persisting need to make data on the salt content available on the label of each of these products so it could be easier for consumers to make a decision when buying a product. Depending on the type of meat product, the NaCl quantity did not notably differ between batches. This indicates the identical application of the prescribed recipe of the producer and similarity of the method of processing meat products. We concluded that the salting technology is strictly followed in the production process.



## Sadržaj natrijum-hlorida u različitim proizvodima od mesa lokalnog proizvođača

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### Rezime

Natrijum hlorid (NaCl) predstavlja jedan od najvažnijih aditiva koji se može naći u hrani i ima značajan uticaj na senzorna i mikrobiološka svojstva proizvoda od mesa. Prema pravilniku o kvalitetu usitnjenog mesa, poluproizvoda od mesa i proizvoda od mesa (Sl. glasnik RS 50/2019), sadržaj soli u proizvodima od mesa nije definisan, te se prosečne vrednosti NaCl u ovim proizvodima mogu zaključiti komparacijom sa dostupnim eksperimentalnim i literaturnim podacima. Cilj ovog istraživanja je bio da se ispita sadržaj natrijum-hlorida u različitim proizvodima od mesa iz 3 različite proizvodne šarže jednog lokalnog proizvođača. Ukupno je ispitano 42 uzorka, i to: kulen i čajna kobasica (fermentisane kobasice), suva (fino usitnjena barena kobasica), srpska kobasica (grubo usitnjena barena kobasica) i panceta (slanina). Najveći prosečan sadržaj natrijum-hlorida utvrđen je u suvoj pečenici (4.49 g / 100 g) dok je najmanji sadržaj izmeren u viršli (1.88 g/100 g). Upoređivanjem dobijenih vrednosti sadržaja natrijum-hlorida sa vrednostima koje su drugi autori dobili za fermentisane proizvode (kulen i čajna kobasica), ispitivani proizvodi imali su znatno više vrednosti koncentracije soli, dok je najmanji prosečni sadržaj natrijum-hlorida utvrđen u uzorcima dimljene pečenice. Za ostale proizvode sadržaj ispitivanog parametra je bio sličan vrednostima navedenim u literaturi. Nakon izvršenih analiza dostupnih uzoraka utvrđeno je da se proizvođač pridržavao propisanih količina NaCl koji se dodaje, prema recepturi, u svaki od proizvoda, te da nije bilo značajnih odstupanja prilikom pripreme praćenih proizvoda od mesa.

**Ključne reči:** natrijum-hlorid, proizvodi od mesa

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