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Review Paper

Salt reduction in cooked sausages

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A R T I C L E I N F O

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A B S T R A C T

In modern times, the daily intake of sodium chloride is relatively high, especially in industrially developed countries. Increased consumption of sodium chloride can lead to essential hypertension, which is associated with other cardiovascular and renal diseases. Reducing the sodium content in meat products has become an increasingly important trend in contemporary nutrition due to the adverse health effects of excessive salt intake. In the production of cooked sausages, sodium chloride affects both the functional properties of meat products, such as water-binding capacity, and the sensory characteristics of the product, including tenderness, juiciness, and textural attributes. Therefore, one of the main objectives in reducing sodium chloride in such products is to maintain product stability during thermal processing, while preserving a sufficiently salty and desirable taste, as well as the mentioned textural properties.

1. The role of salt in meat products

Sodium chloride is the first known food preservative, especially for meat, and it has remained in use to this day. In addition to its role in food preservation, the desirable salty taste is one of the most important effects that sodium chloride imparts to food (*Multhauf*, 1987). A widely accepted theory is that sodium ions play a primary role in the perception of salty taste, while chloride ions act as modulators (*Bartoshuk*, 1985).

Adding salt to food increases the desire to consume that food to a certain extent. Sodium chloride not only creates a salty taste but also plays other important roles in many types of food. It affects the perception of firmness, enhances sweetness, masks metallic and undesirable flavors, and rounds out the overall taste, contributing to its intensity (*Gillette*, 1985).

The main source of sodium in food products comes from sodium chloride, that is, table salt, and its intake significantly exceeds nutritional recommendations, especially in modern and industrially developed countries. The consumption of table salt is influenced not only by physiological needs (such as in athletes) but also by habits formed early in childhood, as well as by dietary traditions (climate conditions, food preparation, livestock resources, etc.).

At the beginning of the twentieth century, salt consumption reached its peak and continued to grow as industrial food production developed. Salt was once a source of life, but today it has started to pose a high health risk to modern humans. Nowadays, the daily intake of sodium chloride is quite high, especially in developed countries, that is, in populations that primarily consume industrially produced food. Of the total daily salt intake through usual quantities of food (homemade dishes, bread, bakery products,

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cheese), meat products belong to the top five food categories that contribute the most to this intake (*Dunteman et al*., 2022).

Excessive sodium intake is recognized as the leading cause of essential hypertension, which is one of the primary risk factors for the development of cardiovascular and renal diseases (*Diehl and Ludington*, 2007; *He and MacGregor*, 2013; *O'Donnell et al*., 2021; *Xiao et al,* 2022).

Research has shown that high levels of sodium in the diet increase fluid retention in the body, which can put strain on the heart and blood vessels (*MacGregor and Ashby*, 2013). Despite this, salt consumption peaked at the beginning of the twentieth century and continued to rise as industrial food production developed.

Reduction of salt content in meat products can be achieved in several ways:

(1) by reducing the amount of added sodium chloride (*Sofos*, 1983); (2) by replacing part of the sodium chloride with other salts (*Sofos*, 1983; *Terell*, 1983; *Guàrdia et al*., 2006); (3) by using flavor enhancers, and masking agents (*Desmond*, 2006); (4) by combining the aforementioned methods (*Sofos*, 1983; *Terell*, 1983); (5) by adding herbs or spice extracts to meat products (*Lilić and Matekalo-Sverak*, 2007); (6) by optimizing the physical form of the salt (*Angus et al*., 2005) and; (7) by using alternative processing techniques (*Claus and Sørheim*, 2006).

However, reducing sodium in meat products presents a major challenge.

2. Possibility of reducing salt in cooked sausages

According to research conducted in Serbia, the salt content in cooked sausages ranged from 1.28-2.03g/100 g, with a mean of 1.66g/100 g (*Vranić et al*., 2009). Reducing sodium in the most commonly consumed meat products, such as cooked sausages, can contribute to lowering excessive sodium intake (Petit et al., 2019).

In the production of cooked sausages, salt does not play a significant role in preservation due to the temperature regime to which these sausages are subjected (pasteurization). However, sodium chloride affects the functional properties of meat products in terms of water binding, as well as the sensory characteristics of the product, such as tenderness, juiciness, and textural properties. One way to reduce its use is by substituting sodium chloride with other salts, in order to maintain the product's stability during thermal processing, as well as to preserve a sufficiently salty or desirable taste and the aforementioned textural characteristics.

Potassium chloride is most commonly used salt substitute; however, complete replacement of sodium chloride is not possible because, according to many studies, even at 50% substitution, it results in an increased bitter taste and a reduced perception of saltiness. The use of potassium salts is often contested due to the potential sensitivity of certain segments of the population, such as people with type I diabetes, chronic renal insufficiency, those in the final stage of kidney diseases, and individuals with heart and adrenal insufficiency (*FSAI*, 2005). In the guide *Dietary Guidelines for Americans* (2005), it is specified that a diet rich in potassium reduces the effects of salt on blood pressure and recommends a daily potassium intake of 4700 mg. Dietary salts that are a mixture of sodium chloride and potassium chloride, usually with the addition of L-lysine hydrochloride, which masks the bitter taste of the salt and promotes the excretion of sodium from the body, are already available on the market. (*Ruusunen end Poulanne*, 2005).

Phosphates have also proven to be effective in reducing the salt content in meat products, as they act synergistically with sodium chloride. They increase the water-holding capacity (WHC) by increasing ionic strength, where free negatively charged groups allow proteins to bind more water (*Trout and Schmidt*, 1984). However, phosphates are also carriers of sodium. Thus, sodium polyphosphate contains 31.24% sodium compared to 39.34% found in sodium chloride; however, sodium polyphosphate use is limited to about 0.5% in the product.

Ruusunen et al. (2002) determined that it is possible to produce Bologna sausage and cooked ham with a lower salt content (1.0–1.4%) and that it is possible to reduce sodium content by using potassium salts. *Lilić et al.* (2008) established that substitution of sodium chloride with potassium chloride in an amount up to 40% in cooked sausages is possible without a significant impact on taste acceptability. The substitution did not affect the product's appearance, nor the acceptability of color and texture.

One of the possible ways to reduce the salt content in meat products is the use of flavor enhancer and masking agent blends. There are many commercial blends that typically contain yeast extract, lactates, monosodium glutamate, and nucleotides. Flavor enhancers work by activating receptors in the oral cavity, which help compensate for the reduced salt content in the product (*Brandsma,* 2006).

Some authors (*Pasin et al*., 1989) have determined that it is possible to reduce sodium chloride addition by up to 75% in cooked sausages by combining potassium chloride with a ribotide preparation (a commercial mixture of 5′-ribonucleotides IMP and GMP). In such cases, any addition of monosodium glutamate leads to a decrease in product flavor acceptability by up to 50%, due to the enhancement of the bitter taste caused by potassium salts. Linguagen, a U.S. company, has patented a bitter taste blocker, adenosine 5′-monophosphate, which works by blocking the activation of gustducin in taste receptor cells and thus prevents the stimulation of the nerve that innervates the taste receptors (*McGregor*, 2004). This blocker can be used to improve flavor when using combinations of potassium chloride and sodium chloride.

Other combinations, such as lysine and succinic acid, are used as salt substitutes (*Turk*, 1993). These substances have a salty taste and possess some antimicrobial and antioxidant properties, and can be used to replace up to 75% of salt. For technological purposes, particularly water-binding capacity, phosphates, starches, and gums can also be used. The degree of saltiness also depends on the physical form of the salt. Flake salt has proven to be more functional in terms of water-binding capacity, increasing pH, and enhancing protein solubility in emulsion model systems (*Campbell*, 1979). Salt in flake form is better and more quickly soluble than granulated salt, which can be an issue in formulations where water is not used. Therefore, flake salt can be suitable for products that do not involve added water, such as dry-cured meat. Leatherhead Food International has researched the optimization of the physical form of salt and monitored the changes in its physical state, which make it more bioavailable and thus usable in smaller quantities. This includes increasing salt efficiency, altering its structure, and modifying salt perception (*Angus et al*., 2005).

Alternative processing techniques involve the use of pre-rigor meat in the production of meat products or the application of high-pressure technology in manufacturing (*Claus and Sørheim*, 2006). High-power ultrasound (HPU) has the ability to alter protein structure and improve the distribution of ingredients within the meat matrix (*Gomez-Salazar et al*., 2021). It can also be used to reduce sodium content in meat products. The combination of HPU with a low level of potassium chloride (0.5%) can overcome technological issues caused by a 50% reduction of sodium chloride in meat emulsions (*Pinton et al*., 2020). However, these products exhibited a reduced intensity of salty taste.

3. Conclusion

Reducing the salt content in food is becoming an increasingly important trend in modern nutrition due to the negative effects that excessive salt intake can have on human health.

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