

# Inorganic additives in meat production and processing

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**Abstract.** The present research focuses on the different ways that inorganic chemicals can affect processed meat quality and its impact on the final food quality. The processed meat products (ham, bacon, frankfurters, sausages, salami, and so on) are treated with food additives to increase its shelf life and/or taste (curing, smoking, salting, or the application of chemical preservatives and additives). One area of focus is the preservation and extension of shelf life and other area is to identify the effects and benefits. By incorporating natural additives, such as essential oils and plant extracts, through nano systems, antioxidant effects and improved properties have been observed when applied directly to meat or during manufacturing processes. Additionally, the general trend is a decrease in the level of sodium chloride of processed meat products. Many studies have looked into the use of NaCl substitutes to limit the pro-oxidant effects and control microbial development, including Potassium Chloride (KCl), K-lactate, Calcium Chloride (CaCl<sub>2</sub>) and Magnesium Chloride (MgCl<sub>2</sub>) microspheres and it should be governed to minimise and control the use of inorganic substances to reduce impact to the consumers.

## 1 Introduction

There are several ways that inorganic additives can impact the quality of processed meat. One issue is the preservation and expansion of shelf life [1]. Barrier technologies, which combine complementary technologies with the removal or replacement of synthetic chemicals, have been investigated as a means of developing more natural and simpler beef product [2]. However, the sensory quality and potential adverse effects of high potassium intake must be considered [3]. Furthermore, the addition of colour and flavour, slowing lipid oxidation, and inhibiting microbial development can be achieved by using inorganic additions such as sodium nitrite (NaNO<sub>2</sub>) in meat products.

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## 2 Methods

In order to examine the inorganic food additives in the manufacture of meat, the data gathered through extensive database searches. The thirty three English-language research and publications published between 2019 and 2024 were used and observed for this review work. Keywords like "meat quality," "alternatives additives," and "inorganic additives" were used to search research publications. Publications regarding possible substitutes for inorganic compounds and their effects were observed.

## 3 Results and Discussions

### 3.1 Inorganic chemical additives in meat

#### 3.1.1 Phosphates

Phosphates additives are widely applied in food processing companies to enhance product quality and water holding capacity. In addition, the use of such additive's conflicts with consumer preferences [4]. The impact of phosphate substitutes on processed meats' texture and juiciness has been the subject of numerous studies. Bovine skin gelatine hydrolysates have been found to improve the firmness of heat-treated chicken, achieving a similar firmness and color difference to sodium tripolyphosphate, a commercial phosphate additive [5]. Freeze-dried vegetables such as Brussels sprouts and Red Kuri squash have also been shown to effectively replace phosphates in sausage meat, resulting in similar weight gain, stress, and tenderness [6]. A 2% chia mucilage gel was found to be a feasible strategy to replace 50% phosphate in low-fat bologna sausages, resulting in less tough and chewy sausages [7]. It has been shown that adding liquid ingredients such as emulsion and lecithin—which are not sourced from animals—can alter the texture and sensory qualities of meat substitutes [8].

#### 3.1.2 Salt (*Sodium Chloride*)

Excessive quantities of sodium chloride can result in excessive salt content in the finished goods, which can impact proteolysis and endogenous protease activity [9]. The meat enterprise has a problem lowering salt chloride concentration without compromising quality or safety. As part of a natural protease-mediated treatment, the technology of salt substitution reduces the sodium concentration without damaging product quality [10]. A mixture of potassium salts and high-pressure processing (HPP) developed the texture of chicken sausages while reducing the sodium level. It suggests a possible means of lowering sodium chloride levels without compromising the desired textural qualities for consumers [11]. Although methods involving salt replacement and HPP could reduce these effects, sodium chloride may still have an overall effect on the texture and juiciness of meat products [12-13].

#### 3.1.3 *Sodium Tripolyphosphate (STPP)*

Sodium tripolyphosphate (STPP) is added to the chicken batter to improve texture properties and enhance cooking yield [10]. There is no significant correlation between cooked sausages' sensory attributes and the reduction of the STPP additive level [6]. However, because consumers are becoming more and more interested in clean products,

there has been discussion about the usage of STPP as a phosphate ingredient in processed meat products. Possible replacement of STPP in processed meat with new additives and processing methods such as high-pressure processing [11, 14].

#### **3.1.4 Potassium Chloride**

Potassium chloride (KCl) does not negatively affect the texture of processed meat [10]. High-pressure processing (HPP) in combination with K-salts, including KCl, can enhance the textural attributes of reduced-sodium chicken sausages [13]. However, HPP treatment in combination with K-lactate or K-citrate reduced the perceived saltiness of sausages [15]. Reduction of NaCl content in beef burgers, achieved by the addition of 1.0% micronized salt (which includes KCl), did not significantly affect texture parameters, dynamic sensory profile, or overall product palatability [16]. The use of KCl together with other K-salts as a partial substitute for NaCl in dry-cured meat products can affect the physicochemical properties, proteolysis, and sensory evaluation [9].

#### **3.1.5 Nitrites and Nitrates**

Low concentrations of sodium nitrite can prevent myofibrillar protein change, improve texture, and limit the exposure of hydrophobic groups [17-18]. In contrast, the synthesis of nitrosamines is correlated with the addition of extra salts such as nitrites and nitrates, which may affect the quality of meat products [18]. Although polysaccharides have been observed to enhance the texture, oxidative stability, and sensory features of meat products, scientists have investigated using them as organic alternatives to solve this problem [19]. Lipid oxidation in dry-cured fermented sausages is limited without producing non-volatile nitrosamines when reducing the amount of sodium nitrite and sodium nitrate in processed meat products [20]. Nitrites and nitrates influence processed meat texture and juiciness in positive and negative ways [11, 21].

#### **3.1.6 Inorganic Minerals additives**

Minerals such as iron, zinc, calcium, and magnesium influence the texture and juiciness of processed meat [22]. The content and bioavailability of these minerals in processed pork and beef products can vary between brands and batches [23]. Many in vitro digestion tests were applied to evaluate the bioavailability of these minerals, with the dialysis test showing the lowest bioavailability percentages compared to other methods [24]. Contamination of toxic heavy metals such as cadmium and chromium in ground pork can accelerate discoloration, lipid oxidation, and carbonyl formation, affecting overall meat quality [25]. Protein oxidation that occurs during storage and processing can also affect the texture and water-holding capacity of the meat [26]. Plant-based meat products that are developed as an alternative to traditional animal meat also require attention to texture quality, with various ingredients and processing methods affecting the texture of these products.

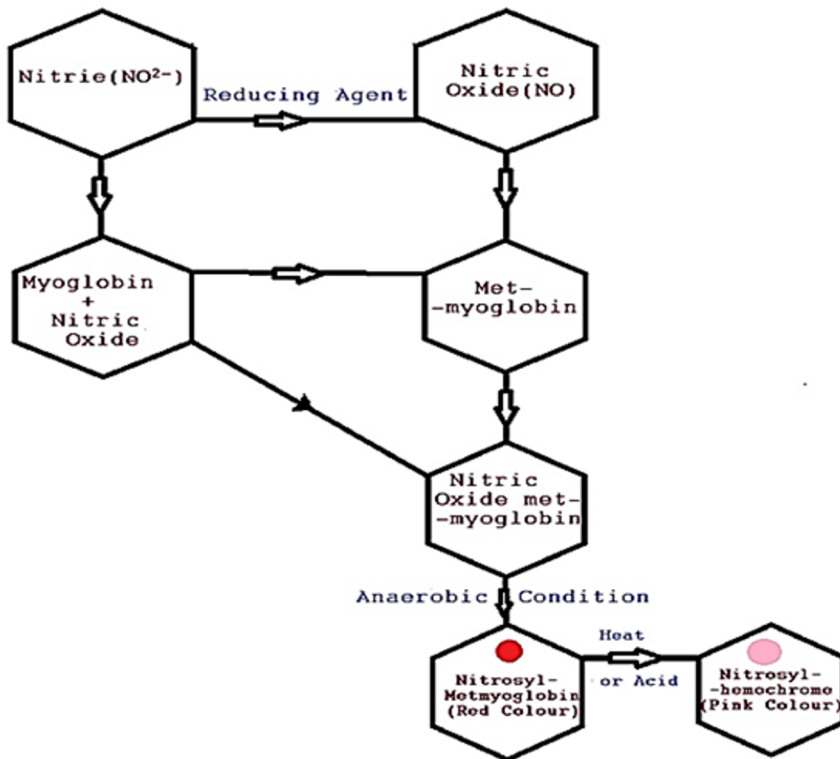
#### **3.1.7 Preservative agents in meat products**

Inorganic additives, such as preservatives in processed meat and meat products, can have different effects. Some chemicals, including sulfites, provide antioxidant, color-stabilizing, antibacterial, and anti-browning qualities; consuming them has been linked to undesirable consequences and dysbiosis events in the oral and gut microbiota.<sup>3</sup> However, compared to nisin treatment, the use of potassium sorbate as a preservative results in more lipid losses,

suggesting potential adverse effects on meat quality [17, 27]. It is important that regulations govern the use of additives in meat products, and proper usage and residual limitations need to be observed to guarantee food safety [28]. Researchers and industry are also investigating alternatives to synthetic additives and are focusing on developing more natural and simpler meat products with an extended shelf life [29].

### 3.1.8 Color Stability

Sulfites, nitrites, and Ca salts are examples of inorganic additives that have different impacts on the color stability of processed meat and meat products. Sulfites, which are commonly used as food additives and may stabilize color, can be beneficial for meat products [29]. The impact of nitrites and nitrates are shown in Figure 1.



**Fig.1.** Impact of nitrate and nitrite additives on processed meat colour.

Meat is provided a reddish-pink color by nitrites, especially sodium nitrite, which also reduces the oxidation of fats. However, whether nitrite intake is excessive or not, nitrosamines, which cause cancer, can be produced [3]. Increased concentrations of calcium salts, including calcium lactate and chloride, can affect color stability and result in deteriorating color features in cured meat sausages [2, 17, 24].

**Table 1.** The application of inorganic additives, purpose.

<b>Chemical additive</b>	<b>Purpose of addition</b>
Phosphates	<ol style="list-style-type: none"> <li>1. Increase water holding capacity [5]</li> <li>2. Enhance the juiciness and the texture of meat [6]</li> <li>3. Improve the firmness of heat-treated chicken [7]</li> </ol>
Salt (sodium chloride)	<ol style="list-style-type: none"> <li>1. Impact proteolysis and endogenous protease activity</li> <li>2. Effect on the juiciness and texture of processed meat products [6]</li> </ol>
(STPP) - Sodium tripolyphosphate	<ol style="list-style-type: none"> <li>1. To improve texture properties and enhance cooking yield [10]</li> <li>2. Help processed meats have a better texture and juiciness [14]</li> </ol>
Nitrites and nitrates.	<ol style="list-style-type: none"> <li>1. Prevent myofibrillar protein change, improve texture, and limit the exposure of hydrophobic groups [17-18]</li> <li>2. Enhance the texture, oxidative stability, and sensory features of meat products [18]</li> <li>3. Limited without producing non-volatile nitrosamines</li> <li>4. Influence processed meat texture and juiciness in positive and negative ways [21]</li> <li>5. Low-dose sodium nitrite can enhance the quality of salted meat and prevent protein oxidation during the curing process [18].</li> </ol>
Inorganic minerals additives	<ol style="list-style-type: none"> <li>1. Influence the texture and juiciness of processed meat [22]</li> </ol>
Potassium sorbate	<ol style="list-style-type: none"> <li>1. Antimicrobial activity [3]</li> </ol>
Sulfites	<ol style="list-style-type: none"> <li>1. Provide antioxidant, color-stabilizing, antibacterial, and anti-browning qualities</li> </ol>

These inorganic additives facilitate the retention of acceptable color in processed meat and meat products; their application needs to be regulated to ensure food safety and minimize any potential risks.

### 3.1.9 Flavor Enhancement additives in meat

Processed meat and meat products have been the subject of studies on flavor enhancers in inorganic food additives. The goal of research has been to find and isolate naturally occurring taste enhancers from plants, fungi, and dairy products that include components of umami and kokumi [3]. High concentrations of taste and flavor enhancers may be obtained from these natural sources, and they can be further enhanced by heating or by enzymes treating the basic ingredients [29]. It is necessary to identify and isolate this taste and flavor enhancers before using them, and adding them to meat products can aid in the production of clean-label, more natural beef products [2,30]. Roasting beef meat revealed that marinades and seasoning formulas made using traditional spices and condiments enhance the meat's fragrance profile [31]. The above research outcomes are utilized as a specification for marinated meat production.

### 3.1.10 Nutritional Enriching agents in meat

According to the nutritional deficiency in iron and zinc in society, meat products are enriched with these minerals [32]. The meat processing industry's research aims to remove hazardous components and fortify deficient nutrients without reducing processed meat quality. To fulfill the above requirement, the meat processing industry utilizes advanced processing technologies and natural plant extraction additives [27]. Additionally, attempts are being made to use natural additives in meat products in order to lessen the number of chemical additives that are used. Natural substances, such as important oils and plant extracts, in meat products as a less expensive and sustainable method to increase their shelf life [33]. These techniques aim to prolong the shelf life of meat products and ensure food safety using the least number of artificial additives [3, 34-35].

## 4 Conclusion

Inorganic additives impact the texture, juiciness, colour, taste, and preservation of processed meat products. Preserving meat quality that the meat processing sector trend in research and development to lowering risk. Ensuring taste and food safety requires plant-based additives and innovative processing technologies utilized to enhance shelf life and clearer labelling. Regulation and control of inorganic additives are mandatory as complex chemical changes occur during fermentation, curing, and the cooking of processed meat. Certain additives, such as nitrites and phosphates, have a high risk, and current research is conducted on plant extracts and natural additive replacement. Due to consumer perception, natural food and cleaner labelling targets the application of inorganic additives and natural alternative combination methods to preserve meat quality. This approach aims to retain customers who are more concerned with their wellbeing.

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