Impact of incorporating inorganic additives in processed meat production

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Abstract. This study explores the complex effects of inorganic chemicals on the quality of meat and the health of consumers at different stages of processing. It is determined that nitrites, phosphates, potassium sorbate, sodium chloride, antioxidants, and monosodium glutamate (MSG) contribute to improving meat products' sensory qualities, shelf life, and oxidative stability. On the other hand, health problems related to their consumption, including metabolic disorders and carcinogenicity, are a cause for concern. The clean-label effort has impacted consumer opinions, which in turn have created demand for natural and additive-free meat. As inorganic compounds are essential to the processing of meat, initiatives are being made to develop solutions that will satisfy customer preferences. The study underlines the need for more research into the complex relationships between chemicals and meat quality, enabling the manufacture of meat products that are healthy, secure, and attractive in accordance with changing customer preferences and health considerations.

1 Introduction

Nitrites and nitrates are often applicable chemical additives in processed meat products, and these additives have a chemical impact on both the quality of meat products and health concerns. Chemical preservatives in meat products, such as nitrites, have a high potential to produce carcinogenic N-nitrosamines [1]. Therefore, meat industry observers should obtain alternative methods to minimize or eliminate the application of nitrites without affecting sensory and nutritive content [2]. Different kinds of meat production technologies, such as thermal processing, microwave, irradiation, and multitarget preservation technology, can decrease nitrite usage and improve the shelf life of processed meat [3]. Utilization of synthetic nitrates and nitrates with natural additives such as ascorbate and polyphenols illustrate enhancing “clean label” meat products having minimum changes in the nutritional level of the products [4].

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Different cooking treatments and methods alternate the degree of residual nitrites and nitrates in processed meat [5].

2 Methodology

For the purpose of analysing the impact of inorganic additives in meat production, the information collected by searching major databases. For this review paper utilized and observed from sixty-three English-language research and papers published during 2019 and 2023. Research papers were browsed using the following keywords such as “inorganic additives”, “meat quality”, “impact” and “alternatives additives”. However, there were also publications about the potential alternatives to inorganic chemicals and their impact on human health. Reviews that focused on the detrimental effects of inorganic additions on animals’ health or the health of other species were not included. For the purpose of creating this review article, reliable and accurate data from particular research about the effects of inorganic chemicals on meat products, their effects on human health, and their alternatives were retrieved.

3 Results and Discussion

3.1 Impact of inorganic chemical additives in meat products

3.1.1 Nitrates and Nitrites Effect

Carcinogens included in processed meat, such as N-nitroso compounds made from sodium nitrite, enhance the risk of cancer of the intestines [6]. Low-dose sodium nitrite can enhance the quality of salted meat and prevent protein oxidation during the curing process [7]. The impact of nitrites and nitrates additive in meat product is shown in Figure 1.

![Fig. 1. Impact of Nitrate and Nitrite Additives on Meat Quality and Human Health.](image-url)
Nitrites and nitrates can influence an increase in metabolic disorders and create pro-
carcinogenic secondary N-nitrosamines when they are introduced to the meat processing
process [8]. The majority of nitrates and nitrites that are consumed come from natural fruits
and vegetables rather than food additives [9-10].

3.1.2 Phosphates Effect

Meat phosphorus levels may be harmful to one's health. Phosphates in processed meat
products might be hard to get rid of without affecting the quality of the product [6]. The
product has phosphates added to it. Phosphorus is necessary for all species and is absorbed
and excreted by the kidneys [11]. A higher risk of prostate cancer is caused by consuming
an excessive amount of processed meat, which is rich in phosphates [5]. Processed meat
enriched with sodium nitrite additives facilitates the increase of carcinogenic compounds
and colon cancer formation in the body [11]. Phosphates in processed meat products and
human health effect analysis depend on many factors, such as individual salt consumption,
genetic composition, and dietary habits; therefore, more epidemiological examination is
essential [12].

3.1.3 Sodium Chloride Effect

Sodium chloride is vital in meat products for developing meat quality and sensory attributes
[13]. On the contrary, hypertension and cardiovascular disease are correlated with excess
sodium chloride intake and health problems that lead to reduced processed meat
consumption in society [14]. However, modern meat processing methods minimize
potential health risks [15]. In addition, research on the health benefits of sodium nitrite
originating from sodium chloride in processed meats is continuing. It leads to a positive
impact on reproduction and cardiovascular well-being [6].

3.1.4 Potassium Sorbate Effect

Compared to nisin-like preservatives, potassium sorbate consumption in processed meat
facilitates significant fat reduction and dramatic alteration in the meat lipid profile, which
affects 106 lipids in 12 various groups [6]. These changes can affect the nutritional value
and shelf life of meat [16]. Nisin was found to be a superior preservative for increasing
meat shelf life and nutrient loss [7]. Therefore, the potential health effects of consumption
of meat containing potassium sorbate should be monitored by fat content, vitamin content,
and the benefits of alternative medicine replacement [17]. The impact of inorganic
additives, purpose and the health concerns are given in Table 01.

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Health problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphates</td>
<td>1. Increase of carcinogenic compounds and colon cancer formation in the body [11]</td>
</tr>
<tr>
<td></td>
<td>2. Individual salt consumption, genetic composition, and dietary habits; therefore, more epidemiological examination is essential [12]</td>
</tr>
<tr>
<td>Salt (sodium chloride)</td>
<td>1. Hypertension and cardiovascular disease are correlated with excess sodium chloride intake and health problems that lead to reduced processed meat consumption in society [14].</td>
</tr>
<tr>
<td>Sodium tripolyphosphate (stpp)</td>
<td>1. Rancidity in meat products causes health hazard in cells due to the rancid chemical accumulations [10]</td>
</tr>
<tr>
<td>Nitrites and nitrates</td>
<td>1. Carcinogens included in processed meat, such as n-nitroso compounds made from sodium nitrite</td>
</tr>
<tr>
<td></td>
<td>2. Enhance the risk of cancer of the intestines [6]</td>
</tr>
</tbody>
</table>
3. Nitrates and nitrites can influence an increase in metabolic disorders and create pro-carcinogenic secondary n-nitrosamines when they are introduced to the meat processing process [8].

<table>
<thead>
<tr>
<th>Inorganic minerals additives</th>
<th>1. 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 leads to health issues in human [15].</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium sorbate</td>
<td>1. More lipid losses suggest potential adverse effects on meat quality leads health problem [27]. 2. Significant fat reduction and dramatic alteration in the meat lipid profile, which affects 106 lipids in 12 various groups [34].</td>
</tr>
<tr>
<td>Sulfites</td>
<td>1. Consuming them has been linked to undesirable consequences and dysbiosis events in the oral and gut microbiota [5, 35].</td>
</tr>
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</table>

### 3.1.5 Antioxidants (BHA, BHT) Effect

Meat is rich in two types of antioxidants, BHA and BHT, which have been linked to adverse health effects. Although antibiotics are used in the food trade, questions have been raised about the long-term health effects resulting from their use [18]. The impact of antioxidant addition on meat quality is show in Figure 2.

[Fig. 2. Impact of Antioxidant (BHA, BHT) Additives on Meat Quality and Human Health [46].](image)

Scholars have explored the feasibility of using antibiotics against pathogens in animal products to replace those naturally derived from plants. Meat oxidative processes were effectively inhibited by natural antioxidants such as rutin, α-tocopherol, and ferulic acid, and their quality was preserved [19]. Seed antioxidants added to meat ingredients prevent oxidative reactions and improve the quality of the ingredients [20]. In addition to providing health advantages, natural antioxidants have the potential to displace synthetic antioxidants [21]. Nevertheless, research continues to determine the usefulness, efficacy, and possible health advantages of antioxidants available in the meat systems, and the industry's widespread abuse of these resources have not yet been thoroughly established [22].

### 3.1.6 Monosodium Glutamate (MSG) Effect

Consuming monosodium glutamate (MSG) additives in meat does not have significant negative health effects. Preclinical studies have connected MSG administration to several negative results, such as low-grade inflammation, hepatotoxicity, neurotoxicity, metabolic...
disturbance, and cardiovascular damage [23-24]. The impacts of MSG Additives are shown in Figure 3.

Fig. 3. Impact of Monosodium Glutamate (MSG) Additives on Meat Quality and Human Health [24].

There is no conclusive evidence to suggest that consuming MSG additives in meat has significant negative health effects [25-26].

3.1.7 Consumer Perception

Numerous factors affect how consumers perceive inorganic additions in meat products. Consumer perceptions are also shaped by the demand for additive-free and natural food products, as part of the clean-label movement [27]. Aspects including the method of production and processing, nutritional value, sensory appeal, and moral, social, or religious implications all have an impact on consumers' views of healthier meat products [28]. The desire for food that has fewer or no artificial additives has prompted efforts to create substitutes for these substances in meat products [29]. Research and business efforts are concentrated on creating simpler, more natural beef products that are recognizable to customers and are thought to have clean labelling [30].

3.2 Quality changes in meat during processing

The present investigation focused on the effect of inorganic additives on the meat quality throughout various stages of processing, which encompass fermentation, curing, and frying. The addition of meat fats and proteins and other interactions have a profound effect on the final product. The trend is to conduct experiments to improve the ingredients and their influence on consumers and the meat industry [29].

3.2.1 Inorganic additives influence meat quality during Curing

Inorganic additives, including nitrite and calcium salts, have been used to evaluate the quality of meat throughout the curing process. Commonly added to cured pork, nitrite decreases lipid oxidation and increases heme iron nitrosylation and S-nitrosation [31]. It is now well known that during sausage processing and storage, calcium salts, such as calcium lactate (CaLac) and calcium chloride (CaCl₂), promote pH reduction, loss of cooking, and oxidation of fats [8, 33] if they affect the product, besides inappropriate texture and colour.
It has been demonstrated that substituting metal ions for sodium in CaCl$_2$ and MgCl$_2$ can increase the activity of cathepsin and proteolysis in dry-cured pork, improve dehydration, and accelerate pH lowering [16]. The results above indicate that inorganic additives may affect meat quality during curing in both favourable and unfavourable ways, depending on their specific qualities and amounts.

3.2.2 Inorganic additives influence meat quality during Fermentation

It has been shown that inorganic additions, such as salt replacements, affect the chemical processes and meat quality during processing. Partial substitution of NaCl for sodium can lead to more oxidation of fats and proteins in dried sausages. This is due to the low NaCl content of the sausage, which prevents oxidation. Also, salt substitution promotes the oxidation and esterification of β-lipids and the synthesis of volatile compounds from the metabolism of carbohydrates and amino acids; all of these processes contribute to sausage flavour seduction. Research has shown these additives are important for perception; the latter fractions decreased the NaCl concentration [34].

3.2.3 Inorganic additives influence meat quality during cooking

More specifically, when mixed with sulfites—which are frequently added to food products—a mixing of the organic and inorganic components of meat may change the meat's colour, antioxidant content, and antibacterial capabilities [29]. Cooking itself can cause antibiotic substances such as sulfamethoxazole to degrade thermally, which leaves cooked meat significantly depleted of these compounds [34].

4 Conclusion

The effect of inorganic meat additives on consumer health and meat quality is complicated. Inorganic chemical additives enhance product attributes such as texture, colour, and shelf life; however, exceeding the recommended standard for those additives leads to potential health hazards. In particular, carcinogenic and metabolic disorders are key health issues regarding inorganic meat additives. As a result, meat producers and consumers are concerned about cleaner labels and natural products, which encourages the sector to utilize alternative processing methods and additives. There is much investigation required to identify the co-relationship between food safety, nutrition value, and consumer acceptability between meat quality and inorganic additives during different meat processing stages and finished product storage.

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