

## Research Article

# Investigation and Analysis of Nitrite Levels in Pickled Vegetables and Meat Products Sold in Futian District Shenzhen

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## Abstract

**Objective:** This study aimed to investigate the current nitrite levels in pickled vegetables and meat products sold in Futian District, Shenzhen, to provide data for food safety risk assessment and regulatory measures. Nitrites, known to form in pickled foods due to degradation and pickling processes, have raised public health concerns due to their potential health risks, including the formation of carcinogenic nitrosamines. Understanding the nitrite levels in these products is crucial for ensuring consumer safety. **Methods:** Random sampling of pickled vegetables and meat products was conducted in local markets and supermarkets in the district. Nitrite levels were measured using the hydrochloric acid naphthylethylenediamine method according to GB/T 5009.33—2016. The results were evaluated based on GB2760-2014 "National Food Safety Standard for Food Additive Use" and GB2762—2017 "National Food Safety Standard for Contaminant Limits in Food." **Results:** From 2022 to 2023, a total of 88 samples were collected. The detection rates were 85.29% for pickled vegetables and 100% for meat products. No samples exceeded the maximum allowable limits. Nitrite levels in meat products were generally higher than in vegetables, and samples from local markets had higher nitrite levels than those from supermarkets. **Conclusion:** The nitrite levels in pickled vegetables and meat products sold in Futian District are generally low, with no samples exceeding safety standards. However, the high detection rate, especially in unpackaged products, indicates potential exposure risks. Consumers are advised to limit the consumption of high-nitrite pickled foods.

## Keywords

Pickled Vegetables, Pickled Meat Products, Nitrite, Detection Rate

## 1. Introduction

Pickled foods, favored for their extended shelf life and distinctive flavors, are known to contain higher nitrite levels than regular foods. As public awareness of food safety increases with improved living standards, the presence of nitrites in food has gained more attention. Nitrites can form in vegetables as they degrade and during the pickling process of

fresh vegetables, resulting in increased nitrite levels [1, 3]. In meat products, nitrites are often used as additives for their preservative and coloring properties [4, 5]. However, nitrites are oxidizing agents that can convert hemoglobin to methemoglobin, impairing its oxygen-carrying capacity, and may cause vasodilation, leading to symptoms such as tissue hy-

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poxia, cyanosis, tachycardia, respiratory distress, nausea, vomiting, abdominal pain, and diarrhea. Nitrites can also react with secondary amines in food or the stomach to form potent carcinogens, such as nitrosamines [6-8], which have been linked to cancers of the esophagus, stomach, liver, and colon [9]. Chronic consumption of high-nitrite foods poses serious health risks. Given the absence of effective methods to reduce nitrite content in foods, a thorough investigation of nitrite levels in pickled vegetables and meat products sold in local markets is essential to enhance public health and food safety.

## 2. Materials and Methods

### 2.1. Sample Collection

Random sampling was conducted in markets and supermarkets in Futian District, Shenzhen, targeting pickled vegetables (leafy greens, root vegetables, and others) and meat products (ham, sausage, bacon, etc.). Samples were categorized into packaged and unpackaged groups; packaged products were further divided based on the purchase location (market or supermarket). In total, 22 brands of packaged pickled vegetables (11 from markets and 11 from supermarkets), 19 brands of unpackaged pickled vegetables, 70 brands of packaged sausages and bacon (25 from markets and 45 from supermarkets), and 23 brands of unpackaged sausages and bacon were collected.

### 2.2. Detection Method

Nitrite levels were measured using the hydrochloric acid naphthylethylenediamine method as described in the "National Food Safety Standard for Determination of Nitrites and Nitrates in Foods" (GB/T5009.33—2016) [10]. The edible portions of the samples were finely chopped, ground, and measured. Each sample was tested three times, and the average value was recorded. The detection limit of the method was 1 mg/kg [11, 12].

### 2.3. Evaluation Criteria

According to GB2760-2014 "National Food Safety Standard for Food Additive Use," nitrite levels  $\geq 30$  mg/kg are considered excessive [13]. GB2762-2017 "National Food Safety Standard for Contaminant Limits in Food" stipulates that nitrite levels above 20 mg/kg in pickled vegetables are also considered excessive.

### 2.4. Observed Indicators

Nitrite levels were compared between packaged and unpackaged pickled vegetables and sausage/bacon products, as well as between products purchased from markets and supermarkets.

### 2.5. Statistical Methods

Data were double-entered using Excel and analyzed with SPSS 20.0. The Shapiro-Wilk test was used to determine normal distribution, and the Levene's test assessed homogeneity of variance. Quantitative data were expressed as mean  $\pm$  standard deviation ( $\bar{x} \pm s$ ), and t-tests were conducted for group comparisons. A P-value  $< 0.05$  was considered statistically significant.

## 3. Results

### 3.1. Nitrite Detection Results

Among the 88 samples, the overall detection rate was 94.00%. The detection rates for packaged sausages/bacon and unpackaged bacon were both 100.00%, for packaged pickled vegetables 89.00%, and for unpackaged pickled vegetables 84.00%. The highest detected value was 8.70 mg/kg (unpackaged bacon) (Table 1).

**Table 1.** Nitrite Detection in Various Food Categories.

Sample Type	Number (n)	Detection Range (mg/kg)	Median (P25, P75) (mg/kg)	Detection Rate (%)
Packaged Pickled Vegetables	19	0-3.45	0.74 (0.50, 1.45)	89.00
Unpackaged Pickled Vegetables	19	0-0.74	0.35 (0.12, 0.57)	84.00
Packaged Sausage/Bacon	36	1.23-8.26	3.13 (2.11, 4.32)	100.00
Unpackaged Bacon	14	2.66-8.70	4.28 (3.28, 6.79)	100.00
Total	88	0-8.70	2.06 (0.59, 3.57)	94.00

### 3.2. Comparison of Nitrite Content

Unpackaged pickled vegetables had lower nitrite levels compared to packaged ones ( $t=3.65$ ,  $P<0.05$ ) (Figure 1). Market-purchased samples showed significantly higher nitrite levels than supermarket-purchased samples ( $t=2.28$ ,  $P<0.05$ ) (Figure 2).

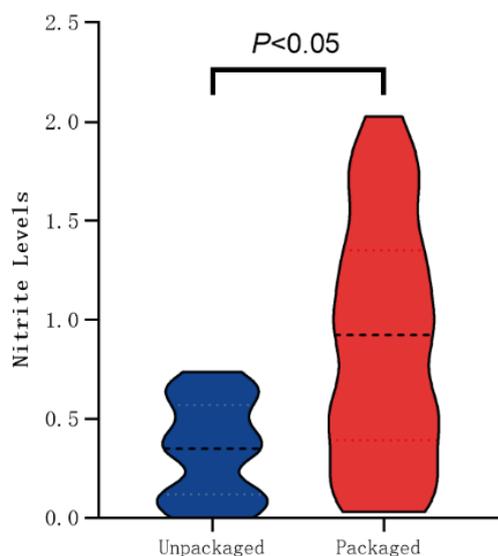


Figure 1. Differences in Nitrite Content between Unpackaged and Packaged Pickled Vegetables.

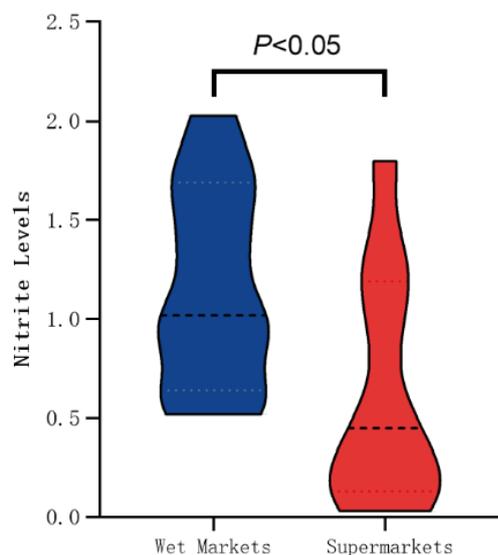


Figure 2. Differences in Nitrite Content in Pickled Vegetables from Wet Markets and Supermarkets.

### 3.3. Nitrite Levels in Sausages and Bacon

Nitrite levels in unpackaged sausage and bacon products were higher than in packaged ones ( $t=4.73$ ,  $P<0.05$ ) (Figure 3). Market-purchased products also showed higher nitrite levels than those from supermarkets ( $t=2.08$ ,  $P<0.05$ ) (Figure 4).

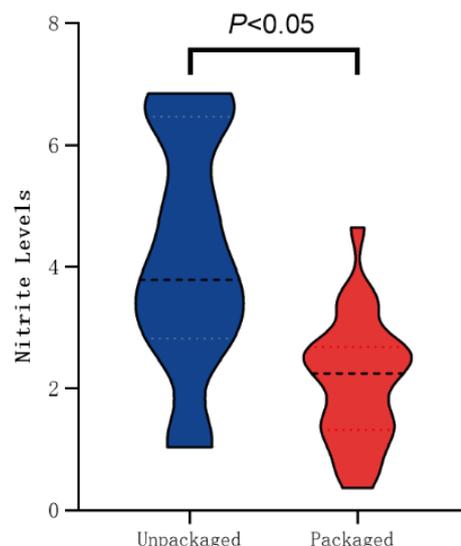


Figure 3. Differences in Nitrite Content between Unpackaged and Packaged Sausages and Bacon.

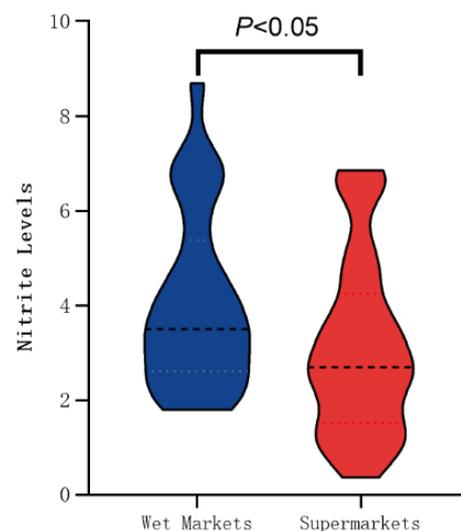


Figure 4. Differences in Nitrite Content in Sausages and Bacon from Wet Markets and Supermarkets.

## 4. Discussion

From 2022 to 2023, no nitrite levels exceeding the standard were detected in commercially available pickled products in Futian District; however, the detection rate was relatively high, with a detection rate of 85.29% in pickled vegetables and 100% in pickled meat products. Particularly, the overall nitrite levels in bulk-cured meat products were higher than those in sausage and pickled vegetable categories, indicating a higher risk. This detection rate is even higher than the 89.99% nitrite detection rate in meat samples reported by Yu Gentao et al. from 2012 to 2019 [14-16]. The World Health Organization has set the acceptable daily intake of nitrites at  $\leq 0.2$  mg/kg, and long-term consumption of foods with high nitrite content can increase the risk of cancer [17]. Therefore, citizens who

favor pickled foods should reduce or avoid consuming pickled products with high nitrite content.

Overall nitrite levels in pickled vegetables were low, with lower levels in unpackaged products compared to packaged ones ( $t=3.65$ ,  $P<0.05$ ). Market-purchased vegetables had higher levels than those from supermarkets ( $t=2.28$ ,  $P<0.05$ ), likely due to differences in production processes, vegetable types, and storage conditions. Leafy vegetables tend to have higher nitrite levels than root vegetables. Nitrites can oxidize to nitrates during storage, but in anaerobic conditions, such as in packaged products, nitrites remain relatively stable, leading to higher levels. Additionally, market products often come from diverse sources, including small workshops and individual vendors, compared to supermarkets, which primarily source from industrial food factories with better quality control.

Sausages and bacon were primarily sourced from different types of producers. Packaged products generally came from larger food factories or brands, while unpackaged products were often from smaller factories or individual vendors. This discrepancy in nitrite levels ( $t=4.73$ ,  $P<0.05$  for packaging;  $t=2.08$ ,  $P<0.05$  for purchase location) could be attributed to varying standards in production practices and storage conditions, with small vendors likely having limited storage capabilities, potentially increasing bacterial growth and nitrite formation [18-20].

This study did not include samples from small workshops or mobile vendors in urban villages, nor from unlicensed vendors, possibly explaining the absence of samples exceeding nitrite limits. Further comprehensive surveys are needed to fully assess nitrite levels in all commercially available pickled foods.

## 5. Conclusion

The study findings indicate that while nitrite levels in pickled vegetables and meat products sold in Futian District, Shenzhen, are within the safety standards, the high detection rates, particularly in unpackaged products, suggest a need for vigilance. The study underscores the importance of monitoring nitrite levels in food products to mitigate potential health risks associated with long-term consumption. It is recommended that consumers be cautious about their intake of pickled foods with high nitrite content and that regulatory bodies continue to enforce strict standards to ensure food safety.

## Abbreviations

P25 25th Percentile  
P75 75th Percentile

## Author Contributions

**Shengbo Zeng:** Conceptualization, Data curation, Funding acquisition, Writing – review & editing

**Ke Li:** Data curation, Formal Analysis

**Quan Wen:** Software, Writing – original draft, Writing – review & editing

**Chen Tang:** Investigation, Software, Validation, Visualization, Writing – review & editing

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## Conflict of Interest

The authors declare no conflict of interest.

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