Journal of Nutrition and Food Security
Shahid Sadoughi University of Medical Sciences
School of Public Health
Department of Nutrition

Shahid Sadoughi University of Medical Sciences School of Public Health

eISSN: 2476-7425 pISSN: 2476-7417 JNFS 2025; 10(4): 492-502 Website: jnfs.ssu.ac.ir

# Sodium Content in Biryani and Grilled Lungs as Traditional Food in Isfahan, Iran: Monte Carlo Simulation-Based Risk Assessment Study

**Zahra Abbasi; MSc [1,2], Zahra Esfandiari; PhD [1,2]*, Yadolah Fakhri; PhD [3], Marjan Mansourian; PhD [4,5], Farzaneh Vaseghi Baba; PhD [6], Zeinab Mokhtari; PhD [1]& Mansour Siavash; PhD [7]**

*[1] Nutrition and Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran; [2] Department of Food Science and Technology, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran; [3] Food Health Research Center, Hormozgan University of Medical Sciences, Bandar Abbas, Iran; [4] Pediatric Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran; [5] Department of Epidemiology and Biostatistics, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran; [6] Department of Food Hygiene and Quality Control, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran; [7] Isfahan Endocrine and Metabolism Research Center, Isfahan University of Medical Sciences, Isfahan, Iran*

***ARTICLE INFO***

***ORIGINAL ARTICLE***

***Article history:***
Received: 5 Mar 2025
Revised: 22 Jun 2025
Accepted: 21 Jul 2025

***Corresponding author:***
zesfandiary24@yahoo.com
Department of Food Science and Technology, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran.

***Postal code:*** 81746-73461
***Tel:*** +98 3137923155

***Keywords*:**
*Sodium; Salt; Traditional food; Biryani; Grilled lungs; Isfahan; Iran.*

***ABSTRACT***

**Background**: High sodium intake is linked to increased blood pressure and a higher risk of cardiovascular diseases. The purpose of this study was to investigate the sodium content in Biryani and grilled lungs as the traditional food in Isfahan, Iran. **Methods:** The sodium content in 25 samples of these dishes was analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES), with results converted to salt equivalents using a 2.5 multiplication factor. Additionally, a Monte Carlo Simulation using the Target Hazard Quotient (THQ) method was employed to evaluate the non-carcinogenic health risks associated with sodium intake from Biryani and grilled lungs. **Results**: The mean concentrations of sodium in Biryani and grilled lung samples were 347.4±170.7 and 377.4±287.1 mg/100 g, respectively. The study's findings revealed that children who consume Biryani may be at risk of non-carcinogenic health effects due to excessive sodium exposure (THQ>1), whereas adults are not. **Conclusions**: Totally, these traditional dishes can be prepared with lower sodium content based on the variable levels of sodium.

## Introduction

Consuming excessive amounts of sodium, a vital mineral, has been associated with several health problems, most notably hypertension or high blood pressure (Cook *et al.*, 2020, Israr *et al.*, 2016, Malczyk *et al.*, 2024). Sodium is introduced as the primary risk factor of diseases such as

***This paper should be cited as:*** Abbasi Z, Esfandiari Z, Fakhri Y, Mansourian M, Vaseghi Baba F, Mokhtari Z, et al. ***Sodium Content in Biryani and Grilled Lungs as Traditional Food in Isfahan, Iran: Monte Carlo Simulation-Based Risk Assessment Study.*** *Journal of Nutrition and Food Security (JNFS)*, 2025; 10(4): 492-502.



[ DOI: 10.18502/jnfs.v10i4.20004 ]

hypertension and cardiovascular diseases. Therefore, lowering sodium consumption is one of the top priorities aimed at preventing such non-communicable diseases in global and national initiatives (Esfandiari *et al.*, 2019). Changes in eating patterns, marked by reduced consumption of fruits and vegetables and increased consumption of meat and processed foods, have resulted in excessive salt intake among different population groups (Esfandiari *et al.*, 2019, Esfandiari *et al.*, 2021). Salt, also known as sodium chloride, serves as a flavor enhancer and plays a significant role in determining the palatability of a product (Cobb *et al.*, 2012, Tremblay *et al.*, 2024). Common high-sodium or salt foods include seafood, grains, vegetables, dairy products, and frozen and processed foods.

Dietary salt intake originates from three primary sources: (1) salt used in cooking, (2) salt added during food consumption, and (3) processed or pre-prepared food products (Mazloomi Mahmoodabad et al., 2011). The World Health Organization (WHO) recommends a daily intake of less than 5 grams of salt for adults (World Health Organization, 2012). However, many countries, including Iran, exceed this recommended amount (Gholami et al., 2022, Zendeboodi et al., 2021). In Iran, the average daily salt intake is approximately 9.52 grams, which is significantly higher than the WHO's suggested limit (Rezaei et al., 2018).

Reducing daily salt intake to the World Health Organization's recommended 5 grams can have significant health benefits. This reduction can decrease the risk of stroke by 23% and heart disease by 17% each year, potentially preventing 4 million deaths globally (Kloss *et al.*, 2015, Rafieifar *et al.*, 2016). As a result, numerous national and international organizations have promoted initiatives to reduce salt consumption in populations worldwide (Thout *et al.*, 2019). Efforts to reduce salt intake can help lower blood pressure, but a significant challenge lies in the "hidden" salt content in processed foods, which is often beyond individual control (Hunter *et al.*, 2022).

Salt is a cheap and versatile additive commonly used in the food industry, making it essential to monitor and regulate salt levels in cooked foods; particularly during preparation and distribution (Nurmilah *et al.*, 2022). Several studies worldwide have highlighted this issue, emphasizing the importance of accurate salt measurement to balance flavor and nutrition while minimizing sodium content (Gonçalves *et al.*, 2020, Khodaei *et al.*, 2023, Shirani *et al.*, 2024).

Traditional foods are dishes that are originated from specific regions and prepared using regional ingredients and unique cooking techniques (Haghweisi *et al.*, 2014). Traditional foods can significantly contribute to sodium intake in the Iranian diet (Amerzadeh *et al.*, 2022). Sodium is a key component of salt, and many traditional dishes in Iranian cuisine rely on salt and other high-sodium ingredients for flavor and preservation. Biryani, a cherished Iranian dish rooted in Isfahan's culinary history, is a mixture of lamb, liver, onions, and various spices, including salt. This grilled and patty-like dish is typically accompanied by separately grilled lungs, as shown in **Figure 1**. However, due to its high levels of fat and salt, frequent consumption of Biryani can increase the risk of developing non-communicable diseases, such as cardiovascular disease, with excessive salt consumption being a major contributing factor (Haghweisi *et al.*, 2014).

The vulnerability of children to potential health risks associated with high sodium intake from foods has prompted increased monitoring of sodium content in food products and assessments of the associated health risks. Quantitative risk assessment is a vital approach for evaluating the potential health risks associated with exposure of sodium. To address these concerns, a probabilistic approach using the US EPA's methodology has gained popularity. Moreover, the Monte Carlo Simulation technique has been widely adopted as a comprehensive and reliable method for assessing cancer and non-cancer risks in different contexts. By providing valuable insights into carcinogenic and non-carcinogenic risks, these assessments inform risk managers in their decision-making. A key aspect of risk analysis is accounting for uncertainty, which can be effectively modeled



[ DOI: 10.18502/jnfs.v10i4.20004 ]

using Monte Carlo Simulations to ensure more reliable risk estimates (Khodaei *et al.*, 2023). In fact, by examining how often and in what quantities people consume Biryani, it can identify trends that may highlight potential health concerns, such as high salt and fat intake, which are linked to non-communicable diseases like cardiovascular issues. In essence, analyzing consumption patterns offers valuable insights into Biryani's cultural significance, elucidating its role in societal traditions and practices. This perspective strengthens the study's rationale by contextualizing culinary habits within broader cultural frameworks.


**Figure 1.** Biryani and grilled lungs as traditional foods in Isfahan.

Despite the popularity and high consumption of Biryani and grilled lungs, the salt content in these dishes and thier potential health consequences for consumers, have yet to be thoroughly examined in Isfahan, Iran. This study addressed this gap in knowledge by conducting the first-ever investigation into this issue, thereby shedding light on its implications for public health.

## Materials and Methods

The sample size was calculated using the formula: $N = ([(Z^2 \times P(1-P))/\alpha^2]) \times def.$, assuming a 50% proportion (p) due to the lack of analogous studies in the region, a 5% margin of error (α), and a 95% confidence level. This calculation yielded a minimum required sample size of 25, with a design effect (def.) of 9.4 (Jaworowska *et al.*, 2012). The samples of locally Biryani and grilled lungs were purchased at local restaurants from the Isfahan, Iran during the second six months of 2023. The collected samples were stored at room temperature (25 °C) throughout the whole study. The samples were homogenized in a miller, weighed (0.1 g), and transferred to vessels. Hydrogen peroxide and nitric acid were then added, followed by a 10% cesium chloride solution for microwave digestion.

To quantify sodium levels, calibration curves were established using inductively coupled plasma-optical emission spectroscopy (ICP-OES; Varian Vista Pro, Australia) analysis of blank and standard samples with sodium concentrations of 2.5, 5, and 15 ppm. The wavelengths used to determine element concentrations were selected based on baseline signals and interference observed during experimental analysis. The Limit of Detection (LOD) represents the lowest amount of an analyte that can be distinguished from zero but not precisely calculated. The method validation parameters for salt analysis included an $r^2$ value of 0.993, a recovery rate of 94% and LOD of $4.8\times10^{-4}$ mg $L^{-1}$ with wavelength of 589.099 nm. Strict quality control measures were taken to prevent contamination, including acid-washing of equipment and use of deionized water (Shirani *et al.*, 2024). The salt content was calculated by multiplying the sodium concentration by 2.5.

The risk of non-carcinogenic diseases due to sodium consumption was assessed by Estimating the Daily Intake (EDI) of sodium, which represents the dose of oral exposure over a given time period. This calculation is performed using **equation 1**, which provides a quantitative measure of the average daily sodium intake.

$$EDI=[C\times IR]/[BW] \quad \textbf{Equation 1}$$

The equation for EDI of salt involves several key components. C represents the average concentration (mg $kg^{-1}$) of salt in food. IR is the daily food consumption per person and BW represents the body weight of 24 and 70 kg for children and adults, respectively.

To estimate the rate of Biryani consumption in





[ DOI: 10.18502/jnfs.v10i4.20004 ]

Isfahan city, considering both daily and yearly consumption patterns, it was assessed the associated salt risk. With a 5% margin of error, the maximum sample size was determined to be 200 participants. This estimation was based on a P-value of 50% (due to the absence of similar studies or pilot data) and an assumed effect size of 0.03. It was population selected using a systematic cluster sampling method across the municipal areas of Isfahan, ensuring representation from all socio-economic backgrounds by covering northern, southern, eastern, western, and central regions. Municipal areas were chosen based on their suitability. The number of participants required from each area was determined according to demographic factors. From each selected municipal area, a health center was chosen, and individuals visiting these centers were invited to participate. The study's purpose was explained to participants, and their Biryani consumption habits were assessed through two specific questions, including the total number of Biryani was consumed in the past year and the quantity consumed per occasion. The survey revealed that annual consumption of Biryani ranged from 30 to 50 servings, with a corresponding consumption of 6000 to 10,000 grams of Biryani. Similarly, annual consumption of grilled lungs ranged from 30 to 50 servings, equivalent to 1500 to 2500 grams.

The non-carcinogenic risk assessment framework is commonly used to measure the potential health hazards posed by elements. This approach involves calculating the Total Hazard Quotient (THQ), a quantitative measure of hazard potential ratio. THQ values are determined through the analysis of food consumption equation among residents of a particular region. The THQ is typically calculated using **equation 2**.

$$THQ = EDI/RFD \qquad \textbf{Equation 2}$$

In the above equation, EDI and Chronic Reference Dose (RFD) were used to evaluate potential health effects. EDI is calculated in **Equation 1**, while RFD is a predetermined value set by the US Environmental Protection Agency (USEPA). Specifically, the RFD for sodium is 0.03, which serves as a benchmark for assessing health risks associated with sodium consumption. The interpretation of the THQ is straightforward; a value greater than one indicates a potential health risk from non-cancerous diseases, while a value less than one suggests that the risk is negligible or non-existent (U.S. Envrionmental Protection Agency, 2022).

**Equation 3** was used to evaluate the combined risk of consuming Biryani and grilled lungs, providing a thorough assessment of the potential health effects of eating these two food items together.

$$TTHQ = \Sigma THQ \qquad \textbf{Equation 3}$$

Measurements were conducted in duplicate to minimize errors, and the resulting data were then processed using SPSS software (version 26) to calculate the mean and standard deviation of sodium concentrations. Crystal Ball software version 11.1.2.4 was used for non-carcinogenic health risk assessment with the Monte Carlo Simulation method. The simulation was repeated 100,000 times with a specified seed value and bin size (seed=999 and bin=500), and the results were reported at a 95% confidence level. The Weibull distribution model was identified as the best fit for the data, providing a robust basis for the analysis.

## Results

The average sodium concentration was found to be 347.4 and 377.4 mg/100 g in Biryani and grilled lungs, respectively (**Table 1**). **Figure 2** illustrates the non-carcinogenic risk associated with sodium intake from consuming Biryani and grilled lungs in both adults and children, assessed using a Monte Carlo Simulation under the worst-case scenario. The study revealed that THQ for sodium in Biryani was 0.7 for adults and 2.001 for children. For grilled lungs, the THQ values were 0.18 for adults and 0.54 for children. The combined THQ for consuming both Biryani and grilled lungs was found to be 0.88 for adults and 2.54 for children, as shown in **Figure 3**.

## Discussion

***Concentrations of Sodium in Biryani and grilled lung samples***



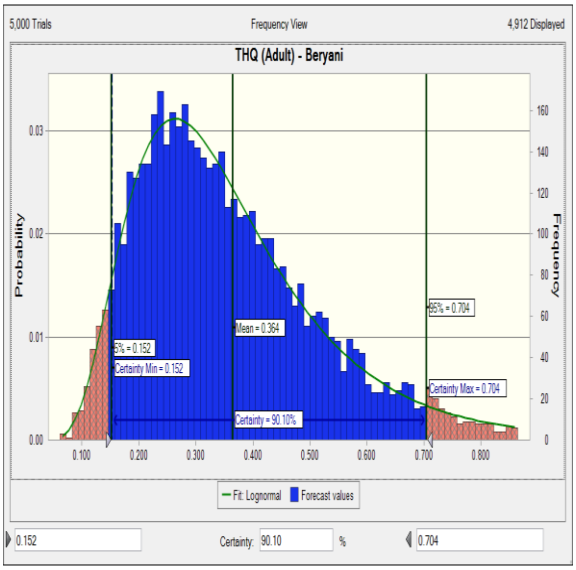
[ DOI: 10.18502/jnfs.v10i4.20004 ]

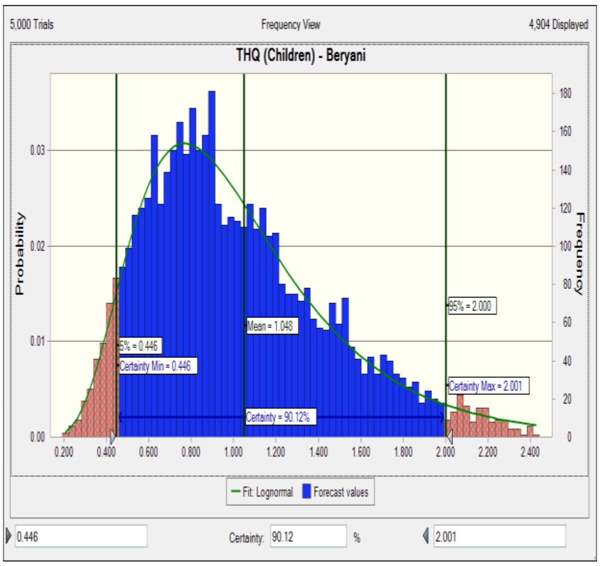
In this study, the amount of sodium was examined in Biryani and grilled lungs collected in Isfahan city, Iran. Detailed consumption data can help in designing targeted public health interventions or educational campaigns aimed at reducing the health risks associated with frequent Biryani consumption. The study revealed that the sodium content in all samples was below the WHO's daily recommended limit of less than 5 grams or 2 grams of sodium of salt per day (World Health Organization, 2012). The average sodium content was measured at 347.4 mg/100 g for Biryani and 377.4 mg/100 g for grilled lungs, respectively (**Table 1**). The findings of this study were compared to similar studies globally, although a direct comparison for sodium content in Biryani and grilled lungs was not possible due to a lack of existing data. Instead, the results were compared to the salt and sodium content in other meat-based food products in different countries, as referenced below.

**Table 1.** The concentration of sodium and salt (mg/100 g) in Biryani and grilled lungs collected from Isfahan, Iran.

| Type of sample | Sodium | | Salt[a] | |
|---|---|---|---|---|
| | Mean± SD | Range (Min-Max) | Mean± SD | Range (Min-Max) |
| Biryani | 347.4 ± 170.7 | 86.5- 676.41 | 836.4± 426.7 | 216.2-1691 |
| Grilled lungs | 377.4± 287.1 | 86.8-1150.01 | 893.4± 662.9 | 217.3-1624.2 |

*[a]: To convert sodium values to equivalent salt amounts, the sodium levels are multiplied by a conversion factor of 2.5.*






[ DOI: 10.18502/jnfs.v10i4.20004 ]

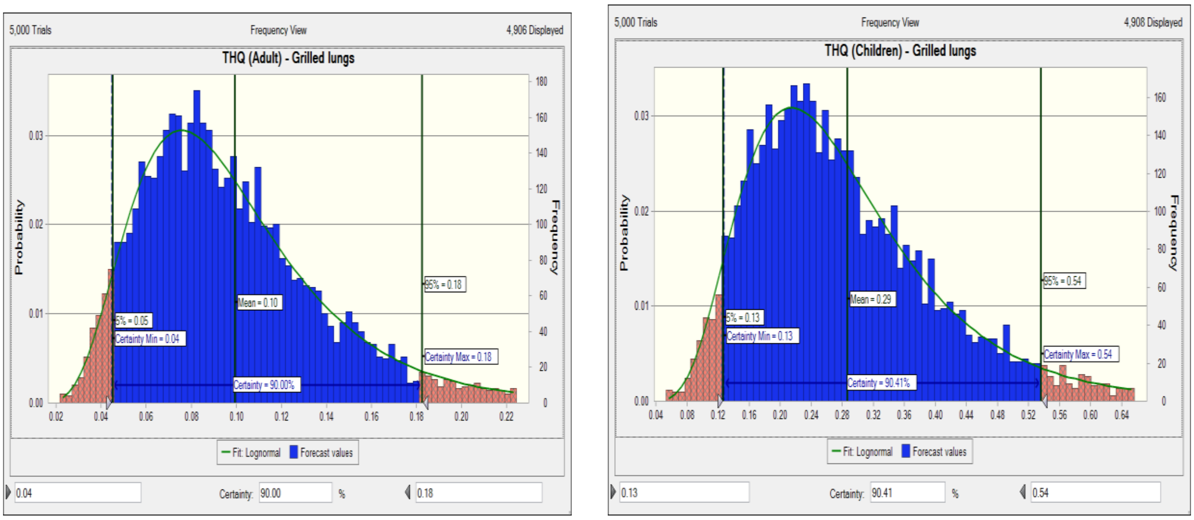



**Figure 2.** Non-carcinogenic risk associated with sodium in Biryani and grilled lungs in adults and child consumers.

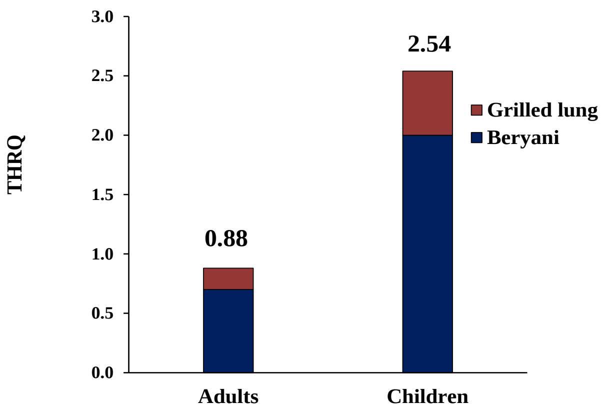



**Figure 3.** Total THQ attributed to sodium exposure from Biryani and grilled lungs in adults and children's consumers.

A study in Australia, analyzing 10 food groups, found that sauces and spreads contained the highest amount of sodium, at 1283 mg per 100 g, followed by processed meat with 846 mg per 100 g (Webster *et al.*, 2010). Pizzas had the highest salt content, with 945 mg per 100 g, according to a study in England, that examined 34 groups of processed foods. Chinese meals, kebabs, and Indian meals also had high salt levels, with 80.7, 62.1, and 47.3 mg per 100 g, respectively. The results revealed notable variations in salt content within the same food group, suggesting that significant salt reductions are possible in evaluated meals (Jaworowska *et al.*, 2012). A similar study was performed to analyze sodium content in processed foods in the Netherlands. Processed meat-based products had a notably high sodium content at 1030 mg per 100 g (Capuano *et al.*, 2013). Finding of an examination on Canadian packaged food supplies, showed that sodium content varied widely across different food groups such as dry soup (834±256 mg/100 g), condensed soup (754±163 mg/100 g), ready-to-serve soups (636±173 mg/100 g), oriental noodles (783±433 mg/100 g), broth (642±239 mg/100 g), and frozen appetizers/sides (642±292 mg/100 g). Furthermore, a significant proportion of meats (61.2%) and canned vegetables and legumes (29.6%) exceeded the recommended maximum sodium levels (Arcand *et al.*, 2014). In Argentina, an investigation on the sodium content in different types and categories of processed food products revealed that meat-based products had the highest average sodium content, with a mean of 750 mg/ 100 g (Allemandi *et al.*, 2015). The sodium content of popular and common fast foods was analyzed in a study in New Zealand, which demonstrated that potato dishes, filled rolls, hamburgers, and battered fish were major contributors to sodium intake among fast-food consumers. It was concluded that these foods should be prioritized for reformulation with lower sodium content in order to reduce


[ DOI: 10.18502/jnfs.v10i4.20004 ]

sodium consumption (Prentice *et al.*, 2016). Processed foods, particularly frozen meats like chicken, turkey ham, sausage, beef, veal, and pork, are high in sodium. Consuming excessive amounts of these products can lead to high sodium intake. It was found that meat dishes contained an average of 552 mg of sodium per 100 g, making them a significant contributor to sodium consumption in Mexico (Nieto *et al.*, 2018). A study on traditional foods revealed that over 60% of the samples exceeded recommended sodium levels. Findings indicated the variations in regional sodium content, with ranges of 120-720 mg/ 100 g in Mount Lebanon, 240-960 mg/100 g in Bekaa, 80-520 mg/ 100 g in Beirut, 252-1952 mg/100 g in Tripoli, and 40-680 mg/100 g in Saida. The highest sodium levels were found in Fatayer Sabanikh and Malfouf Mehche dishes, with mean values exceeding 600 mg/100 g (Hoteit *et al.*, 2020). In Victoria, Canada, the sodium intake of 338 citizens was analyzed and found that 38% of the sodium consumption came from convenience foods, primarily from retail stores (51%), restaurants and fast food (28%), and fresh food markets (9%). The study also revealed that 32% of participants added salt during cooking, and 61% added salt at the table. Notably, the average sodium intake in Victoria exceeded the WHO's recommended levels (Bolton *et al.*, 2020). Additionally, a study in Serbia analyzed the sodium content of 42 traditional meat-based food samples, including fermented sausages (Kulen and Canja sausage), cured meat products (tenderloin), smoked products (smoked tenderloin), finely chopped boiled sausage (hot dog), coarsely chopped boiled sausage (Serbian sausage), and bacon (pancetta). The results showed that dry fillet (tenderloin) had the highest average sodium chloride content at 449 mg/100 g, while hot dogs had the lowest at 188 mg/100 g (Stamenić *et al.*, 2021). In three major Chinese cities, it was demonstrated that meat-based dishes contained an average of 443.8 mg of sodium per 100 g (Xu *et al.*, 2022). Across four regions of Serbia, the sodium content of 339 meat products was measured and the consumption data from 3594 individuals were collected. The results showed that dry fermented sausage and dry meat had the highest salt content, with average values of 3.78±0.37 g/100 g and 4.40±1.21 g/100 g, respectively (Jelena *et al.*, 2023). A comparison of the current study's results with other studies on meat-based products revealed varying levels of sodium content, with some studies reporting higher levels (Allemandi *et al.*, 2015, Arcand *et al.*, 2014, Bolton *et al.*, 2020, Hoteit *et al.*, 2020, Nieto *et al.*, 2018, Stamenić *et al.*, 2021, Webster *et al.*, 2010, Xu *et al.*, 2022), and others reporting lower levels (Jaworowska *et al.*, 2012, Jelena *et al.*, 2023, Prentice *et al.*, 2016, Stamenić *et al.*, 2021). The varying levels of sodium in food samples worldwide can be attributed to several factors, including differences in food culture and recipes, different methods of cooking, using different amounts of salt, measurement techniques, and the number of samples analyzed.

WHO recommends reducing salt in food as a cost-effective intervention to control and prevent non-communicable diseases. Most sodium intake is attributed to packaged and restaurant foods, therefore, initiatives are underway to decrease the sodium content in these products. However, while it's easier to regulate sodium levels in packaged foods than to monitor the sodium content in restaurant-prepared foods (Maalouf *et al.*, 2013). While encouraging food manufacturers to reformulate their products can be challenging, experience has shown that it is technically possible to significantly reduce salt content in foods, including meat-based products, without affecting their quality. To promote salt reduction, nationwide awareness campaigns should be launched to educate the public about the health risks associated with excessive salt consumption, empowering them to make informed choices (Esfandiari *et al.*, 2019). Moreover, legislation on mandatory food labeling should be implemented or strengthened to help consumers make informed decisions and encourage manufacturers to reduce salt levels in their products, ultimately supporting the achievement of salt reduction targets (Esfandiari *et al.*, 2021, Ghazavi *et al.*, 2020).




[ DOI: 10.18502/jnfs.v10i4.20004 ]

***Non-carcinogenic risk of sodium via Biryani and grilled lungs***

**Figure 2** demonstrates the non-carcinogenic risk of sodium intake from Biryani and grilled lungs consumption in adults and children through Monte Carlo Simulation considering the worst case scenario. According to the findings, the THQ values of sodium in Biryani for adults and children were 0.7 and 2.001, respectively. Similarly, THQ was 0.18 and 0.54 for the consumption of grilled lungs in adults and children, respectively. Likely, it is due to lower yearly consumption levels of grilled lungs (2000 g) compared with Biryani (8000 g). The results indicated that the overall risk was negligible for both adults and children, as the calculated THQ values were below 1, indicating no significant health risk. However, children who consumed Biryani had a higher THQ value of 1, suggesting a potential non-carcinogenic risk. This is due to the lower weight of children (24 kg) compared to adults (70 kg). As illustrated in Figure 3, the combined risk of eating Biryani and grilled lungs at the same time was 0.88 and 2.54 for adults and children, respectively. Furthermore, the cumulative risk value exceeds the acceptable limit of one for children, making it unacceptable. Studies indicate that children consume more fast food than adults, posing a potential health threat to this age group given the high cumulative risk associated with consumption of Biryani and grilled lungs (Lee and Yoon, 2018, Paeratakul *et al.*, 2003). Due to the high sodium intake and related health risks in children, parents are advised to take steps to reduce their children's sodium consumption to safer levels.

The varying sodium levels found in the examined samples suggest that it is technically possible to produce lower-sodium dishes of Biryani and grilled lungs. Coupled with evidence that gradual sodium reductions do not affect consumer acceptance or taste, this indicates that significant salt reduction is achievable in these foods. Therefore, it should be considered to implement a nationwide salt reduction program, similar to those in other countries, to promote healthier food options in Iran. Furthermore, recent advancements in sodium reduction strategies and risk assessment methodologies have helped to address the global challenge of excessive sodium intake. These innovations are related to food technology, public health policy, and consumer education, providing a comprehensive approach to reducing sodium-related health risks while preserving the taste and cultural significance of foods like Biryani. By integrating these advancements, it is possible to mitigate the risks associated with high sodium consumption and promote healthier dietary habits (Jachimowicz-Rogowska and Winiarska-Mieczan, 2023).

It's notable that this study's findings may be limited by certain factors, including the exclusion of sodium measurement in traditional bread (Sangak), often served with Biryani in restaurants, as well as the lack of data on sodium content in beverages like Doogh (a type of yogurt drink), commonly offered in restaurant menus with Biryani. Another limitation would be the differences in preparation methods or cultural practices that may restrict the applicability of comparisons between the sodium and salt content in Biryani and other studies. While the study compared sodium levels in Biryani and grilled lungs to other global meat-based dishes, it acknowledges the lack of direct comparators for such analyses. In fact, investigating the ingredients used and the methods of preparation can reveal variations that might influence health outcomes. This information can be crucial for understanding the nutritional impact of Biryani consumption. In addition, Monte Carlo Simulations, as powerful tools for probabilistic risk assessment, have limitations due to their reliance on assumptions regarding distribution models and uncertainties in input parameters.

## Conclusion

This study assessed the sodium levels in traditional Iranian dishes, specifically Biryani and grilled lungs, in Isfahan. Although the sodium content was within the WHO recommended daily limit of 5 g, the results showed a potential non-carcinogenic risk of sodium exposure (THQ>1) associated with Biryani consumption among children. While no such risk was found for adults. This discrepancy may be attributed to the fact that an increased amount of Biryani



[ DOI: 10.18502/jnfs.v10i4.20004 ]

consumption would directly raise the sodium dose, thereby potentially increasing the THQ. Since the dose is often normalized by body weight, the lower body weight in children would result in a higher dose per kilogram, elevating the THQ. By varying these parameters within realistic ranges, their relative impact on the THQ can be determined. This analysis would help prioritize data collection efforts and risk management strategies. This finding underscores the importance of considering individual exposure factors and potentially revising sodium intake limits with specific considerations for children. Furthermore, the study's findings of varying sodium levels in Biryani and grilled lung samples indicate that it is feasible to prepare these traditional dishes with lower sodium content. To address the issue of reducing sodium intake in children consuming dishes like Biryani, actionable strategies beyond general recommendations, such as parental guidance, should be proposed. These strategies can be tailored to target different aspects of sodium consumption, including food preparation, education, and policy-level interventions. Further research should be conducted on other traditional food products to identify the primary sources of salt consumption in different national diets. Additionally, incorporating age-specific consumption data will also enhance the accuracy of risk assessments.

## Authors' contributions

Abbasi Z: Conceptualization, material preparation, analysis, data collection, design of the manuscript. Esfandiari Z: Conceptualization, design of the manuscript, data collection, Fakhri Y: Conceptualization, data collection, analysis, Mansourian M: data collection, analysis, Vaseghi Baba F: data collection, analysis, Mokhtari Z: Conceptualization, data collection, analysis, Siavash M: Conceptualization. All authors contributed towards manuscript writing and analysis.

## Conflict of interests

The authors declare no conflict of interest associated with the publication of this study.

## Funding

This study received financial support from the Vice-Chancellor of Research and Technology in Isfahan University of Medical Sciences with grant number 2401301.

## References

**Allemandi L, et al.** 2015. Sodium content in processed foods in Argentina: compliance with the national law. *Cardiovascular diagnosis and therapy*. **5 (3)**: 197.

**Amerzadeh M, Takian A, Pouraram H, Sari AA & Ostovar A** 2022. Policy analysis of socio-cultural determinants of salt, sugar and fat consumption in Iran. *BMC nutrition.* **8 (1)**: 26.

**Arcand J, Au JT, Schermel A & L'Abbe MR** 2014. A comprehensive analysis of sodium levels in the Canadian packaged food supply. *American journal of preventive medicine.* **46 (6)**: 633-642.

**Bolton KA, et al.** 2020. Sources of dietary sodium and implications for a statewide salt reduction initiative in Victoria, Australia. *British journal of nutrition.* **123 (10)**: 1165-1175.

**Capuano E, et al.** 2013. Comparison of a sodium-based and a chloride-based approach for the determination of sodium chloride content of processed foods in the Netherlands. *Journal of food composition and analysis.* **31 (1)**: 129-136.

**Cobb LK, Appel LJ & Anderson CA** 2012. Strategies to reduce dietary sodium intake. *Current treatment options in cardiovascular medicine.* **14 (4)**: 425-434.

**Cook NR, He FJ, MacGregor GA & Graudal N** 2020. Sodium and health-concordance and controversy. *British medical journal.* **369**: :m2440.

**Esfandiari Z, et al.** 2019. Influence of education on knowledge, attitude and practices of students of Isfahan University of Medical Sciences to traffic light inserted on food labeling. *Tehran University medical journal.* **77 (1)**: 54-62.

**Esfandiari Z, et al.** 2021. Effect of face-to-face education on knowledge, attitudes, and practices toward "traffic light" food labeling in Isfahan society, Iran. *International quarterly of community health education.* **41 (3)**: 275-284.

**Ghazavi N, Rahimi E, Esfandiari Z & Shakerian A** 2020. Accuracy of the amount of trans-fatty acids in traffic light labelling of traditional sweets



[ DOI: 10.18502/jnfs.v10i4.20004 ]

distributed in Isfahan, Iran. *ARYA atherosclerosis.* **16 (2)**: 79.

**Gholami A, et al.** 2022. National and sub-national trends of salt intake in Iranians from 2000 to 2016: a systematic analysis. *Archives of public health.* **80 (1)**: 120.

**Gonçalves C, et al.** 2020. Innovative equipment to monitor and control salt usage when cooking at home: iMC SALT research protocol for a randomised controlled trial. *BMJ open.* **10 (5)**: e035898.

**Haghweisi A, Abdollahi A & Janghorban Z** 2014. Iranian Traditional foods. Andishemandegar Publication: Tehran. Iran.

**Hoteit M, et al.** 2020. Nutritional value of the Middle Eastern diet: Analysis of total sugar, salt, and iron in Lebanese traditional dishes. *F1000Research.* **9**: 1254.

**Hunter RW, Dhaun N & Bailey MA** 2022. The impact of excessive salt intake on human health. *Nature reviews nephrology.* **18 (5)**: 321-335.

**Israr T, Rakha A, Sohail M, Rashid S & Shehzad A** 2016. Salt reduction in baked products: Strategies and constraints. *Trends in food science & technology.* **51**: 98-105.

**Jachimowicz-Rogowska K & Winiarska-Mieczan A** 2023. Initiatives to reduce the content of sodium in food products and meals and improve the population's health. *Nutrients.* **15 (10)**: 2393.

**Jaworowska A, Blackham T, Stevenson L & Davies IG** 2012. Determination of salt content in hot takeaway meals in the United Kingdom. *Appetite.* **59 (2)**: 517-522.

**Jelena M, et al.** 2023. Dietary intake of salt from meat products in Serbian population. *International journal of environmental research and public health.* **20 (5)**: 4192.

**Khodaei SM, Esfandiari Z, Sami M & Ahmadi A** 2023. Determination of metal (oids) in different traditional flat breads distributed in Isfahan city, Iran: health risk assessment study by Latin hypercube sampling. *Toxicology reports.* **10**: 382-388.

**Kloss L, Meyer JD, Graeve L & Vetter W** 2015. Sodium intake and its reduction by food reformulation in the European Union—A review. *NFS journal.* **1**: 9-19.

**Lee EY & Yoon K-H** 2018. Epidemic obesity in children and adolescents: risk factors and prevention. *Frontiers of medicine.* **12**: 658-666.

**Maalouf J, et al.** 2013. Monitoring the sodium content of restaurant foods: public health challenges and opportunities. *American journal of public health.* **103 (9)**: e21-e30.

**Malczyk E, Muc-Wierzgoń M, Fatyga E & Dzięgielewska-Gęsiak S** 2024. Salt intake of children and adolescents: influence of socio-environmental factors and school education. *Nutrients.* **16 (4)**: 555.

**Mazloomi Mahmoodabad SS, Motlagh Z, Morowati Sharifabad MA, Mozaffari-Khosravi H & Askarshahi M** 2011. The efficacy of reasoned action theory in determining factors related to salt consumption among women referring to yazd health care centers, Iran. *Journal of health system research.* **7 (4)**: 0-0.

**Nieto C, et al.** 2018. Sodium content of processed foods available in the Mexican market. *Nutrients.* **10 (12)**: 2008.

**Nurmilah S, Cahyana Y, Utama GL & Aït-Kaddour A** 2022. Strategies to reduce salt content and its effect on food characteristics and acceptance: a review. *Foods.* **11 (19)**: 3120.

**Paeratakul S, Ferdinand DP, Champagne CM, Ryan DH & Bray GA** 2003. Fast-food consumption among US adults and children: dietary and nutrient intake profile. *Journal of the American dietetic association.* **103 (10)**: 1332-1338.

**Prentice CA, Smith C & McLean RM** 2016. Sodium in commonly consumed fast foods in New Zealand: a public health opportunity. *Public health nutrition.* **19 (6)**: 958-966.

**Rafieifar S, et al.** 2016. Strategies and opportunities ahead to reduce salt intake. *Archives of Iranian medicine.* **19 (10)**: 0-0.

**Rezaei S, et al.** 2018. Salt intake among Iranian population: the first national report on salt intake in Iran. *Journal of hypertension.* **36 (12)**: 2380-2389.

**Shirani F, et al.** 2024. Accuracy of Declared Salt



[ DOI: 10.18502/jnfs.v10i4.20004 ]

Content on Traffic Light Labelling of Nuts and Seeds in Isfahan, Iran. *Journal of research in health sciences.* **24 (2)**: e00616.

**Stamenić T, et al.** 2021. Contents of sodium-chloride in various groups of locally manufactured meat. *Biotechnology in animal husbandry.* **37 (3)**: 223-234.

**Thout SR, et al.** 2019. The Science of Salt: Updating the evidence on global estimates of salt intake. *Journal of clinical hypertension.* **21 (6)**: 710-721.

**Tremblay A, et al.** 2024. Sodium and human health: What can be done to improve Sodium balance beyond food processing? *Nutrients.* **16 (8)**: 1199.

**U.S. Envrionmental Protection Agency** 2022. sodium salt, https://iris.epa.gov/static/ pdfs/ 0146_summary.pdf.

**Webster JL, Dunford EK & Neal BC** 2010. A systematic survey of the sodium contents of processed foods. *American journal of clinical nutrition.* **91 (2)**: 413-420.

**World Health Organization** 2012. Guideline: sodium intake for adults and children. World Health Organization: Geneva, Switzerland.

**Xu W, et al.** 2022. Sodium content in takeaway meals sampled from three large China cities. *Food and nutrition sciences.* **13 (5)**: 471-478.

**Zendeboodi F, et al.** 2021. Salt content of processed foods in the Islamic Republic of Iran, and compliance with salt standards. *Eastern Mediterranean health journal.* **27 (7)**.



[ DOI: 10.18502/jnfs.v10i4.20004 ]