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Research Paper:

Sodium Dithionite Concentration in Traditional Bread and Health Risk Assessment: A Case Study in Qom City

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ABSTRACT

Background & Aims of the Study: This study aimed to determine sodium dithionite as an additive in traditional bread and its health risk assessment in Qom province and was designed in two stages.

Materials and Methods: It was designed in two stages. In the first stage, the concentration of Sodium dithionite in the traditional breads (4 type of bread with code number of 1, 2, 3, and 4) were measured. 70 samples were randomly selected from the bakeries and analyzed by spectrophotometer in 560 nm and Instrumental detection limit (LOD) of 1 mg/l. In the second stage, health risk assessment was determined. Required data were extracted by a questionnaire (NUTRIKAP) used as a survey tools for household food basket. The sampling method at households Level at the single stage cluster sampling with sample size was estimated for 456 (57 clusters of 8 people in Qom province).

Results: The results of Sodium dithionite test in bread samples showed that in 40% of all samples, Sodium dithionite concentration was 1.23±0.99 ppm. The risk assessment for all age groups showed that the hazard quotient (HQ) was <1.

Conclusion: according to the pattern of bread consumption, the daily intake of Sodium dithionite does not pose a significant health risk. However, training to Bakers and bakery workers and related food industries is essential and continuous monitoring of additives in bread is more of concern.

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1. Introduction

Bread is a valuable and cheap food that has played an important role as a large part of the food basket in supplying energy, 60-65% of demanded protein, and 2/3 of minerals and vitamins for Iranian families. Rapid changes in lifestyles, urbanization, and industrialization forced people to eat convenience foods, which require less preparation time. In Iran, most bakeries use some chemicals, such as baking soda, sodium hydrolysate, and the excess amount of salt to speed up the fermentation process, cover the poor flour quality and apparent defects of bread and reduce the fluidity of gluten in bread dough, respectively [1-2].

Chemical materials and their residues as additives in food may affect human health or food manufacturers, processors, restaurants, fast foods, etc., all contribute to food contamination in one or more ways by using a variety of harmful chemicals and toxic food additives. Toxicological and chemical characteristics of food additives are the primary concern of food safety [3-5].

Sulphites or sulphiting agents refer to sodium hydrogen sulfite and use sodium as food additives, which are in abundance and in high quantities used by the food industry as well as in other cosmetics industries and chemicals [6]. Hydrosulfite with a chemical formula of Na2S2O4 is used as a bleaching compound during the dyeing process in some industries, like food drying, sugar, textile, and paper, and also for dyeing of cellulose fibers.

Using high quantities of hydrosulfite in food industries can cause hazard problems. Identification of sodium dithionite safety data sheet, including eye and skin conditions, in addition to inhalation and ingestion may cause allergic respiratory reactions in asthmatics [7, 8]. Some studies have reported that Blanchite is effective in blocking the body's enzymes, especially insulin; therefore, directly increases blood sugar and causes diabetes in rats [9]. Moreover, sodium dithionite has the ability to cause chromosomal abnormalities and affects fertility and growth by its toxicity. The maximum permissible level of sulfur compounds remaining in white sugar is 15 mg/kg of body weight per day based on the CODEX 2001. According to the Institute of Standards & Industrial Research of Iran (ISIRI), the maximum permissible dose of Blanchite is 10 ppm in bread [10].

Some bakeries use Blanchite for rapid fermentation and preparation of bread dough and increasing the tensile strength of the dough. In this study, the traditional bread produced in the Qom province was investigated in terms of unauthorized use of Blanchite, and the risk of its consumption was determined.

2. Materials and Methods

Setting of Study

This cross-sectional study was designed and accomplished in two stages in Qom city with approximately 1300,000 inhabitants. In the first stage of the study, the concentration of sodium dithionite in the traditional bread (four types of bread with code numbers of 1, 2, 3, and 4) was measured. In the second stage, health risk assessment was determined.

Measurement of sodium dithionite

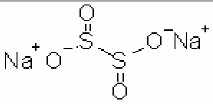
The physicochemical properties of sodium dithionite and the fate of this compound in an aquatic environment extracted by software (EPI Suite 4.1) are shown in Table 1 [11]. General information about sodium dithionite implies that the solubility of this substance is very high (186 g/l) and considering the partition coefficient (log Kow<-4.2), this compound has high mobility in water and the process of human risk assessment is significant [12].

The methods employed for the determination of Blanchite have been described by the National Standard Organization of Iran [13]. In this study, sodium dithionite measurement in four types of traditional bread with code numbers 1, 2, 3, and 4 were considered. In total, 70 samples were randomly selected from the bread production center.

Chemicals and reagents, Sample preparation and Method validation

High-quality sodium hydrosulfite/Blanchite (≥99%) and saccharose (Purity≥99%) were obtained from Sigma Aldrich. Sodium hydroxide (0.1 M), hydrochloric acid (0.1 M), iodine solution (0.05M), sodium thiosulfate (0.1M), starch solution (0.1M), and saturated rosanilin hydrochloride were obtained from Merck. To draw a linear calibration curve, the target compound of 1, 2, 3, 4, and 5 mg/l by stock solution (100 mg/l) of sodium hydrosulfite was prepared by adding 4ml of sodium hydroxide solution (0.1 M), which reaches 100ml by adding saccharose solution. We removed 10ml from each balloon and by adding 2ml of formaldehyde solution and 2 ml of rosanilin hydrochloride to it, after 30 minutes, the absorption value was read at the wavelength of 560 nm by spectrophotometer. The method fitted a linear model with R^2= 0.974 and a Limit Of Detection (LOD) of 1

Table 1. Characteristics and some environmental fate of sodium dithionite

Compound	Structure	Physico-chemical Properties					
		Molecular Mass	log k(w)	Solubility	pKa	Melting Point	Vapor Pressure
Sodium dithionite		174.114 g/mol	< – 4.7	182 g/l (20°C)	1.8E+009	Decomposition >90°C	2.43E-021

mg/l (Figure 1). In the samples test, 10 g of the dried and powdered traditional bread from each sample was added to a 100 ml balloon, and 4ml of sodium hydroxide solution (0.1 M) was added, which reached 100 ml by adding with distilled water. The same process was performed simultaneously with the control sample (flour and dough without Blanchite) and both tubes were centrifuged to settle the particles. We removed 10 ml of each filtered solution and added 2ml of rosanilin solution and 2ml of formaldehyde to the test and control tubes, and after 30 minutes, the absorption value was read at 560 nm by the spectrophotometer [14].

Health risk assessment

In the process of health risk assessment, the related criteria were determined. These include Acceptable Daily Intake (ADI) that is expressed in milligrams of sodium dithionite per kilogram of body weight (0 - 0.7 mg/kg/bw) expressed as sulfur dioxide (in this study for worth scenario 0.1 were considered), estimated daily intake (EDI) in order to obtain information on the actual amounts of bread consumed by an individual or household, and Average Daily Dose (ADD) that is calculated according to the following equation (Equation 1):

$$1.\ AAD=\frac{C\times IR\times ED\times EF}{EW\times AT}$$

C: the amount of Sodium dithionite in bread (ppm)

ED: exposure duration with regard to the age range of population: 5-18, 19-29, 30-59, and >60 years, respectively.

IR: Bread consumption (g/day) for respondents of the questionnaire <30, 30-70, 70-100 and >100. Sodium dithionite concentration in bread consumption was assumed to be 100% of absorption because data on sodium dithionite absorption via food has not been reported.

EF: exposure frequency (365 days/year)

BW: body weight for age groups according to the weight of fifty percentile of the corresponding WHO age-weight curve; the age range of 5-18 years (60 kg) and older (70 kg) was considered.

AT: average lifetime (ED×365 days/years)

Hazard quotient (HQ) for risk characterization was estimated through following equation (Equation 2):

$$2.\ HQ=\frac{ADD}{ADI}$$

HQ<1.0 indicates no significant risk and HQ>1.0 indicates significant risk [11].

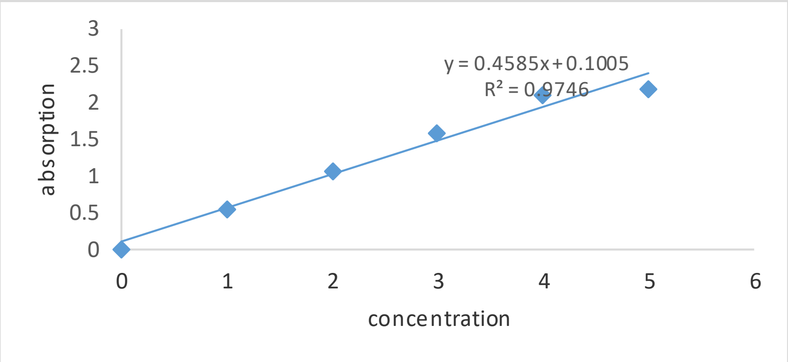


Figure 1. Calibration curve of the UV Spectrophotometer at 560 nm

Using the NUTRIKAP questionnaire and through the interview with the eligible subject in each household, the required data were collected [15, 16]. The validity and reliability of the questionnaire were evaluated in the pilot study. The head of the household or any member of the household who was above 15 years old and responsible for cooking was interviewed in this study. The sampling method at the household level was the single-stage cluster sampling and a sample size of 456 (57 clusters of 8 people in Qom province) was estimated [15].

3. Results

Measurement of Sodium dithionite concentration in the traditional bread

Table 2 shows the statistical characteristics of the sodium dithionite in the traditional bread samples in Qom city. Also, Figure 2 shows the concentration of sodium dithionite in different bread types.

Exposure and health risk assessment

Table 3 indicates the health risk assessment of sodium dithionite in the traditional bread in four age groups in Qom City.

4. Discussion

The results of sodium dithionite concentration in bread samples showed that in 40% of all samples, the amount of sodium dithionite was at the range of 1.23± 0.99 ppm. As shown in Figure 2, the highest use of sodium dithionite is related to bread with code number 1 (Lavash). Findings indicated that the amount of bread consumed daily (gr/day) in age groups was as follows: 80 and CI 95%: 79.1-84.3, 100 and CI 95%: 98.8-103.2, 100 and CI 95%: 99.2-104.2, and 100 and CI 95%: 99.5-103.9, respectively. According to the standards for sodium dithionite as a food additive (10 ppm) [13] and concentrations of sodium dithionite in bread samples in this study, sodium dithionite does not pose any hazard to the consumers.

The results of the risk assessment of consuming bread with sodium dithionite for all age groups showed that the HQ was less than 1; therefore, according to the pattern of bread consumption, the daily intake of sodium dithionite does not pose a significant health risk (Table 3). As shown in Table 3, due to the consumption of sodium dithionite in the age groups of 29-29 years and 30-59 years and considering the consumption patterns of bread,

Table 2. Sodium dithionite concentration (ppm) in the traditional bread

Bread Code	Samples	Sodium Dithionite (Mean Concentration)	SD	pH (Mean)
1	14	0.58	0.40	6.12
2	21	0.89	0.79	6.46
3	21	1.63	1.19	6.44
4	14	0.75	0.45	6.32

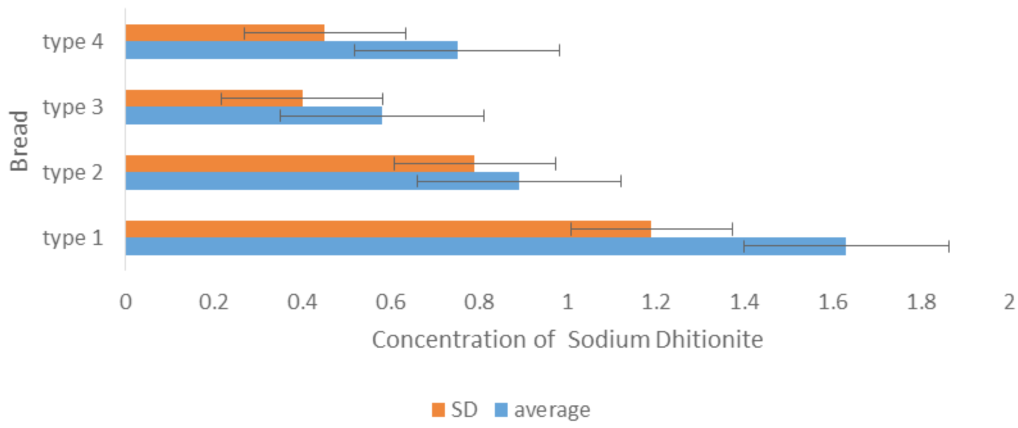


Figure 2. The concentration of sodium dithionite (ppm) in bread types

Table 3. Health risk assessment of sodium dithionite in the traditional bread in age groups

Age Group, year	C (mean ,mg/kg)	IR (g/day)	BW (kg)	ED (year)	EF	ADD (mg/kg/year)	AT (day)	HQ
5-18	0.96	80	60	18	5706	11E-4	6570	11E-3
19-29	0.96	100	70	29	9048	11E-3	10585	11E-2
30-59	0.96	100	70	59	21535	13E-3	21535	13E-2
> 60	0.96	100	70	60	21900	13E-4	21900	13E-3

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especially bread type 1, the value of the risk factor increased for these groups. Numerous studies have been implemented to determine and evaluate the health effects of sodium dithionite in food. Claudia et al. developed a method by application of flow injection analysis for determining sulphites in food and beverages [17].

Differential pulse polarography by Alizadeh was applied to determine the dithionite content of sugar and loaf sugar samples [18]. The results showed that the dithionite content in the samples ranged from <1.40 to 13.24 mg/l, considering that both methods used to determine the dithionite values are newer methods of instrumental analysis, but the results of the present study showed that the spectrophotometric method can be used to monitor the dithionite values in bread at common concentrations [19]. Asgari et al. investigated sodium dithionite concentration, as an unauthorized additive, in Hamadan (a province in the center of Iran) bakeries in 2016, and also risk assessment of food consumption was done. The sodium dithionite was not found in 97% of samples and only 3% of samples (Lavash bread) had the Blanchite. The target hazard quotient (TQH) index was 0.0041 (less than 1) and the consumption of bread with this concentration will not endanger human health [13]. Considering the similarities between the results related to the HQ in this study, it seems that the remaining amounts of sodium dithionite as an unauthorized additive in traditional Iranian bread did not pose a risk to the consumer. Jian Bo et al. assessed the risk of sulfites in food consumed by the Chinese and their results showed that the Maximum-Permitted Level (MPL) of sulfites in national food safety standard for uses of food additives (GB 2760-2011) for the intake of sulfites was lower than the acceptable daily intake (ADI). Moreover, children aged 1-6 years are at a high risk to intake excess sulfites.

Compared to other regulations, GB 2760-2011 has many differences in the use of sulfites [20, 21]. Food Standards Australia New Zealand (FSANZ) about sodium hydrosulphite as a food additive reported that during the preparation and production of canned abalone, the residual hydrosulphite produced during chemical reactions in the final product is not detectable, and using sodium dithionite as a food additive showed that it does not pose health risks. Residues in the edible portion of the uncooked product not to exceed 100 ppm (mg/kg), calculated as sulfur dioxide [22]. The results of all these studies together with the present study indicate that sodium dithionite as a food additive in the areas where it has been used does not pose a health risk to the consumers.

5. Conclusion

Although according to the results obtained from health risk assessment of sodium dithionite residual amount in traditional bread shows no significant hazard for consumers, due to the large share of bread in the daily food basket, continuous monitoring of unauthorized additives, including sodium dithionite, is inevitable.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualization and Supervision: Yadollah Ghafuri and Zahra Atafar; Methodology: Rahim Aali, Writing – original draft: Hassan Izanloo. All authors equally contributed to preparing this article.

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Conflict of interest

The authors declared no conflicts of interests.

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