ÓBUDA University

Rejtő Sándor Faculty of Light Industry

and Environmental Engineering and Natural Sciences

Nitrate content in fruits and vegetables

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2023. Student‘s herd’-book number: **T-2704/FI12904/R**

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THESIS ASSIGNMENT

Student's surname, forename (s): Zhengqi Duan
Thesis number: [redacted]
Registration number: T-2704/FI12904/R **Neptun code:** [redacted]

Branch of study: Environmental Engineering (BSc)
Specialization: Light industrial
Green energy specialization

Thesis title: Nitrate content in fruits and vegetables
Task description:
As we known nitrate can be found in fruits and vegetables. Nitrate is necessary to human body. But if human take too much nitrate will cause some problem. So, it is important to know how much nitrate you take per day.
In this thesis I choose different samples from different shops. Though the experiment to learn the concentration in those samples. And I will try to find if there are any different in those fruits and vegetables which from different shops. And analysis the samples themselves which part of them will be healthy.

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The limitation period of the theme issued: 01.07.2025.
Deadline for submission of Thesis: 15.05.2023.

The thesis is: Not secreted.

Issued: Budapest, 25.05.2023.

ÓBUDAI EGYETEM
P.H
1. Budapest

Director of Institute

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STUDENT STATEMENT

I, Zhengqi Duan the undersigned student, declare that the thesis is the result of my own work, the literature and the tools I used were communicated identifiable. The results of the completed thesis can be used by the university and the institute for its own use, free of charge, with encryption restrictions it is necessary.

Budapest, 2023. 05. 29.....

Duan Zhengqi

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Stundent's signature

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1. Introduction

1.1 Research Background

The problem of environmental nitrate pollution has caused wide concern worldwide. Nitrate is an aerosol component in the atmosphere. It will not only lead to acidification of the atmosphere (in nitric acid form), land, water, and other ecosystems, posing a threat to human health, production, and life but also have an important impact on the nitrogen cycle and global climate.

As we all know that nitrogen is up to 78 percent of the air, but nitrogen molecule is not active. Nitrates play an important role in the biosphere. The primary function of nitrate is to facilitate the absorption of nutrients by plants. Since nitrogen is not only an essential component of amino acids and proteins but also can produce chlorophyll and stimulate photosynthesis, plants that are deficient in nitrogen will have yellow leaves.

In daily life, people must eat a certain amount of food to ensure the necessary energy intake. The consumption of fruits and vegetables accounted for a large portion. Fruits and vegetables contain many vitamins and other minerals, these are not other foods that can be replenished for the human body. Therefore, eating lots of fruits and vegetables seems to be good for the human body. But there is a saying in China “Too much is not always a good thing”. This sentence is the same true here. The content of nitrate in fruits and vegetables has an important effect on human health.

1.2 Goal of the study (experimental design)

As can be seen from the above, nitrate is very important to the human body. Because fruits and vegetables are one of the main sources of human intake of nitrate. The author is interested in the nitrate content of fruits and vegetables around him. This paper selected several common fruits and vegetables as the research object. It is hoped that the nitrate content of these fruits and vegetables can be determined by

experiments. I wanted to know what the nitrate-N intake of some vegetables and fruits is for the citizens of Budapest.

2. Review of the Literature

2.1 Foreword

The study of nitrates in plants is a gradual process. With the deepening of research, people gradually realized the two-sided effect of nitrate on the human body. People need a certain number of nitrates to stay healthy, but excess nitrates can cause disease. So moderate nitrate intake becomes particularly important. In this case, the detection of nitrate content in fruits and vegetables has also aroused people's attention.

2.2 Nitrate with Human

As mentioned earlier, nitrates take a large part of the biosphere. So, nitrates are also very close to human contact. It has been shown to have favorable effects on both blood pressure and the functioning of the heart, which has led some individuals to believe that taking in little amounts of nitrates is good for one's health. However, the attention of health authorities has mostly been focused on the two hazards that have been detected by such ingestion: blue newborn sickness, also known as methemoglobins, and the possibility of the generation of cancer-causing nitrosamines from nitrate-derived nitrites. Blue infant disease or methemoglobins is a condition in which a child's red blood cells become abnormally large, and methemoglobins.

The major sources of nitrates and nitrites for humans are diet and endogenous formation. Nitrates and nitrites in the human organism are partially excreted as well as circulating and reduced to nitrite and nitrogen oxides which ensures a nitrate-nitrite-NO balance [1]. Nitrates are unstable in acidic conditions, and so spontaneously decompose to nitrites and nitrogen dioxide. Thus, nitrites resulting from nitrate metabolism as well as those supplied with food can additionally react in the gastrointestinal tract with precursors of N-nitroso compounds (such as amines and amides) and result in the formation of N-nitroso compounds. Because it might result in the creation of carcinogenic nitrosamines, the interaction of nitrite with secondary

amines is regarded as one of the most harmful chemical reactions possible to the human body. This reaction is possible for individuals who ingested an excessive amount of nitrate while it was in their stomach.

There is an old saying in China that “disease comes from the mouth”. Humans not only get energy from food but something else. Deaths of around 702,308 people due to heart disease, stroke, and type 2 diabetes, 318,656 (45%) were associated with inadequate consumption of certain foods and nutrients widely considered vital for healthy living and overconsumption of other foods that are not [2]. Not only the disease described above but a significant proportion of diseases are related to eating.

Humans get nitrate from foods, too. Humans consume nitrates mainly from vegetables, fruits, and water. Nitrates are abundant in vegetables and fruits, and trace amounts are found in almost all tap water. The nitrate in the soil is the most important source of vegetables and fruits because plants can absorb the nitrate in the soil as they grow. It is important to note that the use of chemical fertilizers can increase nitrate levels in the soil, so excessive fertilizer use poses potential risks to human health.

In addition, meat and gut flora are also sources of nitrate in humans.

Nitrates can be converted to nitrites, which are reduced by stomach acid to imines, and N-nitroso compounds, which are harmful to human health. Excessive consumption of foods containing nitrites, such as cured meats and grilled meats, has been linked to an increased risk of intestinal disease and cancer. In addition, the formation of nitrite can also be achieved through the metabolic process of some bacterial groups. For example, bacteria in the gut of primates, in the presence of nitrate and sulfate, can reduce sulfate to sulfide and nitrate to nitrite, producing large amounts of nitroso compounds. Therefore, people need to avoid excessive intake of nitrate through various dietary planning and dietary control, to protect the health of the body.

2.3 Nitrates and food safety

With the development of science and technology, people's quality of life is constantly improving. Diet, as an indispensable part of life, has attracted much attention from scholars. In 2015 Sharon Friel & Laura Ford's "Systems, food security, and human health" [3] mention that food security is not just a food policy issue. What, when, where, and how much people eat is influenced by a complex mix of factors at the societal and individual levels. These influences operate both directly through the food system and indirectly through political, economic, social, and cultural pathways - peoples' dietary behaviors are a response to the broader daily living conditions in which they are born, live, learn, work, and age. In their writings, food not only affects health but also social development. A healthy food supply also has a positive impact on the country. In nature, the nitrogen cycle is one of the most important cycles of life. Some nitrogen is absorbed as nitrate or nitrite via the food chain throughout this cycle. Because of their link to cancer, (in a landmark study published in Nature [4] in 1970, Lijinsky and Epstein demonstrated that nitrosamines were highly selective carcinogens). These anions have gotten a lot of attention from nutritionists. But as research continues, researchers were discovering some of the benefits of nitrates. In 2013 Nathan S. Bryan and Hans van Grinsven published an article "The Role of Nitrate in Human Health" [5] which meanly introduce the benefits of nitrate. In 2017 Nathan S. Bryan and Joseph Loscalzo published a book "Nitrite and Nitrate in Human Health and Disease" [6]. This book summarizes previous research on the effects of nitrates and nitrites on the human body and systematically summarizes the benefits and disadvantages, and presents several potential treatments based on the findings. For now, it is widely believed that consuming a reasonable number of nitrates is beneficial to human health, but consuming an excessive number of nitrates is hazardous. More studies will be released to assist people in better understanding nitrates. "The main sources of nitrate intake are meat, water, fruits, and vegetables," [7] Sotiria Kotopoulou, Antonis Zampelas, and Emmanuella Magriplis concluded in

their article “Dietary nitrate and nitrite and human health: a narrative review by intake source”. In Zeynep Kalaycıoglu and F. Bedia Erim 's article ‘Nitrate and Nitrites in Foods: Worldwide Regional Distribution Given Their Risks and Benefits’ [8]. Reports on the nitrate content of fruit and vegetables, meat, and water from all over the world have been collected. The comparison in the report shows that fruit and vegetables have significantly higher nitrate levels than meat and drinking water. So, the nitrate content of fruit and vegetables is more important for humans. In this paper, nitrate in fruits and vegetables is taken as the research object.

2.4 Preliminary study on nitrate content in plants

Earlier studies focused on the relationship between nitrogen, nitrate, and plants [2]. Already in 1978, O.A. Lorenz published an article entitled "‘Potential nitrate levels in edible plant parts” [9]. In it, the experiments carried out were described. 25 common edible plants were used in the experiment. These were planted and fertilizer treatments were applied at different rates. Nitrate content was detected in different parts of the plant during its growth. In his experiments, it was found that the leaf and stem tissues accumulated the highest amount of nitrate, followed by the roots. Fruit and flower parts accumulate only small amounts of nitrate in plants. It is also suggested that a certain amount of nitrate accumulation is a natural and necessary process and that nitrate levels in plants cannot be reduced too much without reducing production. The degree of product development at harvest has a minimal effect on nitrate accumulation. Nitrate levels in crops of the same species often did not differ significantly. As the rate of nitrogen fertilization increased, nitrate accumulation increased. Nitrate content in plants increased as the rate of nitrogen application increased. It was also mentioned that the nitrate content of fruits and vegetables was not harmful.

‘Nitrate accumulation in vegetables and its quality relationship ‘[10] was published by Margetha Blom-Zandstra in 1989. In this paper, the relationship between nitrate and plant growth was studied by experiments. The paper states that plants take in nitrogen and convert it into nitrates that are fixed in their leaves. The plant then fixes carbon in the environment with the help of nitrates to form nutrients that the plant needs to promote plant growth. This paper helps people know why nitrate is important for plants. Since nitrite is produced by the nitrate-rich assembly in plants, many scholars hoped to find an alternative to nitrate through experiments. Margetha Blom-Zandstra's article [10] summarizes some representative experiments and suggests that replacing nitrates leads to lower plant quality. The idea is that nitrate concentrations affect plant development and therefore plant quality.

In 2004， Bao-Ming Chen et al. published an article “Effects of nitrate supply on plant growth, nitrate accumulation, metabolic nitrate concentration, and nitrate reductase activity in three leafy vegetables” [11]. This paper describes the accumulation of these nitrates on the leaves of plants after the absorption of nitrogen fertilizer into nitrate and the effect of nitrate on the active enzymes on the leaves.

In 2018, Giuseppe Colla et al. published a paper “Nitrate in fruits and vegetables” [12]. In this study, they analyzed and summarized the findings of past investigations on the buildup of nitrates in various fruits and vegetables. It was explained in detail what the nitrate content of plants was throughout various periods. A discussion on the connection between fruit and nitrate was included as well and the effect of other elements in the plant on nitrate. Following the discussion of the connection between plants and nitrate, this article moves on to discuss the connection between environmental factors and nitrate levels in plants. The accumulation of nitrate in fruits and vegetables and the possibility of nitrate being converted into nitrite after people harvest fruits and vegetables were further discussed. At the end of the study, several methods were analyzed to reduce the nitrate content of vegetables, fruits, and herbs. As well as suggested actions for future research topics.

2.5 Factors affecting nitrate content in plants

Many external factors affect the growth of plants, so it is difficult to find out what is related to the nitrate content in plants. In 1999 Raúl Cárdenas-Navarro, Stéphane Adamowicz, and Paul Robin wrote an article “Nitrate accumulation in plants: a role for water” [13], they found that water content influenced nitrate in plants during plant growth through comparative experiments. In 2017, scholars led by Yasir Arafat explored the mutually beneficial relationship between soil, microorganisms, and plants in the soil through the study of tea [14]. In their study, the relationship between soil, microorganisms, and plants is presented in detail. It has also been shown that nutrients absorbed by plants come from microbes and the soil. This article is of great significance for the research on the sources of nitrate content in plants. Of course, the impact of human activities on plants is also huge. As the most commonly used agricultural products, chemical fertilizers also greatly affect the substance content of plants. The effect on nitrate content is inevitable, too. Earlier in 2013, in “Long-term fate of nitrate fertilizer in agricultural soils” [15]. Mathieu Sebilo and his team used isotope labeling to study the flow direction of nitrogen in fertilizers. His research shows that 60 percent of nitrogen is taken up by plants It can be seen that fertilizer has a relatively large effect on nitrate content in plants. In 2014, Liu et al. published an article” Effects of Nitrogen Fertilizers on the Growth and Nitrate Content of Lettuce (Lactuca sativa L.)” [16]. In this study, Liu et al. confirmed the research of Mathieu Sebilo and his team on the effect of nitrogen fertilizer on lettuce growth. Also, the relationship between the use of nitrogen fertilizer and the nitrate content of lettuce was shown. Their research contributed to the rational use of nitrogen fertilizer. It is obvious that human activities, especially fertilizer use, have the greatest effect on the nitrate concentration of plant species. The study objective of modern academics is to improve this condition, with the overarching topic of current scholarship being the promotion of green, healthy, and sustainable development around the globe. In

the article ‘Nitrate Accumulation in Plants, Factors Affecting the Process, and Human Health Implications. A review’ [17] The author introduced the effect of nitrate on plants and the harm of nitrate to humans and the effect of nitrate concentration on plants was investigated in detail by summarizing the study of ancestors. Meanwhile，based on the actual situation, it puts forward some measures to reduce the nitrate content in plants and some suggestions on diet and life.

2.6 Detection of nitrate in fruits and vegetables

Over the years scholars have also devoted themselves to studying fruits and vegetables in a definite region, for example, “Study of nitrate levels in fruits and vegetables to assess the potential health risks in Bangladesh “written by Rayhan Uddin et al. [18]. The experiment described in this article was conducted in Bangladesh, and it aimed to determine the levels of nitrate present in some fruits and vegetables in the local place. It has been shown that only carrot's nitrate slightly exceeds the limit. In general, there is no problem for residents to eat local fruits and vegetables.

In 2009, in “Nitrate and nitrite quantification from cured meat and vegetables and their estimated dietary intake in Australians” [19] James Hsu et al. studied nitrate levels in meat, fruits, and vegetables in Australia. They found that the main source of nitrate intake for humans is vegetables and that cured meat products contributed to the majority of dietary nitrate. It was also demonstrated that nitrate and nitrite content tested were below the guideline set by FSANZ (Food Standards Australia New Zealand) and their intake was within the range reported in the Western countries and was below the ADI (Acceptable Daily Intake).

These types of articles are good for helping residents understand their nitrate intake. It raises people's awareness of food safety.

People are increasingly becoming more aware of the relevance of nitrate, and at the same time, they are also improving their methods for detecting nitrate. After all, only

reliable tests can identify foods high in nitrates, and then people can take corrective action. In 2016, Romero-Galindo published the article " Biosensors Used for Quantification of Nitrates in Plants" [20]. This review first introduces several sensors and points out their advantages and disadvantages. The review shows different methods for quantifying nitrogen in plants. Then, the viewpoint of biosensors is put forward, which mainly focuses on biosensors based on genetically modified organisms. At last, this review lists promoters and reporter genes that can be used to develop different types of sensors and presents prospects for quantitative sensor measurement of nitrogen.

In "Detection methods of nitrate in water: A review" [21] Md. Eshrat E. Alahi and Subhas Chandra Mukhopadhyay introduced some direct and indirect methods for measuring nitrate content in water. The advantages and disadvantages of each technique are discussed in the article. Then pointed out that one of the primary issues is developing sensors with high reproducibility, and more studies should be done in this area.

Priyanka Singh and Manish Kumar Singh et al. published the article "A review on spectroscopic methods for determination of nitrite and nitrate in environmental samples" [22]. This study focuses primarily on providing a comprehensive overview of nitrate concentrations by using UV spectrophotometry. Other methods are also discussed at a small length such as Raman spectroscopy, IR and FTIR spectroscopy, atomic absorption spectroscopy, etc. But these methods are not as common as ultraviolet spectrophotometry. Because UV spectroscopy can be used as a detection device in combination with other sophisticated techniques like chromatography due to its low cost, easy feasibility, and high sensitivity. The limitations of ultraviolet spectrophotometry are also described on the page. This article concluded that for assessing nitrate concentration, the technique should be chosen based on its appropriateness for interferences and analyte concentration in the sample.

2.7 Significance of nitrate detection

Nitrate is a common inorganic salt and an important index component in fruits and vegetables. The concentration of nitrate is closely related to the variety of fruits and vegetables, growing environment, season, treatment methods, and other factors. In the market, there are often excessive fruits and vegetables sold, if excessive consumption of these fruits and vegetables containing excessive nitrate, it will cause serious harm to human health.

The significance of nitrate detection is to prevent and control the consumption and circulation of fruits and vegetables with excessive nitrate. By detecting the content of nitrate in fruits and vegetables, excessive fruits and vegetables can be found in time, and the normal consumption of healthy food can be ensured.

While conducting nitrate detection, some precautions need to be taken. Firstly, the appropriate sample should be selected to ensure that the quality of the sample meets the testing requirements. Secondly, the accuracy and reliability of detection methods and equipment should be controlled to ensure real and reliable test results. Finally, after the detection, it is necessary to conduct a scientific analysis and evaluation of the results and take corresponding measures to ensure the correctness and discriminability of the detection results.

3. Methods and Materials

3.1 Methods

In this thesis, the ultraviolet spectrophotometer method is chosen for the experiment. The ultraviolet spectrophotometer is widely used as chemical test equipment. This method can be used for most substance tests. Solution preparation and colorimetric experiment are indispensable parts of routine detection. Compared to other experimental methods, this method is simpler and more friendly to people who have entered the water body examination.

3.2 Sample Selection and Sampling

Due to the limited ability of the author, five kinds of representative fruits and vegetables were selected for the experimental samples. These foods are common staples in many people's diets. They are potato, radish, carrot, apple, and orange. These fruits and vegetables are sourced from the local supermarkets where most people do their shopping. They are Interspar, Tesco, Spar, and the Local market.

(Radish was not found in the local market in this case this data is missing.)

The study also analyzed the peel and pulp of fruits and vegetables (the peel is defined in various ways, but the peel here refers to the part of the fruit that people usually remove from their diet).

3.3Apparatus

UV-VIS spectrophotometer (Figure 1) (Milton Roy Spectronic 1201)

Figure 1. Milton Roy Spectronic 1201 UV-VIS spectorphotometer

Ultrasonic bath apparatus

Drying oven

Funnel， drying dishes， mortar， measuring cylinder, and test tubes.

3.4 Calibration

KNO_3 was used to prepare the calibration solutions. To prepare the stock solution, 0.07312 g of potassium nitrate was dissolved in 1 liter of distilled water in a volumetric flask (the concentration is 0.07312 g/L KNO_3). Then withdraw 1ml, 2ml, 4ml, 8ml, and 16ml solutions into a 50 mL volumetric flask. Filled distilled water to the mark mixed up and waited one minute to ensure it was mixed completely. The last step was using a UV-VIS spectrophotometer to do the measurement. Unfortunately, the upper limit of the photometer was lower than we could have read from the samples. This meant that the nitrate concentration was too high, and the solutions had to be further diluted. Therefore, to continue the experiment, the solution was diluted by a factor of 10, which was already within the measuring range of the instrument. The stock solution was then reconstituted, and the measuring solutions of known concentration were prepared. The results showed that the absorbance values were within the linear range of the instrument.

The calibration curve (Figure 2) was then prepared.

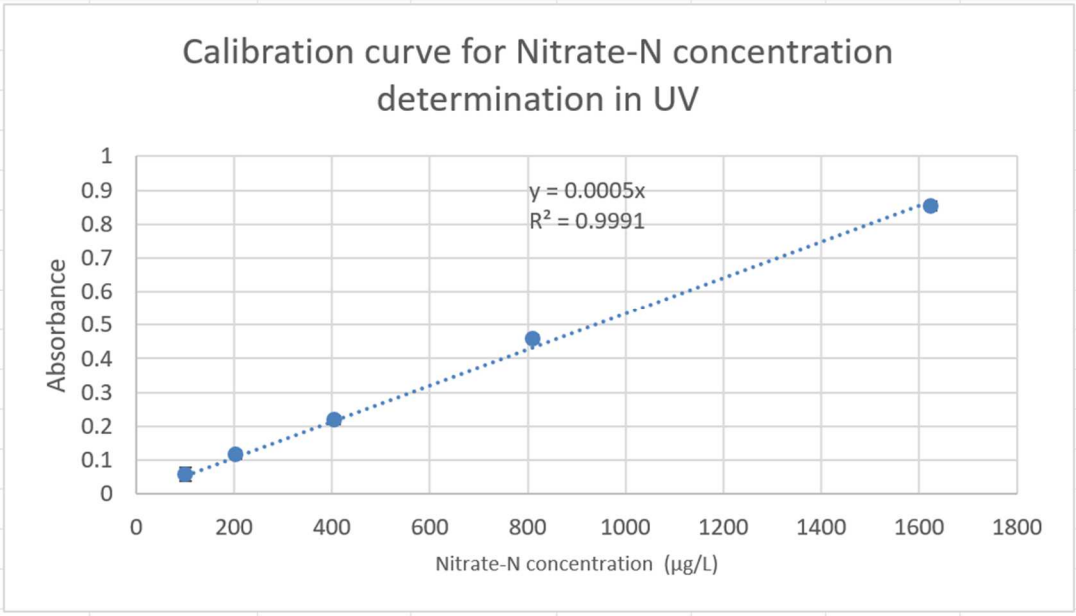

Figure 2 The calibration curve

The coefficient of determination (R^2=0.9991) of the trend line is, which means that the linearity of the trend line is good, in other words, this calibration line is indeed linear. This thesis decided to use this curve as the calibration rd curve for the following photometric measurement.

3.5 Sample preparation and extraction

The samples were pretreated according to Afali's experiment [23]. Took out the samples from the refrigerator and cut them into small pieces. The samples were then left in a drying oven at 80°C for 24 hours. The main purpose of this step was to completely dry out the samples. If this time was not sufficient to dry the samples, they were left in the drying oven until completely dry. Then, using a mortar (Figure 3), the dried samples were ground into smaller particles that are more easily soluble in aqueous solutions and make the nitrate more accessible. Finally, these samples were stored in closable containers.

Figure 3 Dried samples and the mortar

The preparation of the sample solution begins after the pretreatment of the sample. From each dried sample 0.250 g was weighted for the measurements. 50 ml of citric acid solution（0.2 g/l）was measured into a beaker to dissolve the samples and leach the nitrate-N from the particles. Then put the beaker into the ultrasonic bath. The ultrasonic bath was set for 20 minutes to completely remove nitrate from the solid powder samples. Next, it was used filter paper and a funnel to do filtration work. Filtering the sample twice is usually enough to obtain a clear, clear solution, but if not, repeat the filtration until a clear solution is obtained that is suitable for spectrophotometric measurement. The sample solutions prepared in this way were stored in a refrigerator until measurement.

3.6 Sample measurement

Nitrate concentration [24] was determined according to the American Public Health Association standard [25].

The nitrate concentration of the samples was determined by spectrophotometry in the UV range. For this method samples would be analyzed using an Ultraviolet -Visible Spectrophotometer (Figure 1) in the ultraviolet range at wavelengths of 220nm and

275nm.

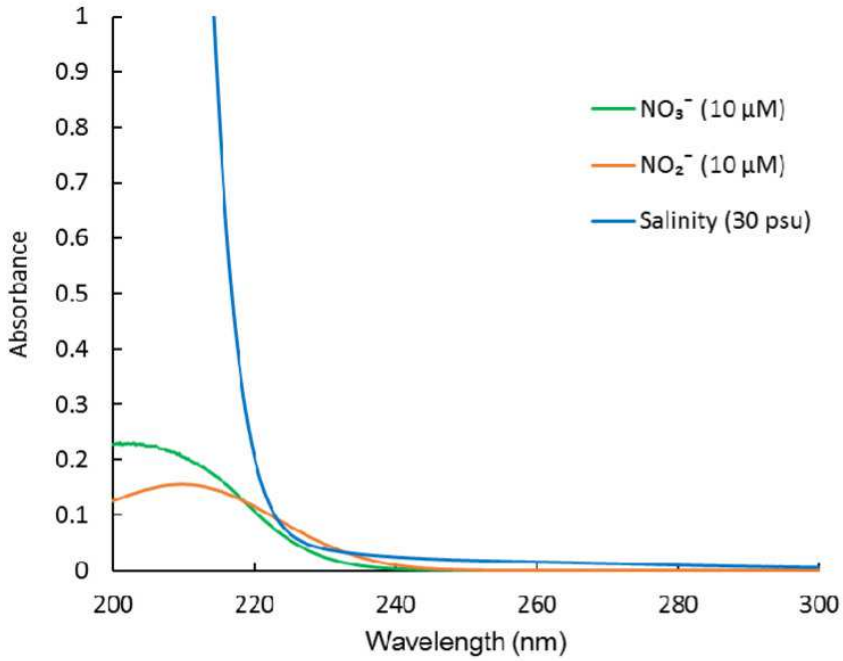

Figure 4. Spectra of Nitrate and Nitrite [26]

Nitrate has absorption around 220nm [26], but no absorption at 275nm, but organic matter does (Figure 4), so measuring at 275nm is used to estimate the amount of organic matter. Measurements at both wavelengths are used to correct for possible interference from dissolved organic matter.

The result of nitrate concentration is calculated according to the following equation:

$$A=A_{220nm}-2*A_{275nm}$$

And then comparing the corrected absorbance to a calibration curve (Figure 2).

5 ml of each sample solution was measured into a 50 ml volumetric flask. Added distilled water into the end line. 1 ml of 1M HCl should be added to minimize interference from dissolved organic matter. Each sample would be analyzed three times using the UV-VIS spectrophotometer and nitrate content was calculated by

using the above method.

The measurements were made at room temperature.

3.7 Statistical Analysis

3.7.1 Description

Experimental data and calculation results are included in Appendix 1.

After the completion of the experiment, all experimental data will be collected and recorded in Excel form. Data processing is done with the help of Excel forms.

3.7.2 Analysis of Variance

The descriptive statistics (Appendix 2) were performed with JASP version 0.17.2.0. According to this, as can be seen from the Q-Q graph, we can consider the data to be linear to a good approximation.

ANOVA (Appendix 2) two-factor analysis of variance SPSS 28.0.1 was performed. According to the “TEST of Between-Subject Effects” table, both vegetables and fruits were significantly different according to nitrate-N content and according to the store where the purchase was made.

4. Results and Discussion

4.1 Result Analysis

Based on the data Appendix 1. this paper also made a bar chart of nitrate content in fruits and vegetables in each store to show the difference.

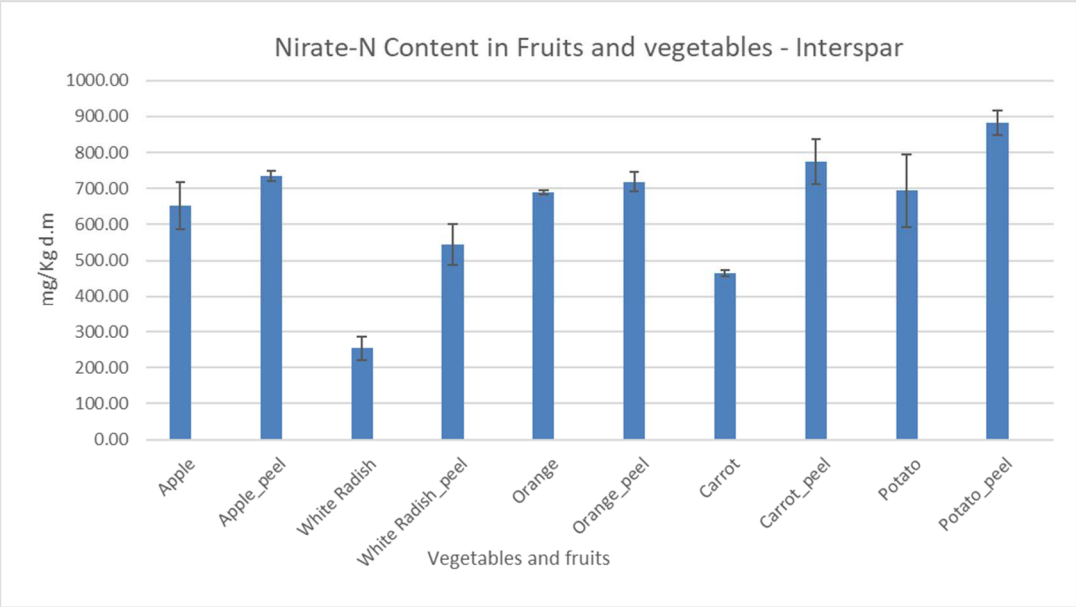

Figure 5 Nitrate-N content in vegetables and fruits-Interspar (d.m.=dry matter)

The nitrate-N content of fruits and vegetables from Interspar was introduced in this bar chart (Figure 5). Potato peel has the highest concentration. Fortunately, potatoes are always peeled when used in cooking. White radish has the lowest nitrate content, both its peel and pulp. The amount of nitrate in apples and oranges is very similar to that in the skin and flesh of the fruit. These types of fruits and vegetables had higher nitrate content in the peel than in the pulp.

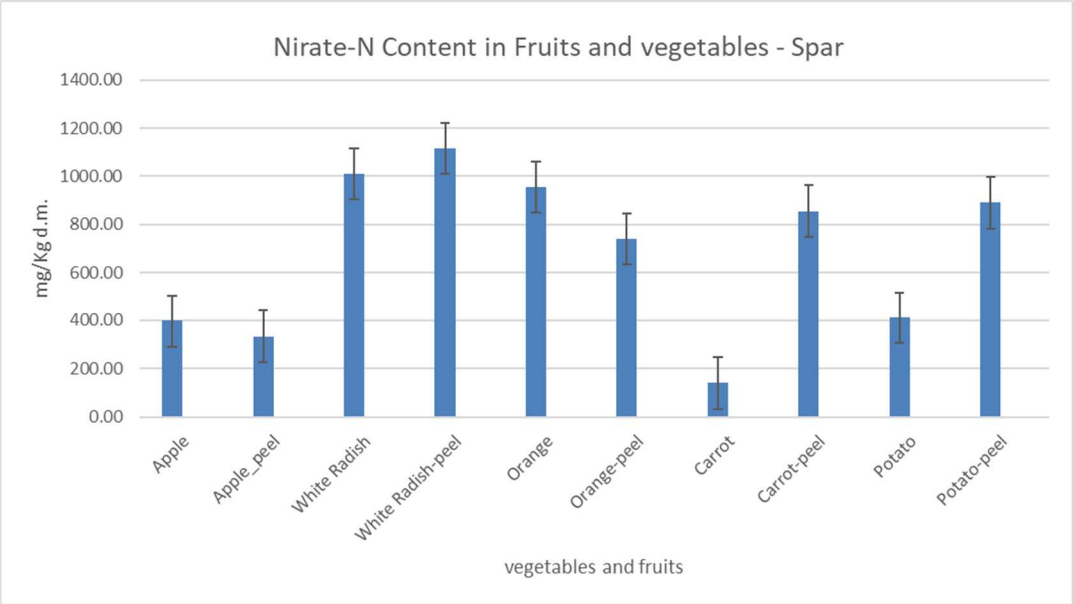

Figure 6 Nitrate-N content in vegetables and fruits-Spar

Figure 6 shows that the nitrate content of fruits and vegetables in Interspar and Spar is very different. Radish, both the peel and the pulp, had the highest nitrate content in Spar. There were also significant differences in nitrate levels between apples and oranges. Carrots had the lowest nitrate concentration.

In the spar's chart, only the rind of orange has less nitrate than the flesh.

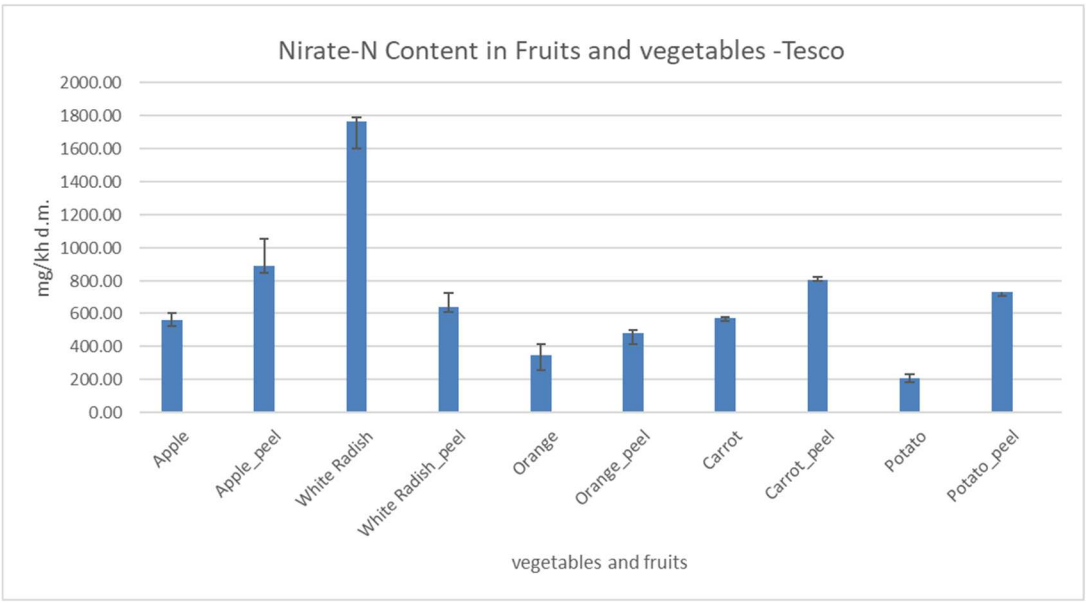

Figure 7 Nitrate content in vegetables and fruits-Tesco

Figure 7 shows the nitrate-N concentration in Tesco has a similar situation to Spar.

White radish had the highest nitrate content among the fruits and vegetables, and the peel had a lower concentration of nitrate than the white radish pulp. The potato has the lowest nitrate content of all.

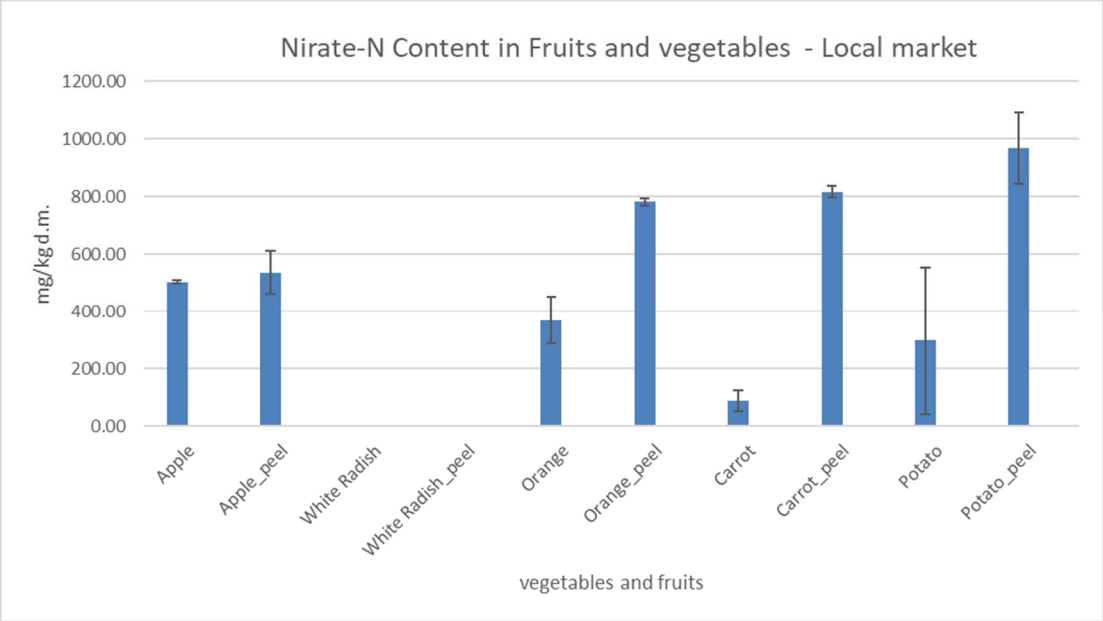

Figure 8 Nitrate-N content in vegetables and fruits in Local Market

Figure 8 shows that the carrot pulp had a lower nitrate content than the other vegetables and fruits, the same can be seen in the samples from Spar. Potato peel has the highest nitrate-N content.

Although the nitrate-N content of the five fruits and vegetables from different stores fluctuated, white radish was found to have higher nitrate content than the other four fruits and vegetables. The other four kinds of fruits and vegetables nitrate-N content in different shops have differences. From the point of view of reducing nitrate intake, it is best to reduce white radish consumption.

In general, fruits and vegetables in the local market have the lowest average nitrate content. Excluding radish, the nitrate levels of fruits and vegetables at Interspar were above average for all four.

To make it easier to compare the performance of the same fruits and vegetables in different stores, the following figures were made.

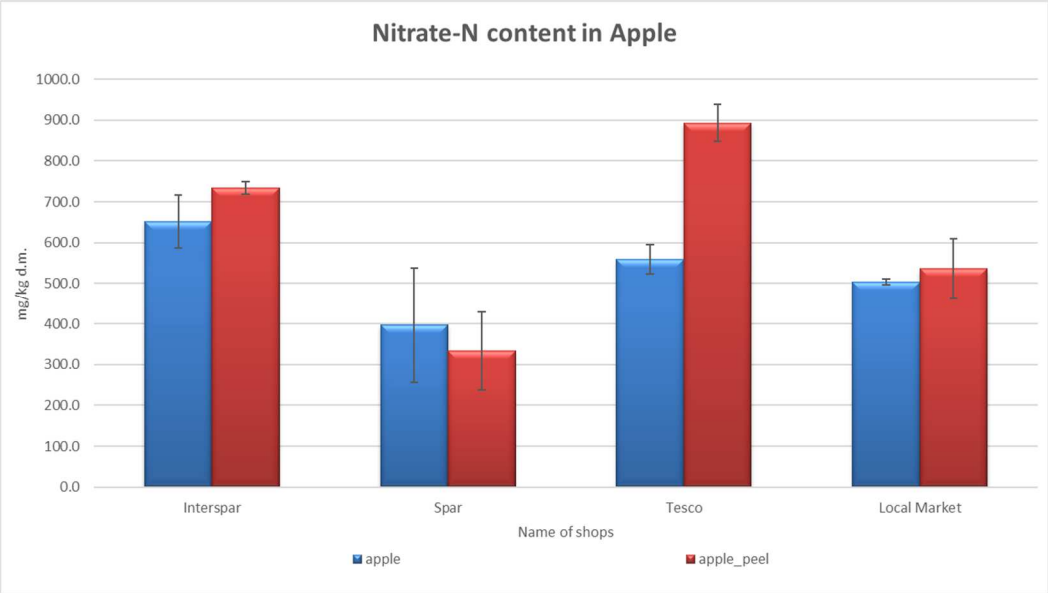

Figure 9 Nitrate-N content in Apple and Apple peel in different shops

Figure 9 shows that there is a significant difference in the nitrate-N concentration of the apple peel in the four stores. The highest concentration of nitrate-N in apple peel was found at Tesco, while the lowest concentration of nitrate-N was found at Spar.

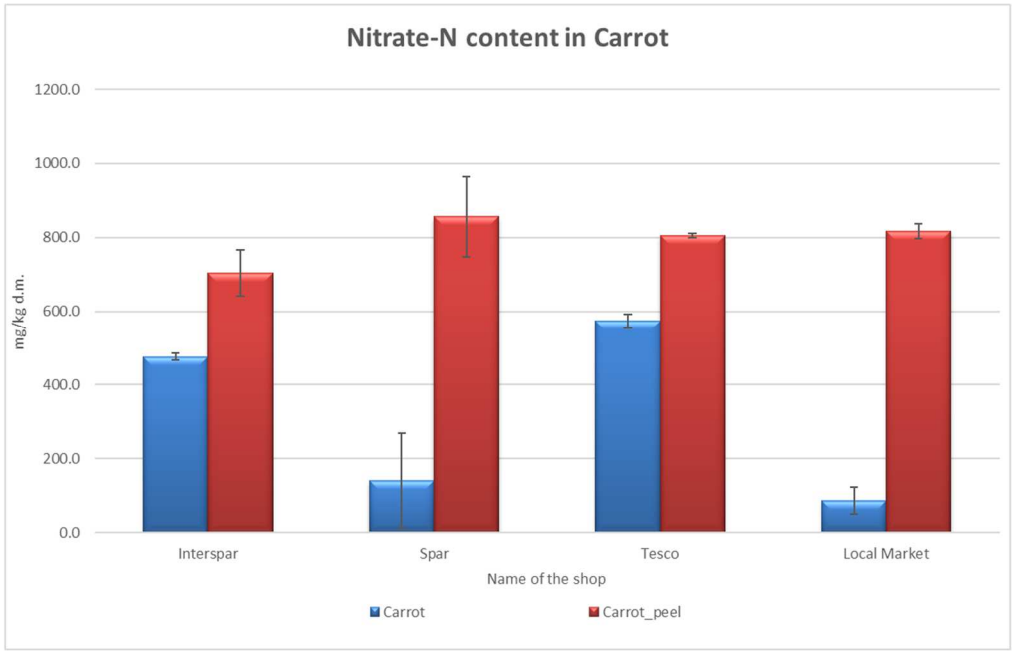

Figure 10 Nitrate-N content in Carrot in different shops

Figure 10 shows that the nitrate-N content of the pulp of carrots is always lower than that of the peel in four stores. Regarding the nitrate content of carrot pulp, Local Market and Spar have low nitrate-N content, while Interspar and Tesco have high nitrate-N content. The nitrate-N content of fruit and vegetables was similar for their outer peel.

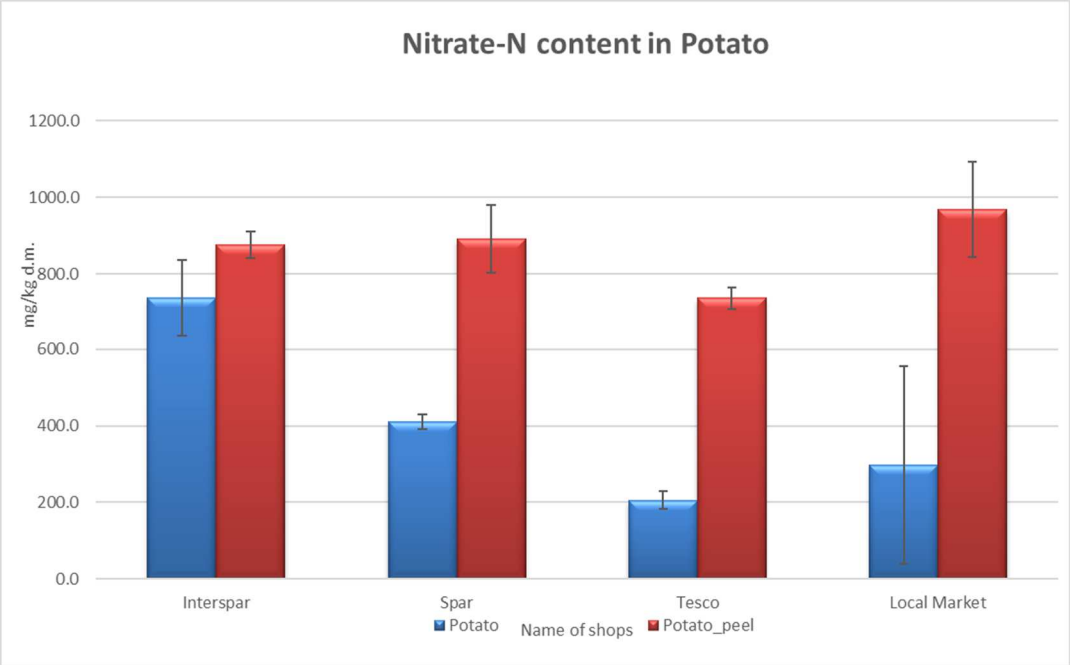

Figure 11 Nitrate-N content in Potato in different shops

Figure 11 shows the amount of nitrate-N in potatoes. Like carrots, potatoes have more nitrate-N in the skin than in the pulp. Potato peel has almost similar nitrate-N content in all four stores. However, Interspar potatoes have a much higher nitrate content in the insides than potatoes from the other three stores.

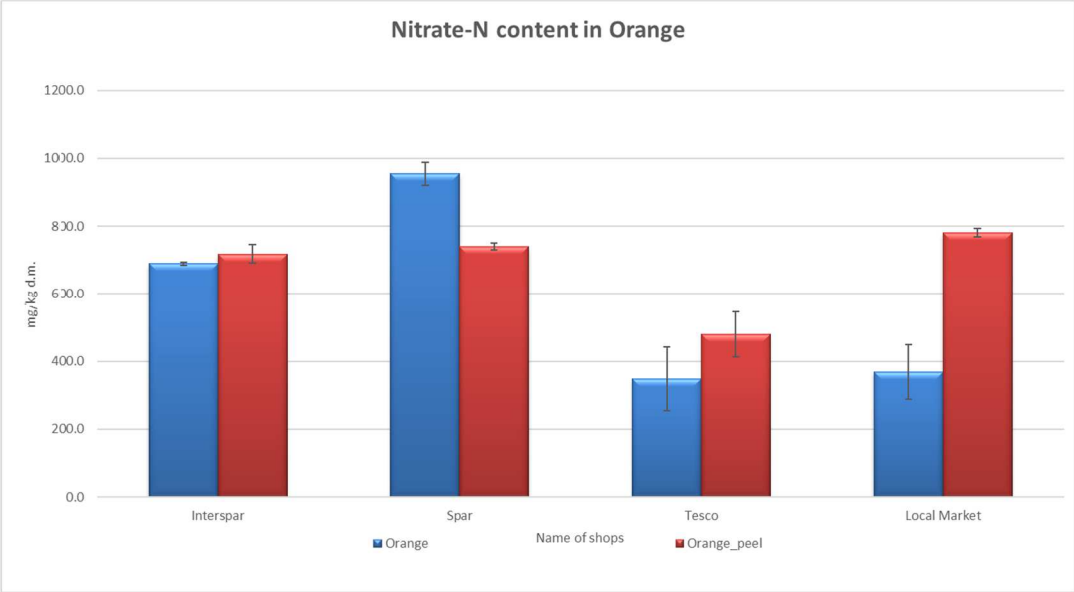

Figure 12 Nitrate-N content in Orange in different shops

The nitrate-N content of oranges in different shops is shown in Figure 12. The results show that the nitrate-N content of orange peel was similar in Spar and Interspar. For Interspar, there was no significant difference between the nitrate-N content of the peel and the inner pulp. Unlike the values measured in other fruits and vegetables. The pulp of Spar oranges had a higher nitrate-N content than the peel, and a similar conclusion can be drawn for the other three oranges. So, it is better not to choose oranges bought at Spar. Tesco is a better choice because it has the lowest nitrate levels in both oranges and orange peel.

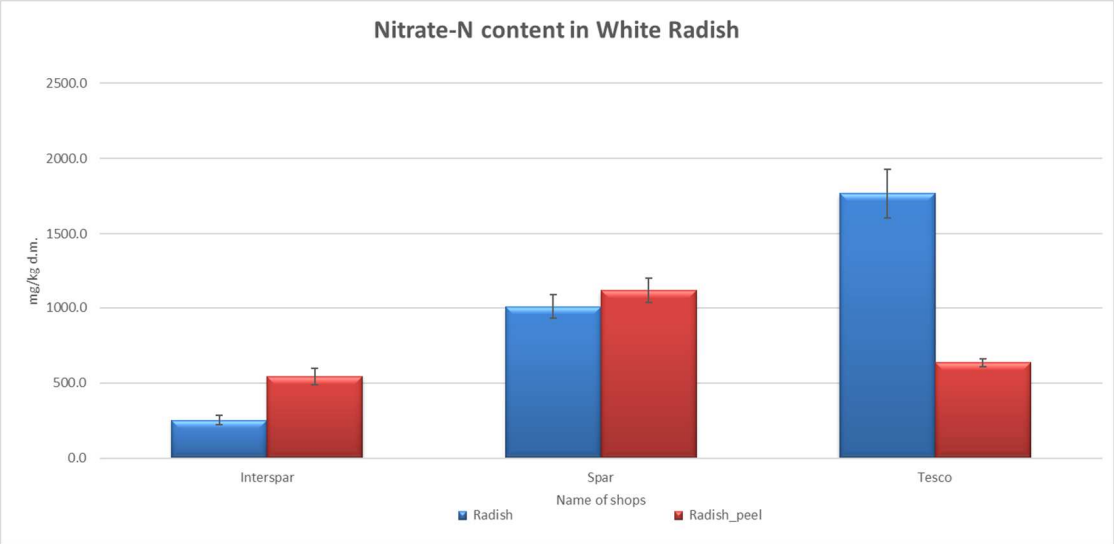

Figure 13 Nitrate-N content in Radish in different shops

According to Figure 13, the nitrate-N content of white radishes varies from store to store. Tesco had the highest nitrate-N content in white radishes, in the inner part of the vegetable. The lowest nitrate-N concentration in white radishes was found in Interspar, both in the peel and the pulp. Spar white radish had the highest internal nitrate-N content, in the middle of the range. In contrast, the peel of the white radish at Spar had the highest N in the three stores. There is no significant difference between the nitrate-N content of the peel of white radish from Tesco and Interspar. The data suggest that buying Interspar white radishes seems to be a good choice.

4.2 Discussion

When all the data were compared, it was discovered that the nitrate-N content of apples varied slightly, while the nitrate concentration of carrots changed the greatest. It may be that the nitrate-N concentration is fixed in proportion to the nutrients in the fruit. But the root, as an important organization for plants to absorb nutrients, is greatly affected by nutrients in the ground. Different soils provide nitrate to plants, so different carrot root has different nitrate-N content. Potatoes and white radishes are also roots and their nitrate-N concentrations fluctuate. Oranges, which are fruits, have

similar levels of nitrate-N.

In fruits and vegetables, the content of nitrate-N in the pulp is less than that in the peel. The main function of the peel is to protect the fruit and support the pulp. So, the peel is rich in cellulose. For plants, fruits and skins play different roles in growth and development, so different nitrate levels are reasonable. However, the flesh and skin of fruits are valuable sources of macronutrients and micronutrients. Humans peel fruits and vegetables mostly because the skin is difficult to clean and because of the fear of pesticide residues on the skin which is toxic to the human body. For this thesis, it is necessary to peel fruits and vegetables. It can be seen from the data that the content of nitrate-N in the peel of potatoes and white radishes is much higher than that in the pulp. So, to avoid unnecessary nitrate intake, keep a healthy diet and peel fruits and vegetables carefully.

For fruits, people should pay attention to apples because their nitrate content is the highest among fruits. There is a saying that “one apple a day keeps the doctor away” which encourages people to eat more apples. Apples are indeed rich in nutrients, but people should also be careful about nitrate intake. As for vegetables, people need to pay attention to potatoes. Europeans， people like to eat chips, although the studying said there is a clear decrease in the levels of nitrate and nitrite for the Punta potato variety, through the stages of French fried and chip potato [27]. People should be aware that potatoes themselves are high in nitrate content. French fries affect the body in other ways, for example, causing obesity problems.

Table 1. shows nitrate concentration in different studies and standard values to do the comparison within this thesis (Data source from [18], [28]).

Table 1 Average nitrate values of fruits and vegetables from other studies

	mg/kg	*mg/kg*
Apple	17.9	103.6
Orange	17.9	132
Potato	307.9	376

	mg/kg	*mg/kg*
Radish	2501.24	626
Carrot	36.8	503

Compare with the data from other studies. The nitrate concentration of fruits in this study is higher than Parvin Mirmiran's [25] than Rayhan Uddin's [18].

However, the nitrate concentration of vegetables was lower than in those studies. Through data comparison, we can see that nitrate concentrations in fruits and vegetables in different regions are different. The soil provided plant-essential nutrients and served as the foundation for human agriculture [29]. The relationship between soil and plants was mentioned earlier [14]. The main source of nutrients for plants is soil. The site of this experiment is different from the above experiments [18],[28] The fruits and vegetables used are the same but come from very different places. Although soil conditions are not mentioned in any of the articles, the authors speculate that soil types must vary widely. The soil will not contain the same amount of nutrients and nitrate. As mentioned above, water and fertilizer can also affect nitrate levels [13],[15]. However, the nitrate content in fruits and vegetables is affected by various factors, in this paper, it is speculated that the main reason affecting the nitrate content of the same fruits and vegetables is the difference in soil.

The ability of this paper is limited, and the specific reasons need to be explored by relevant scholars.

According to studies: The maximum nitrate amount to be ingested daily is less than 3.65 mg/kg by body weight. Accordingly, a person with an average weight of 70 kg should not consume more than 255.5 mg of nitrates daily [30]. Suppose people eat only these five fruits and vegetables, peel them before eating and do not do any cooking, and eat 80g of each. Calculate their daily fruit and vegetable intake based on the experimental data (assuming people only buy food from one store) (People shopping in the local stall will consume 100g each).

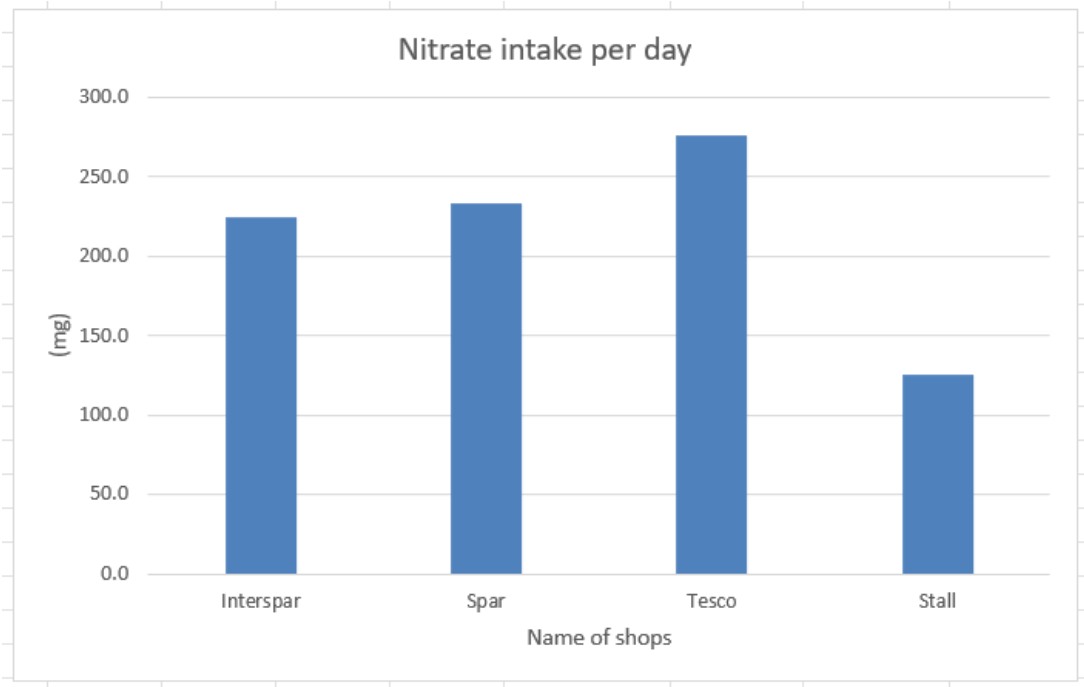

Figure 14 Nitrate intake per day for each shop

Only Tesco exceeded the 255.5mg standard (Figure 14). Those who bought food from the local market had the lowest nitrate intake. Since white radishes have a higher nitrate content than other fruits and vegetables, the lack of white radishes affects the local market calculations. When we calculate Tesco nitrate intake using the same calculation method that we used to calculate the local market. It found that the calculation result was 168.5mg which is 42.8mg higher than the Local Market's figure but lower than the limit of 255.5mg. In conclusion, the nitrate intake of fruits and vegetables from the four stores was safe without considering white radishes. If you want to buy white radish, don't buy it at Tesco. According to the reality of human life，due to the developed food culture, many people may not eat 400g excessive fruits and vegetables every day, and during the cooking process will reduce the nitrate content of vegetables. I think nitrate intake in fruits and vegetables should be very healthy for people living in Budapest.

The main sources of nitrate intake are not only fruits and vegetables, so people should pay attention to nitrate intake in other aspects of the diet.

4.3 Limitations of the Study

Only a few common fruits and vegetables were studied. It doesn't represent all fruits and vegetables. There are many conditions for nitrate content to affect nitrate content in fruits and vegetables. Therefore, many sample surveys are needed to accurately understand the nitrate content of fruits and vegetables in Budapest.

5. Conclusion and Suggestion

5.1 Summarize

Nitrate, when consumed in excessive amounts, will be transformed into nitrite inside the human body, which is harmful to human health. Vegetables and fruits are the leading contributors to dietary nitrates. This thesis studied a nitrate-N concentration of several fruits and vegetables in the local supermarket in Budapest using ultraviolet spectrophotometry. The study found that the fruits and vegetables studied by the WHO-recommended diet resulted in little excess nitrate intake. But the white radish from Tesco is high in nitrate. People need to pay attention to it.

5.2 Expand and Extend

Through the experiment, the author found many problems. The discussion and conjecture here hope to confirm the conjecture through more experiments.

Through comparison with other experiments, we can see that the nitrate content of the same fruits and vegetables from different countries varies greatly. In contrast, the nitrate levels of fruits and vegetables native to Budapest fluctuated less. You can see that the fruit and vegetable content of the market is less than that of the other three stores. The authors of this study propose two theories to explain why the same fruit in Budapest might have varied nitrate levels.

1. Different treatments for planting

Interspar, Spar, and Tesco as large stores need to prepare many goods. Mechanized plantations are now common because they are easy to manage, produce more and save human labor. They are the best place for large stores that need a lot of goods.

For small markets, their fruits and vegetables may come from plantations around the village. These plantations are small and managed by hand. Unlike large estates, people here can change the way they care for different plants based on how much

they know about them. It also allows you to control the amount of fertilizer you use, unlike mechanical plants that must ration fertilizer.

Different amounts of fertilizer and different ways of taking care of plants resulted in different nitrate contents in the same fruits and vegetables.

2. Different ways to store and sell

The shopping centers take a long time to stock up. Fruits and vegetables must be packed from their place of origin and transported long distances to store warehouses, where they must be transported again before they reach the shelves. Because of this process, it takes a lot of time for fruits and vegetables to be picked from their place of origin until they are brought home from the store.

Market stock is different. The owner of the market is probably. In the morning they collected the fruits and vegetables and drove into town to sell them. These fruits and vegetables will probably be on the table by the afternoon.

In this regard, the factors that affect the nitrate levels of fruits and vegetables installed and other stores are because the fruits and vegetables in markets are freshers.

The author can only make these two guesses by inference, and a more accurate investigation is needed to determine the causes affecting the nitrate content of fruits and vegetables in the four stores.

It can be seen from the article that the content of nitrate in the peel of fruits and vegetables is higher than that in the pulp. But the fact that only five types of fruit and vegetables were chosen doesn't say much about the common properties of the pulp and peel. In general, the surface of the fruit can be affected by factors such as environmental pollution or pesticide residues, resulting in higher nitrate levels on the skin of the fruit. The inside of the fruit is less affected by these external factors, so nitrate levels may be lower than in the peel. But it should be noted that the specific situation also depends on different fruit varieties, growing environment and picking time, and other factors to determine. The peel also contains a lot of nutrients as part

of the fruit. It's still very valuable. Once the pesticides are removed from the peel, the peel can be used in many ways, for example, dried orange peel can be soaked in water and people can drink it to absorb the fiber and vitamins in the peel. If you can't determine whether the peels of fruits and vegetables contain pesticides, you can also cut up the peels and use them as organic fertilizer. Compared with chemical fertilizers, they are more nutritionally comprehensive and do not pollute the environment.

5.3 Introspection

Every little error in the experiment can make a big difference, and post-experiment review can help to increase the experience of the experimenter and improve the skill of the experimenter.

There were many shortcomings in my experiment, and I realized some mistakes through self-review.

After I bought the fruit and vegetables, I stored them in the fridge until use. In this step I should pretreat the sample immediately after purchase: cut the sample into pieces and dry it in the Drying oven. Although low temperature can reduce the activity of the plant, it cannot completely stop the activity of the cells in the plant. I realized this by analyzing that the nitrate content of fruits and vegetables install is lower than that of fruits and vegetables in other stores. At the same time, I realized that sample preservation and treatment are also important experimental steps.

In the process of data processing, it was found that the data of some groups were quite different. The best thing to do with this data is to add more experiments. Provide more data to improve the accuracy of the experiment.

6. Summary

The harmful effects of nitrates on the body are converted from nitrite to nitrite and mainly to nitrosamines during food preparation, digestion in the intestinal tract, and storage (nitrate-rich foods such as spinach or carrots at room temperature).

In a healthy person, NO_3^- is excreted, but the 10% nitrite produced from the remaining nitrite is not enough for hemoglobin loss to cause methemoglobinemia in adults.

As we know, nitrate is also found in fruits and vegetables. Nitrate is necessary for the human body. But if a person consumes too much nitrate, it causes a problem. That's why it's important to know how much nitrate we take in daily.

In this thesis, samples of different vegetables and fruits (white radishes, potatoes, oranges, carrots, and apples) from different shops (Interspar, Spar, Tesco, Local Market) were selected. During the experiment, the nitrate concentration in the peel and pulp of each sample was determined in the dried samples. The cut samples were kept in a drying oven for 24 hours until completely dry. The dried samples were ground into powder in a mortar, then 50 ml of 0.2% citric acid solution was added to 0.25g of the sample and placed in an ultrasonic bath for 20 minutes to dissolve the nitrate ions. The samples were filtered twice, and then the filtrate was stored in a refrigerator until use. The samples were measured in the UV range with a spectrophotometer. The samples were measured at both 220nm and 275nm. To reduce the interfering effect of organic substances, 1 ml of 1 M HCl was added to 50 ml of solution. The empirical formula of the corrected absorbance value is as follows: $A=A_{220nm}-2*A_{275nm}$.

Descriptive statistics and two-factor ANOVA were performed. According to statistics, there is a significant difference in the nitrate-N content of fruits and vegetables. Looking at the stores, according to the two-factor ANOVA, there is a significant difference in the Nitrate-N content of vegetables and fruits bought in different stores.

According to the measurements, the Nitrate-N content does not exceed the health limits anywhere.

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Acknowledgments

It took nearly one month to finish the paper. In the process of writing the paper, I get numerous difficulties and obstacles, all of which were spent with the help of my classmates and teachers. I would like to express my strong thanks to my thesis advisor, Ms. Dr. Agnes Balint. She helped me a lot during the experiment. And guide me to write my thesis. I also want to thank my upperclassman, Xue Chu Wang. He gave me a lot of writing advice. Thanks to the authors of my references. Their articles made me learn more deeply about the relationship between nitrate, plants, and human beings. Due to my limited academic level, as my first paper, there are inevitably some shortcomings in my paper. I sincerely hope that our professors.

Appendix 1.

		1	2	3								
Stores	Fruits	Corrected A			c1(ug/L)	c2(ug/L)	c3(ug/L)	c1(mg/kg)	c2(mg/kg)	c3(mg/kg	Average	SD
Interspar	Apple	0.176	0.168	0.145	352.000	336.000	290.000	704.00	672.00	580.00	652.00	64.37
	Apple_peel	0.182	0.188	0.181	364.000	376.000	362.000	728.00	752.00	724.00	734.67	15.14
	White Radish	0.054	0.066	0.070	108.000	132.000	140.000	216.00	264.00	280.00	253.33	33.31
	White Radish_peel	0.125	0.152	0.131	250.000	303.800	262.000	500.00	607.60	524.00	543.87	56.48
	Orange	0.173	0.171	0.173	346.000	342.000	346.000	692.00	684.00	692.00	689.33	4.62
	Orange_peel	0.187	0.178	0.174	374.000	356.000	348.000	748.00	712.00	696.00	718.67	26.63
	Carrot	0.115	0.115	0.119	230.000	230.000	238.000	460.00	460.00	476.00	465.33	9.24
	Carrot_peel	0.205	0.200	0.176	410.000	400.000	352.000	820.00	800.00	704.00	774.67	62.01
	Potato	0.192	0.145	0.184	384.000	290.000	368.000	768.00	580.00	736.00	694.67	100.58
	Potato_peel	0.213	0.230	0.219	426.000	460.000	438.000	852.00	920.00	876.00	882.67	34.49
Spar	Apple	0.140	0.076	0.082	280.000	152.000	164.000	560.00	304.00	328.00	397.33	141.38
	Apple_peel	0.068	0.111	0.071	136.000	222.000	142.000	272.00	444.00	284.00	333.33	96.03
	White Radish	0.233	0.273	0.251	466.000	546.000	502.000	932.00	1092.00	1004.00	1009.33	80.13
	White Radish-peel	0.257	0.283	0.297	514.000	566.000	594.000	1028.00	1132.00	1188.00	1116.00	81.19
	Orange	0.247	0.230	0.239	494.000	460.000	478.000	988.00	920.00	956.00	954.67	34.02
	Orange-peel	0.187	0.182	0.186	374.000	364.000	372.000	748.00	728.00	744.00	740.00	10.58
	Carrot	0.000	0.063	0.042	0.000	126.000	84.000	0.00	252.00	168.00	140.00	128.31
	Carrot-peel	0.183	0.230	0.229	366.000	460.000	458.000	732.00	920.00	916.00	856.00	107.41
	Potato	0.101	0.108	0.099	202.000	216.000	198.000	404.00	432.00	396.00	410.67	18.90
	Potato-peel	0.243	0.226	0.199	486.000	452.000	398.000	972.00	904.00	796.00	890.67	88.75
Tesco	Apple	0.131	0.149	0.139	262.000	298.000	278.000	524.00	596.00	556.00	558.67	36.07
	Apple_peel	0.236	0.219	0.215	472.000	438.000	430.000	944.00	876.00	860.00	893.33	44.60
	White Radish	0.395	0.469	0.461	790.000	938.000	922.000	1580.00	1876.00	1844.00	1766.67	162.45
	Radish_peel	0.155	0.166	0.155	310.000	332.000	310.000	620.00	664.00	620.00	634.67	25.40
	Orange	0.074	0.114	0.073	148.000	228.000	146.000	296.00	456.00	292.00	348.00	93.55
	Orange_peel	0.139	0.112	0.109	278.000	224.000	218.000	556.00	448.00	436.00	480.00	66.09
	Carrot	0.148	0.139	0.143	296.000	278.000	286.000	592.00	556.00	572.00	573.33	18.04
	Carrot_peel	0.203	0.201	0.200	406.000	402.000	400.000	812.00	804.00	800.00	805.33	6.11
	Potato	0.045	0.053	0.056	90.000	106.000	112.000	180.00	212.00	224.00	205.33	22.74
	Potato_peel	0.192	0.181	0.179	384.000	362.000	358.000	768.00	724.00	716.00	736.00	28.00
Local marke	Apple	0.124	0.127	0.127	248.000	254.000	254.000	496.00	508.00	508.00	504.00	6.93
	Apple_peel	0.153	0.116	0.133	306.000	232.000	266.000	612.00	464.00	532.00	536.00	74.08
	Radish											
	White Radish_peel											
	Orange	0.074	0.114	0.089	148.000	228.000	178.000	296.00	456.00	356.00	369.33	80.83
	Orange_peel	0.199	0.194	0.193	398.000	388.000	386.000	796.00	776.00	772.00	781.33	12.86
	Carrot	0.014	0.032	0.019	28.000	64.000	38.000	56.00	128.00	76.00	86.67	37.17
	Carrot_peel	0.210	0.201	0.202	420.000	402.000	404.000	840.00	804.00	808.00	817.33	19.73
	Potato	0.111		0.112	222.000	0.000	224.000	444.00	0.00	448.00	297.33	257.51
	Potato_peel	0.218	0.277	0.231	436.000	554.000	462.000	872.00	1108.00	924.00	968.00	124.00

Appendix 2.

Results of statistics

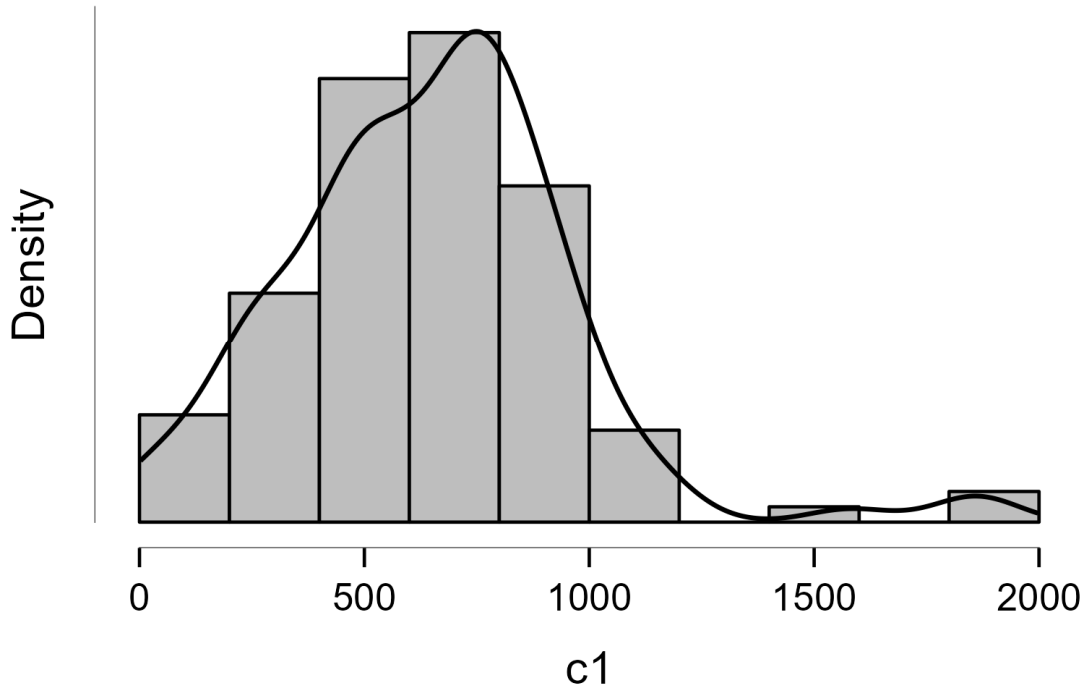
The descriptive statistics were performed with JASP version 0.17.2.0. According to this, as can be seen from the Q-Q graph, we can consider the data to be linear to a good approximation.

Descriptive Statistics

	c1
Valid	114
Missing	6
Median	678.000
Mean	647.856
Std. Deviation	319.760
Skewness	0.864
Std. Error of Skewness	0.226
Kurtosis	2.726
Std. Error of Kurtosis	0.449
Shapiro-Wilk	0.942
P-value of Shapiro-Wilk	< .001
Minimum	0.000
Maximum	1876.000

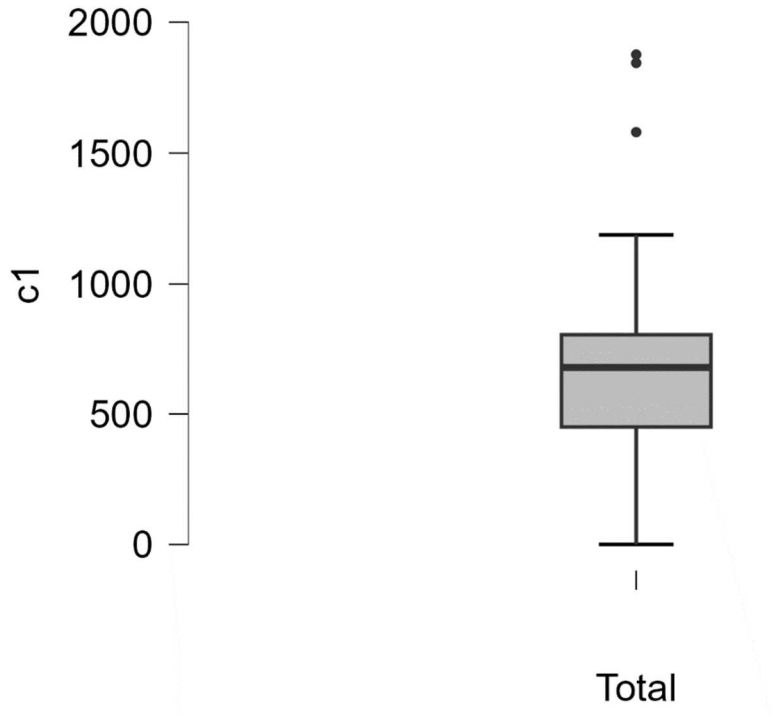
Distribution Plots

c1



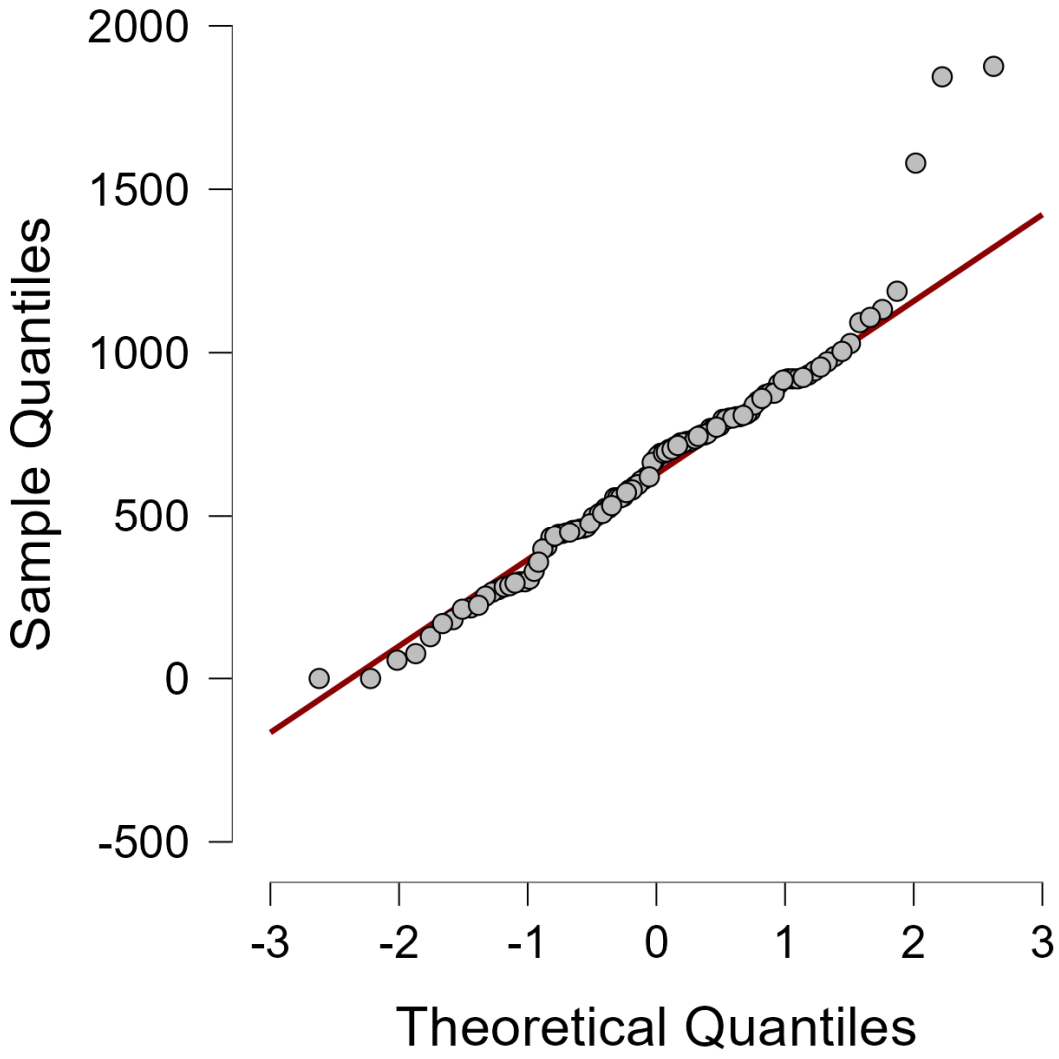
Boxplots

c1



Q-Q Plot

c1


Sample Quantiles
2000
1500
1000
500
0
-500
-3
-2
-1
0
1
2
3
Theoretical Quantiles

ANOVA

ANOVA two-factor analysis of variance SPSS 28.0.1 was performed. According to the "TEST of Between-Subject Effects" table, both vegetables and fruits were significantly different according to nitrate-N content and according to the store where the purchase was made.

Univariate Analysis of Variance

Between-Subjects Factors

		N
Fruits	Apple	12
	Apple_peel	12
	Carrot	12
	Carrot_peel	12
	Orange	12
	Orange_peel	12
	Potato	12
	Potato_peel	12
	White Radish	9
	White Radish_peel	9
Stores	Local market	3
	Interspar	27
	INterspar	3
	Local market	21
	Spar	30
	Tesco	30

Descriptive Statistics

Dependent Variable: Nitrate

Fruits	Stores	Mean	Std. Deviation	N
Apple	Interspar	652.0000	64.37391	3
	Local market	504.0000	6.92820	3
	Spar	397.3333	141.38364	3
	Tesco	558.6667	36.07400	3
	Total	528.0000	117.88438	12
Apple_peel	Interspar	734.6667	15.14376	3
	Local market	536.0000	74.08104	3
	Spar	333.3333	96.02777	3
	Tesco	893.3333	44.60194	3
	Total	624.3333	226.61755	12
Carrot	Interspar	465.3333	9.23760	3
	Local market	86.6667	37.16629	3
	Spar	140.0000	128.31212	3
	Tesco	573.3333	18.03700	3

Descriptive Statistics

Dependent Variable: Nitrate

Fruits	Stores	Mean	Std. Deviation	N
Apple	Interspar	652.0000	64.37391	3
	Local market	504.0000	6.92820	3
	Spar	397.3333	141.38364	3
	Tesco	558.6667	36.07400	3
	Total	528.0000	117.88438	12
Apple_peel	Interspar	734.6667	15.14376	3
	Local market	536.0000	74.08104	3
	Spar	333.3333	96.02777	3
	Tesco	893.3333	44.60194	3
	Total	624.3333	226.61755	12
Carrot	Interspar	465.3333	9.23760	3
	Local market	86.6667	37.16629	3
	Spar	140.0000	128.31212	3
	Tesco	573.3333	18.03700	3
	Total	316.3333	224.17174	12
Carrot_peel	Interspar	774.6667	62.01075	3
	Local market	817.3333	19.73153	3
	Spar	856.0000	107.40577	3
	Tesco	805.3333	6.11010	3
	Total	813.3333	61.64611	12
Orange	Local market	369.3333	80.82904	3
	Interspar	689.3333	4.61880	3
	Spar	954.6667	34.01960	3
	Tesco	348.0000	93.55212	3
	Total	590.3333	266.84123	12
Orange_peel	Interspar	718.6667	26.63331	3
	Local market	781.3333	12.85820	3
	Spar	740.0000	10.58301	3
	Tesco	480.0000	66.09085	3
	Total	680.0000	126.77826	12
Potato	INterspar	694.6667	100.58496	3
	Local market	297.3333	257.50599	3
	Spar	410.6667	18.90326	3
	Tesco	205.3333	22.74496	3
	Total	402.0000	225.76899	12
Potato_peel	Interspar	882.6667	34.48671	3
	Local market	968.0000	124.00000	3
	Spar	890.6667	88.75434	3
	Tesco	736.0000	28.00000	3

Tests of Between-Subjects Effects

Dependent Variable: Nitrate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11063515.561[a]	37	299013.934	46.346	<.001
Intercept	31336152.530	1	31336152.530	4856.949	<.001
Fruits	4731297.681	9	525699.742	81.481	<.001
Stores	730367.015	5	146073.403	22.641	<.001
Fruits * Stores	5838506.176	23	253848.095	39.345	<.001
Error	490338.240	76	6451.819		
Total	59401657.760	114			
Corrected Total	11553853.801	113			

a. R Squared = .958 (Adjusted R Squared = .937)

Post Hoc Tests

Fruits

Multiple Comparisons

Dependent Variable: Nitrate

LSD

(I) Fruits	(J) Fruits	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Lower Bound
Apple	Apple_peel	-96.3333*	32.79182	.004	-161.6439
	Carrot	211.6667*	32.79182	<.001	146.3561
	Carrot_peel	-285.3333*	32.79182	<.001	-350.6439
	Orange	-62.3333	32.79182	.061	-127.6439
	Orange_peel	-152.0000*	32.79182	<.001	-217.3106
	Potato	126.0000*	32.79182	<.001	60.6894
	Potato_peel	-341.3333*	32.79182	<.001	-406.6439
	White Radish	-481.7778*	35.41921	<.001	-552.3212
	White Radish_peel	-236.8444*	35.41921	<.001	-307.3879
Apple_peel	Apple	96.3333*	32.79182	.004	31.0228

Apple	Apple_peel	-96.3333*	32.79182	.004	-161.6439
	Carrot	211.6667*	32.79182	<.001	146.3561
	Carrot_peel	-285.3333*	32.79182	<.001	-350.6439
	Orange	-62.3333	32.79182	.061	-127.6439
	Orange_peel	-152.0000*	32.79182	<.001	-217.3106
	Potato	126.0000*	32.79182	<.001	60.6894
	Potato_peel	-341.3333*	32.79182	<.001	-406.6439
	White Radish	-481.7778*	35.41921	<.001	-552.3212
	White Radish_peel	-236.8444*	35.41921	<.001	-307.3879
Apple_peel	Apple	96.3333*	32.79182	.004	31.0228
	Carrot	308.0000*	32.79182	<.001	242.6894
	Carrot_peel	-189.0000*	32.79182	<.001	-254.3106
	Orange	34.0000	32.79182	.303	-31.3106
	Orange_peel	-55.6667	32.79182	.094	-120.9772
	Potato	222.3333*	32.79182	<.001	157.0228
	Potato_peel	-245.0000*	32.79182	<.001	-310.3106
	White Radish	-385.4444*	35.41921	<.001	-455.9879
	White Radish_peel	-140.5111*	35.41921	<.001	-211.0546
Carrot	Apple	-211.6667*	32.79182	<.001	-276.9772
	Apple_peel	-308.0000*	32.79182	<.001	-373.3106
	Carrot_peel	-497.0000*	32.79182	<.001	-562.3106
	Orange	-274.0000*	32.79182	<.001	-339.3106
	Orange_peel	-363.6667*	32.79182	<.001	-428.9772
	Potato	-85.6667*	32.79182	.011	-150.9772
	Potato_peel	-553.0000*	32.79182	<.001	-618.3106
	White Radish	-693.4444*	35.41921	<.001	-763.9879
	White Radish_peel	-448.5111*	35.41921	<.001	-519.0546
Carrot_peel	Apple	285.3333*	32.79182	<.001	220.0228
	Apple_peel	189.0000*	32.79182	<.001	123.6894
	Carrot	497.0000*	32.79182	<.001	431.6894
	Orange	223.0000*	32.79182	<.001	157.6894
	Orange_peel	133.3333*	32.79182	<.001	68.0228
	Potato	411.3333*	32.79182	<.001	346.0228
	Potato_peel	-56.0000	32.79182	.092	-121.3106
	White Radish	-196.4444*	35.41921	<.001	-266.9879
	White Radish_peel	48.4889	35.41921	.175	-22.0546
Orange	Apple	62.3333	32.79182	.061	-2.9772
	Apple_peel	-34.0000	32.79182	.303	-99.3106
	Carrot	274.0000*	32.79182	<.001	208.6894

Orange_peel	Apple	152.0000*	32.79182	<.001	86.6894
	Apple_peel	55.6667	32.79182	.094	-9.6439
	Carrot	363.6667*	32.79182	<.001	298.3561
	Carrot_peel	-133.3333*	32.79182	<.001	-198.6439
	Orange	89.6667*	32.79182	.008	24.3561
	Potato	278.0000*	32.79182	<.001	212.6894
	Potato_peel	-189.3333*	32.79182	<.001	-254.6439
	White Radish	-329.7778*	35.41921	<.001	-400.3212
	White Radish_peel	-84.8444*	35.41921	.019	-155.3879
Potato	Apple	-126.0000*	32.79182	<.001	-191.3106
	Apple_peel	-222.3333*	32.79182	<.001	-287.6439
	Carrot	85.6667*	32.79182	.011	20.3561
	Carrot_peel	-411.3333*	32.79182	<.001	-476.6439
	Orange	-188.3333*	32.79182	<.001	-253.6439
	Orange_peel	-278.0000*	32.79182	<.001	-343.3106
	Potato_peel	-467.3333*	32.79182	<.001	-532.6439
	White Radish	-607.7778*	35.41921	<.001	-678.3212
	White Radish_peel	-362.8444*	35.41921	<.001	-433.3879
Potato_peel	Apple	341.3333*	32.79182	<.001	276.0228
	Apple_peel	245.0000*	32.79182	<.001	179.6894
	Carrot	553.0000*	32.79182	<.001	487.6894
	Carrot_peel	56.0000	32.79182	.092	-9.3106
	Orange	279.0000*	32.79182	<.001	213.6894
	Orange_peel	189.3333*	32.79182	<.001	124.0228
	Potato	467.3333*	32.79182	<.001	402.0228
	White Radish	-140.4444*	35.41921	<.001	-210.9879
	White Radish_peel	104.4889*	35.41921	.004	33.9454
White Radish	Apple	481.7778*	35.41921	<.001	411.2343
	Apple_peel	385.4444*	35.41921	<.001	314.9010
	Carrot	693.4444*	35.41921	<.001	622.9010
	Carrot_peel	196.4444*	35.41921	<.001	125.9010
	Orange	419.4444*	35.41921	<.001	348.9010
	Orange_peel	329.7778*	35.41921	<.001	259.2343
	Potato	607.7778*	35.41921	<.001	537.2343
	Potato_peel	140.4444*	35.41921	<.001	69.9010
	White Radish_peel	244.9333*	37.86473	<.001	169.5192
White Radish_peel	Apple	236.8444*	35.41921	<.001	166.3010
	Apple_peel	140.5111*	35.41921	<.001	69.9676
	Carrot	448.5111*	35.41921	<.001	377.9676

	Potato_peel	-104.4889*	35.41921	.004	-175.0324	
	White Radish	-244.9333*	37.86473	<.001	-320.3475	

Based on observed means.
The error term is Mean Square(Error) = 6451.819.

*. The mean difference is significant at the .05 level.

Homogeneous Subsets

Stores

Multiple Comparisons

Dependent Variable: Nitrate
LSD

(I) Stores	(J) Stores	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence I Lower Bound	Uppe
Local market	Interspar	-265.6148*	48.88315	<.001	-362.9741	-
	INterspar	-325.3333*	65.58363	<.001	-455.9545	-
	Local market	-200.7619*	49.57656	<.001	-299.5022	-
	Spar	-315.4667*	48.63812	<.001	-412.3379	-
	Tesco	-330.8000*	48.63812	<.001	-427.6712	-
Interspar	Local market	265.6148*	48.88315	<.001	168.2556	
	INterspar	-59.7185	48.88315	.226	-157.0778	
	Local market	64.8529*	23.37062	.007	18.3063	
	Spar	-49.8519*	21.30767	.022	-92.2898	
	Tesco	-65.1852*	21.30767	.003	-107.6231	
INterspar	Local market	325.3333*	65.58363	<.001	194.7122	
	Interspar	59.7185	48.88315	.226	-37.6407	
	Local market	124.5714*	49.57656	.014	25.8311	
	Spar	9.8667	48.63812	.840	-87.0045	
	Tesco	-5.4667	48.63812	.911	-102.3379	
Local market	Local market	200.7619*	49.57656	<.001	102.0216	
	Interspar	-64.8529*	23.37062	.007	-111.3995	
	INterspar	-124.5714*	49.57656	.014	-223.3117	
	Spar	-114.7048*	22.85367	<.001	-160.2218	
	Tesco	-130.0381*	22.85367	<.001	-175.5551	

Spar	Local market	315.4667*	48.63812	<.001	218.5955	
	Interspar	49.8519*	21.30767	.022	7.4139	
	INterspar	-9.8667	48.63812	.840	-106.7379	
	Local market	114.7048*	22.85367	<.001	69.1877	
	Tesco	-15.3333	20.73937	.462	-56.6394	
Tesco	Local market	330.8000*	48.63812	<.001	233.9288	
	Interspar	65.1852*	21.30767	.003	22.7473	
	INterspar	5.4667	48.63812	.911	-91.4045	
	Local market	130.0381*	22.85367	<.001	84.5211	
	Spar	15.3333	20.73937	.462	-25.9727	

Based on observed means.
The error term is Mean Square(Error) = 6451.819.

*. The mean difference is significant at the .05 level.