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Mineral composition of different types of kitchen salts

Composição mineral de diferentes tipos de sais de cozinha

Abstract

Introduction: There is strong evidence showing an association between high sodium intake and the development of cardiovascular diseases, hypertension, and other metabolic complications. Although kitchen salt is an ingredient widely used by the population, the scientific literature about the study of its composition is scarce. Therefore, it is extremely important to know the composition of salts that are frequently used in cooking. ***Objective:*** To analyze the chemical composition of different types of cooking salts: refined/common, Himalayan pink, marine, and light. Parallel to this, pricing and labels were also analyzed to correlate with the chemical analysis. *Method:* The determination of minerals was performed by the method 3050-B rev.02 / SMEWW 3111-B and the quantification of metal levels was made by flame atomic absorption spectrometry. ***Result:*** Significant differences were observed in the amount of minerals found in salts of the same nature from different brands. The results showed that the Himalayan pink salt had the highest levels of calcium, iron, magnesium, and sodium compared to other types of salts ($p < 0.05$). Analyzing pricing and labeling information, prices were significantly different between products, and there was also a lack of information about their chemical composition. ***Conclusion:*** Results demonstrate that there are differences in the mineral composition of salts and indicate the need to identify the composition in the labels, thus enabling the population to make a cost-benefit assessment regarding the best type of salt and/or brand through their labels.

Keywords: Sodium chloride. Micronutrients. Hypertension.

Resumo

Introdução: Fortes evidências demonstram associação entre o alto consumo de sódio e o desenvolvimento de doenças cardiovasculares, hipertensão arterial, entre outras complicações metabólicas. A literatura é escassa, no entanto, em relação ao estudo da composição do sal de cozinha, um ingrediente amplamente utilizado pela população. Assim é de extrema importância conhecer a composição dos sais que se utilizam com frequência na culinária. ***Objetivo**:* Analisar a composição química de diferentes sais de cozinha: refinado/comum, rosa do Himalaia, marinho e light. Paralelamente, a precificação e os rótulos foram também analisados, a fim de relacioná-los com as análises químicas. ***Método**:* A determinação de minerais foi realizada pelo método 3050-B rev.02/SMEWW 3111-B e a quantificação de metais totais foi feita por espectrometria de absorção atômica com chama. ***Resultado**:* Observaram-se diferenças significativas na quantidade de minerais encontrada em sais da mesma natureza, provenientes de diferentes marcas. Os resultados mostraram ainda que o sal rosa do Himalaia apresentou maiores teores de cálcio, ferro, magnésio e sódio em comparação aos demais ($p<0.05$). Analisando precificação e informações de rotulagem, identificaram-se preços significativamente diferentes entre os produtos, além da ausência de informações sobre sua composição química. ***Conclusão**:* Os resultados demonstram que há diferenças na composição mineral de sais de cozinha e indicam a necessidade de identificar a composição desses nutrientes nos rótulos, possibilitando que a população possa escolher o melhor tipo de sal e/ou marca através do rótulo alimentar, levando em consideração o custo-benefício.

Palavras-chave: Cloreto de sódio. Micronutrientes. Hipertensão.

INTRODUCTION

The mineral sodium is found in kitchen salts in the form of sodium chloride. Sodium chloride (NaCl) is a mixture with 60% chloride and 40% sodium.[1] It is an ingredient used daily in food preparation, to add flavor, and to preserve foods.[2]

According to the *Sociedade Brasileira de Cardiologia*, the consumption of sodium in the conventional diet of Brazilians is almost double the maximum limit of intake per day, exceeding the physiological needs of individuals.[3] In Brazil, data from the *Pesquisa de Orçamentos Familiares* (POF) point to an average consumption of 4.7 grams of sodium/person/day,[4] while the reference for maximum sodium consumption in the country is 2.0 g per day of sodium.[3]

In Brazil, hypertension affects 32.5% of adult individuals and more than 60% of the elderly, contributing directly or indirectly to 50% of deaths from cardiovascular disease (CVD).[3] Excessive sodium consumption is one of the main risk factors for high blood pressure, diseases such as stroke, left ventricular hypertrophy, and kidney diseases.[2-4]

Refined salt, used daily by the population, is the main source of sodium in food.[5] This type of salt goes through a refinement process, in which most of the nutrients present are lost, leaving only sodium and chlorine.[1,5]

The pink Himalayan salt is a type of rock salt extracted from the Khewra mines in Pakistan.[6] This type of salt does not undergo refinement processes, which could justify the fact that it has significant amounts of minerals.[6,7] Concerning sea salt, this is a type of salt extracted from the sea, and like Himalayan pink salts, it does not undergo such extensive refinement processes.[1,6] The light salt is obtained from a mixture of 50% sodium chloride and 50% potassium chloride, which gives it a lower sodium content.[1]

There is no consensus regarding the use of salt to supply the body's needs for minerals, such as calcium, iron, magnesium, and zinc.[8-11] There is a lot of available information on the health benefits of these micronutrients,[12-15] however, to date, studies on the nutritional composition of salts and aspects related to their use in cooking are scarce.[5,6] It is also noted that the labels of these products do not have detailed information about their chemical composition. According to the Brazilian Resolution (RDC number 360, 2003), which establishes new rules for nutritional labeling, salt was one of the foods excused from this requirement, and only the quantity of micronutrients sodium and iodine should be included, in a conventional or simplified way. However, the addition of complete information on the chemical composition of the salts would assist the population when choosing the best type of salt and/or brand from the nutritional perspective. Also, another important conditioning element of the purchase is the price, and there is a large discrepancy in this parameter, which makes it even more difficult for consumers to choose.

Therefore, the present work aimed to quantify the sodium contents, as well as the main minerals present in different types of kitchen salts. Additionally, the information available on the labels and the pricing of these products were analyzed, allowing a better understanding of their added value. The results of this study can provide valuable information on the nutritional composition of the salts most commonly used by the population, and their cost-benefit, serving as a basis for future studies in the area of food for the scientific community and the population in general.

METHODS

Sampling and preparation

This experimental study was carried out in a Chemical Food Analysis Laboratory. Through a previous survey in a supermarket, selected for convenience, the most popular brands of each category of salt were evaluated, including refined/common, Himalayan pink salt, marine, and light. Then, the two most described brands for each category of salt were selected (the brands of the analyzed products were kept confidential for ethical reasons).

To carry out the analyzes, the samples were submitted to oven drying (A 5-SED, DELEO, Brazil) at a temperature of 60 ± 5° C for six hours.

Chemical analyzes

The determination of sodium (Na), calcium (Ca), iron (Fe), magnesium (Mg), and zinc (Zn) was performed by the method 3050-B ver.02/SMEWW 3111-B.[16] The quantification of total metals was performed by using flame atomic absorption spectrometry (AANALYST 200, Perkin Helmer, Finland), in equipment coupled with a background corrector and hollow cathode lamp of the element to be determined. The 3111B method provides a direct assessment of the air-acetylene flame. A metal mix standard with a concentration of 10 mg/L (Periodic table mix 1 for ICP) from Sigma-Aldrich (St. Louis, MO, USA) in a 10% nitric acid solution (65% PA, Quimica Moderna, Brazil) was used. The minerals were quantified using the standard curve, as described in Table 1. The acceptance criterion for the calibration curve was R^2>0.99. The analyzes were performed in triplicate and the results were expressed in mg/kg dry basis.

Table 1.Preparation of standard dilutions for the analysis. Caxias do Sul-RS, 2018.

Mineral	Standard 1 (mg/L)	Standard 2 (mg/L)	Standard 3 (mg/L)	Standard 4 (mg/L)	Standard 5 (mg/L)
Fe	0.50	1.00	1.50	2.00	3.00
Zn	0.20	0.40	0.60	0.80	1.20
Ca	0.50	1.00	2.00	3.00	4.00
Mg	0.25	0.50	1.00	1.50	2.00
Na	0.50	1.00	2.00	3.00	5.00

Statistical analyses

Data are expressed as mean (MD) and standard deviation (SD) of at least three independent analyzes for each sample. Statistical analyzes were performed using SPSS® software version 22.0 for Windows (SPSS inc., Chicago, IL). ANOVA analysis and Tukey post-test were used to verify the difference between the sample's mineral levels. For the variable "price", the analysis was performed for intra-group comparison. The *t*-test for independent samples was used to compare the mineral content from each brand. Results were considered statistically significant if p≤0.05.

As it is a study about food, it does not require an ethical appraisal by the Research Ethics Committee.

RESULTS AND DISCUSSION

In the present study, the flame atomic absorption spectrometry method was used for the qualitative and quantitative analysis of kitchen salts. This is a method that presents a high selectivity and sensitivity, reaching concentrations in order of ppm (parts per million) to ppb (parts per billion) of the analyzed substances. Through the flame atomization, the salt samples were volatilized (maximal temperature of 2.850 ºC) and decomposed (atomized) to produce a gas composed of atoms, which was analyzed. Table 2 shows the levels of calcium, iron, magnesium, sodium, and zinc in the analyzed samples. Quantification was based on the pattern curve that exhibited good linearity ($R^2 > 0.99$), and with a constant sensitivity in the working concentration range. In general, calcium was the most prominent among the quantified minerals, and the pink Himalayan salt was the one with the highest mineral content when they were analyzed together.

Table 2. Comparison of minerals (mg/kg) in different brands of salts (n=8). Caxias do Sul-RS, 2018.

Salt	Calcium	Iron	Magnesium	Sodium	Zinc
Refinad					
Brand A	234.88 ± 42.27	21.71 ± 0.31	64.52 ± 2.08	354.30 ± 8.40	2.32 ± 0.37
Brand B	1051.50 ± 120.90	27.66 ± 1.81	85.51 ± 0.77	347.36 ± 5.81	4.15 ± 0.26
p value	0.024*	0.084	0.011*	0.567	0.056
Pink					
Brand A	3615.77 ± 79.27	171.48 ± 28.32	3336.26 ± 158.29	371.08 ± 24.39	4.91 ± 0.10
Brand B	9365.44 ± 1388.59	97.91 ± 10.16	3728.82 ± 326.39	339.68 ± 11.08	5.74 ± 0.18
p value	0.054	0.134	0.392	0.362	0.058
Sea					
Brand A	967.10 ± 84.13	27.94 ± 1.84	226.23 ± 0.35	360.86 ± 19.94	4.63 ± 0.07
Brand B	619.98 ± 13.68	18.05 ± 0.52	100.87 ± 1.24	337.20 ± 1.91	4.12 ± 0.45
p value	0.054	0.035*	0.003*	0.359	0.387
Light					
Brand A	3066.26 ± 203.07	73.40 ± 2.97	129.87 ± 1.54	114.02 ± 2.76	7.99 ± 0.40
Brand B	680.83 ± 26.57	28.25 ± 1.37	134.21 ± 5.36	191.01 ± 3.59	6.91 ± 0.10
p value	0.007*	0.005*	0.518	0.003*	0.121

MD ± DP. *Statistical difference by t-test for independent samples ($p \leq 0.05$).

About the calcium, the Himalayan pink salt brand B had the highest content, about 61% higher than found in their brand A, the second with the highest content. On the other hand, the sample with the lowest calcium content was refined salt brand A, a difference of 97% to the sample with the highest content (pink, brand B). In addition to calcium, the iron was also found in greater amounts in the Himalayan pink salt, being sample A 42% higher than B for this mineral. The same was observed for the amounts of magnesium and sodium, however without statistical difference for the different brands.

In the present study, it was possible to observe higher levels of minerals in the pink salt samples. The composition of the Himalayan pink salt is due to minerals present in Himalayan soil as well as the natural characteristics of its zones.[6,7] This is extracted from the Khewra mines in Pakistan, with elements such as iron, calcium, and magnesium in its composition.[6,7] Except for these minerals, as shown in Table 2, the Himalayan pink salt has similar amounts of sodium compared to refined salt. These data corroborate those found by Bastos et al.[6]

Concerning zinc, the higher levels were found in light salt brand A followed by the light salt brand B (13% variation). The lowest amounts were found in refined salt brand A and sea salt mark B (2.32 and 4.12 mg/kg, respectively). Regarding iron, the smallest amounts were found in sea salt (18.05 mg/kg), followed by refined salt (21.71 mg/kg), both brand B. The mineral magnesium was found in a smaller amount in the refined salt, with a difference of 25% between brands A and B.

About sodium, the light salt contained the lowest levels. This result was not surprising, considering that this is recommended by the legislation. In fact, in the present study, the lowest amounts of this mineral were found in the light salt brand A followed by brand B (114.02 *versus* 191.01 mg/kg), respectively (Table 2). According to what is established by law and observing the label of these products, it was found that the sodium reduction was 66 and 50% in brands A and B, respectively, which helps to explain the difference found for these products.

Iron is a very important mineral for the human body, and its deficiency occurs when the nutritional reserves are depleted, mainly due to the negative balance between iron intake and its availability. When iron deficiency is critical, it can cause anemia.[9] Iron deficiency also causes other physical symptoms, such as tiredness and fatigue.[10]

Calcium, which is also essential for the human body, is responsible for the construction and maintenance of bones and is related to blood clotting and adiposity.[10] It is especially important during periods of accelerated growth, such as childhood and adolescence, and its adequate intake is related to the prevention of obesity, hypertension, insulin resistance, kidney stones, and colon cancer.[11] Magnesium, in turn, acts as a cofactor in metabolic reactions, playing a fundamental role in glucose metabolism, controlling insulin levels, and glycemic homeostasis. It also acts in the stability of the neuromuscular and cardiovascular membranes, in the maintenance of vasomotor tone, and as a physiological regulator of hormonal and immunological functions.[12]

The reduction of immunocompetence and the antioxidant defense system is a problem related to zinc deficiency,[13-15] which is also linked to cardiovascular problems.[13] The main sources of zinc are animal products such as oysters, liver, beef, dark poultry, veal, crab, and eggs. Whole grains also have a high zinc content, but the presence of non-nutritional factors decreases their bioavailability, while refined cereals have very low zinc levels.[8]

The present study aimed to compare the mineral composition of different kitchen salts, and it was observed that the difference in salts of the same type, but of different brands, is very large (Table 2). It needs to be emphasized that this information is not described on their food labels. Since labels are elements of communication that should assist consumers in the purchase decision, [17-19] the inclusion of such information could make a great contribution to increase consumer knowledge and make this market more informative and competitive. Legally, the nutritional label is a fundamental instrument in the act of purchasing, so that when it is well-understood, it allows consumers to make more judicious food choices.[18,19]

According to the Resolution (RDC number 360), [17] which establishes new rules for nutritional labels, salt was one of the foods excused from this requirement. The nutritional labeling of salt should only cover the micronutrients sodium and iodine, declared in conventional or simplified form. The inclusion of total mineral content on their labels would not only allow the population to choose the salutary type of salt and/or brand, but also to compare the best cost-benefit.

To better understand the difference in the mineral composition of the analyzed salts, the averages found in each type of salt were used for comparison (Table 3).

Table 3. Mineral levels (mg/kg) in different salt samples from the local market (n=8). Caxias do Sul-RS, 2018.

	Refined Salt (n=2)	Pink Salt (n=2)	Sea Salt (n=2)	Light Salt (n=2)
Calcium	643.04 ± 408.16 [a]	6490.60 ± 2874.83 [a]	793.54 ± 173.56 [a]	1873.17 ± 1193.09 [a]
Iron	24.68 ± 2.97 [a]	134.69 ± 36.78 [a]	22.99 ± 4.94 [a]	50.82 ± 22.57 [a]
Magnesium	75.01 ± 10.49 [a]	3532.54 ± 196.28 [b]	163.55 ± 62.68 [a]	132.04 ± 2.17 [a]
Sodium	346.33 ± 1.02 [a]	360.92 ± 10.16 [a]	349.03 ± 11.83 [a]	152.51 ± 38.49 [b]
Zinc	< 4.40 [a]	5.32 ± 0.41 [ab]	< 4.40 [a]	7.45 ± 0.54 [b]

MD ± DP. Different letters indicate statistical difference by analysis of variance (ANOVA) and Tukey's post-test ($p \leq 0.05$) for each mineral evaluated.

It is possible to observe that there was no significant difference in the amount of calcium and iron between the different types of salts. Magnesium, found in higher levels in Himalayan pink salts, showed a significant difference when compared to other types of salts ($p < 0.05$). There was also a significant difference between the amounts of sodium, with lower levels found in light salt. Also, high levels of zinc were found in the light salt, followed by Himalayan pink salts.

In a recent study, Karavoltsos et al.[20] compared unrefined sea and rock salts from Greece and found similar levels for iron and zinc in the analyzed samples. Moreover, in the study conducted by Chander et al.,[21] sodium content in black Himalayan salt was lower than found in common sea salt and pink Himalayan salt, highlighting the minerals iron, calcium, and magnesium that were found in higher amounts in black salt.

Differences in the nutrient levels of salts can be explained by the different harvesting techniques, or in the methods of refinement, grinding as well as the variation itself in the marine environment.[5] As previously discussed, the Himalayan pink salt stands out, due to the chemical and geological properties of their sources. Also, as it does not undergo refining, it retains its mineral content. The same does not happen with other types of salts. One of the main sources of sodium in the diet, refined salt [22] is the type that most suffer from refining, then most of the nutrients are lost, leaving only sodium and chlorine. [5] Sea salt, in turn, is closer to the natural, as it does not undergo refining, providing a higher amount of minerals, but with sodium amountssimilar to the refined. Finally, light salt is obtained from a mixture of 50% sodium and 50% potassium chlorides, which gives it a lower sodium content.[1]

There are different types of salts available on the market, so it is extremely important to know their chemical composition to assist the best choice by the consumer. A recommended ideal intake is a maximum of 2.0 g/day,[3] which is easily achieved by healthy eating. Excessive intake is associated with hypertension, which is considered one of the main modifiable risk factors and one of the most important public health problems.[3,22] Just as the excessive consumption of sodium can cause comorbidities,[23] the total exclusion of it is also harmful to health. Sodium present in the bloodstream is one of the elements that keeps the ideal amount of water out of cells to not overload the vessels.[24] In addition to regulating blood pressure, sodium is essential for muscle contraction and transmission of nerve impulses.[25]

One of the criteria that influence consumer choice is the price. Table 4 shows the pricing of the different types of salts studied here.

Table 4. Pricing (R$) of 500 grams of different salt samples from the local market (n=12). Caxias do Sul-RS, 2018.

Samples	Price (R$)
Refined (n=3)	1.13 ± 0.18 [b]
Pink (n=3)	19.29 ± 1.28 [a]
Sea (n=3)	2.81 ± 0.95 [b]
Light (n=3)	18.75 ± 3.18 [a]

MD ± DP. Different letters indicate statistical difference by analysis of variance (ANOVA) and Tukey's post-test ($p \leq 0.05$) for each sample evaluated.

Sea salt and refined salt were the most affordable salts found and showed a statistical difference when compared to the pink and light salts. In comparison to pink Himalayan salt, sea salt is approximately 12 and a half times cheaper, while refined salt is 20 times more affordable.

It is a consensus that a healthy and balanced diet, with all food groups, achieves all the minerals necessary for the body.[26] Since the daily consumption of salt must be low, its use is questioned to meet the needs of consuming minerals such as calcium, iron, magnesium, and zinc. Nevertheless, the best guidance for the use of salts is consumption in moderation. Whether pink, sea, light, or refined, it should be consumed in small quantities for seasoning *in natura* and minimally processed foods, also considering that processed and ultra-processed foods should be avoided, as they have large amounts of sodium *per se*.[1-4]

CONCLUSION

It can be observed, from the quantitative analyzes, that the Himalayan pink salt exhibited a greater amount of calcium, iron, magnesium, and sodium, compared to the other salts. There was also a great difference in the amount of minerals found in salts of the same type, but from different brands, and this information is not described on their labels. If the minerals composition were described on the labels, it would allow the population to choose the best type of salt and/or brand.

Considering the cost-benefit for the population and that the amount of sodium was similar in both types, except for light salt, the best orientation is not to overdo the amounts used. A healthy and balanced diet, with all food groups, contains all necessary and recommended nutrients for the body.

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Contributors

Siviero J and Chilanti G worked on the idealization of the study; Galiotto G worked in the analysis, data interpretation, and writing of the article; Branco CS and Facco EMP acted in the analysis and interpretation of the data; Galiotto G, Siviero J, Branco CS, Facco EMMP, and Chilanti G participated in the final review and approval of the manuscript for submission.

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