Review Article

A historical review of mineral water

Revisão histórica das águas termais

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ABSTRACT

The French cosmetics industry has been marketing thermal mineral waters that have certain biological effects. Previous studies have demonstrated that oligomineral elements have hydrating, antioxidant, and anti-inflammatory properties. This literature review discusses in vitro and in vivo clinical studies of commercially available thermal mineral waters to determine their effects on the skin and their main indications. A historical review was also carried out on the use of thermal mineral waters in dermatology, with an emphasis on identifying their physical and chemical properties and comparing the qualitative composition of the oligominerals present in those waters.

Keywords: Mineral waters, skin, cosmetics, hydrotherapy.

RESUMO

A indústria francesa de cosméticos tem comercializado águas minerais termais com alguns efeitos biológicos. Tem sido demonstrado que elementos oligominerais têm propriedades hidratantes, antioxidantes e anti-inflamatórias. Este trabalho de revisão aborda estudos clínicos in vitro e in vivo com águas minerais termais disponíveis comercialmente, determinando seus efeitos na pele, assim como suas principais indicações. Também foram feitas a revisão histórica dos usos de águas minerais termais na dermatologia com foco na identificação de suas propriedades físicas e químicas, bem como a comparação entre a composição qualitativa dos oligoelementos dessas águas.

Palavras-chave: *águas minerais, pele, cosméticos, hidroterapia.*

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INTRODUÇÃO

The French cosmetics industry has introduced thermal mineral waters as a substance that can generate biological effects, justifying its use in treating various dermatologic disorders. This study compiles historical and clinical references linked to the use of mineral waters in dermatology. In order to achieve that objective, it is necessary to define the various types of mineral waters and differentiate their physicochemical composition, which is crucial for their clinical applicability and use. Mineral waters – both thermal and non-thermal – that are commercially available in Brazil have diverse physicochemical characteristics, such as pH, the amount of oligoelements (light or heavy water), and composition, meaning that each mineral has different biological effects. All of these factors are important, and should be taken into account depending on the desired clinical outcome.

Mineral Waters

Natural mineral waters are solutions formed in specific geological conditions, and are characterized by the presence of "physico-chemical dynamics." They originate in springs, are bacteriologically pure, and have therapeutic potential.[1,2] They can be classified according to their chemical composition into: oligomineral, radipherous, bicarbonate-alkaline, alkaline-earth, calcic alkaline-earth, magnesian alkaline-earth, sulphated, sulfur, nitrate, chlorinated, ferruginous, radioactive, and thorium active and carbogaseous.[3,4] They can also be classified according to their therapeutic action or physicochemical characteristics, such as temperature, capacity, equilibrium, molecular concentration, chemical composition, and presence of oligoelements. Regarding temperature, mineral waters can be classified as cold (< 20°C) or hot (hypothermic if 20-30°C, thermic if 30-40°C, and hyperthermic if > 40°C). Regarding their chemical characteristics, mineral waters can be classified as: 4

- oligomineral water (mineral balance less than 0.2 g/L);
- medium balance water (mineral balance 0.2-1 g/L); or
- mineral water with mineral balance above 1 g/L.

History of Water Use

The use of water is vital to human existence. In some religions it is used in purification and medicinal rituals.[5,6] The Babylonians referred to doctors as water specialists, since they applied hot and cold compresses and used river bathing as part of their therapies.[7] In the time of the pharaohs, Egyptian farmers worshipped the River Nile, attributing supernatural powers to its waters.[8] Priests were required to purify themselves, bathing twice per day and twice per night, in order to be worthy to enter temples.[9] Baths had great importance for the ancient Greek civilization. The Greeks initially used individual bathtubs, but evolved to share public baths because they considered bathing to be a therapy for treating diseases.[10]

Hippocrates (460-370 BC) established the four essential elements (water, air, fire, and earth) as determinants of states of health or illness.[11] Asclepiades (c.124 BC) subsequently introduced hydrotherapy for his patients and used the ingestion of water as an important part of his method of treatment (preventive and curative). That practice was quickly adopted by the Romans, who were fascinated with how the Greeks used water. [12]

The first Roman baths were carried out in cold water. Under the reign of Caesar, the number of public baths, with both hot (tepidarium or calidarium) and cold water (frigidarium) increased rapidly. There were well-known spas, such as Titus', Caracalla's and Constantine's, and various new baths were built to treat diverse conditions, such as gout, fever, psoriasis, burns, and for healing, among others.[12] Galen (131-201) proposed the use of water – particularly cold water – for the treatment of various diseases – a concept that would be adopted and implemented during the following two millennia.[10] Water and baths had become an important part of European civilization due to the influence of the Roman Empire. In the 1st century, the Romans created public baths in regions close to England.[13] In Germany, public baths were adopted and vapor baths were introduced for therapeutic purposes. In Eastern Europe, Turks and Russians also adopted vapor baths.[14] With the fall of the Roman Empire in 476 and the rise of Christianity, the baths were discouraged. The Catholic Church alleged that baths, especially hot, were infamous and meant "an attack against chastity." As a result, the existing Roman baths were abandoned.[8,15] After the medieval period, the Church revised its position and started to support pilgrimages in search of curative water springs.[15]

In the 16th century, many renowned Italian physicians began to direct their attention to balneotherapy. However, those physicians eventually lost their focus and ended up proposing the routine use of water rather than employing it for specific empirical situations.[16] During the next 200 years, the interest in water remained restricted to England, where prominent physicians – such as Edmund Deane (1632), Edward Jorden (1631), and Sir John Floyer (1649-1734) – recognized the value of mineral water for the treatment of numerous illnesses.[10,17] In 1632, Ludovic Rowzee compiled a list of diseases that could be treated with mineral water, including gonorrhea and rheumatic and nervous system conditions. 18 From the 17th century, some spas, such as Lucca and Montecatini, could be found on the European continent. Vichy and Bourbon-Lancy waters became known in France during this period.[19] In the 18th century, baths were rehabilitated by the aristocracy, especially the French.

In the 19th century, hot springs were sought for their healing properties; their locations were called "rest and healing resorts" or "healing and pleasure" – the social amusements therein, rather than the search for health, were more attractive for spas visitors. The various authors who wrote about life in spas in the 19th and early 20th centuries emphasized the playful side, and the search for leisure and entertainment in water resorts.15 In the 19th century, the therapeutic use of mineral waters was transmitted to North America, where water wells were adopted and resorts and hot springs developed in very popular locations. As a consequence, mineral waters and spas became an important activity in the United States. Vincent Priessnitz (1799-1851) created a healing center with cold water in Graefenberg, Austria, that due to its popularity, became a medical school. 20 In the 20th century, the world had begun to become interested in the properties of the minerals contained in mineral waters, and rheumatologists, dermatologists, and psychiatrists were widely using them in their treatments. [21, 22]

The Use of Water in Brazil

In Brazil, the use of thermal waters began in 1818, when the first Brazilian spa was created. In that year, King Dom João VI issued a decree ordering the construction of a thermal hospital that should be governed by the same statutes as the "Hospital das Caldas da Rainha" in Portugal. That is considered the official beginning of hydrotherapy in Brazil (the term hydrotherapy is understood here as a therapeutic practice based on thermal waters applied within a bathing establishment). The thermal practice emerged and developed in Brazilian medical institutions

during the 19th century. It all started with the event of chemical analyzes of the waters in the first half of the 19th century and the construction of some spas (Caldas do Cubatão, Caxambu, and Poços de Caldas) in the second half of that century.

The first news about mineral waters, published in journals edited by the Academia Real de Medicina (The Brazilian Royal Academy of Medicine) in the 19th century (1839) referred to the Goyaz hot springs and the use of its waters in the treatment of morphea. Up to that date, however, few hot springs had been described in articles. It was only from the second half of that century, with the development of chemistry and medicine, that news spread about mineral waters, mainly as a result of analyzes performed that described their therapeutic properties. Physicians wrote and published more frequently than other professionals about this subject. Several medical theses were written on mineral waters; the first dates to 1841, and was written by Antonio Maria de Miranda Castro, who emphasized the potential of mineral waters and the need for Brazil to invest in that field, as was happening in Europe, where mineral waters served as a sanitary means and a valuable resource that underpinned health and prosperity. The knowledge and use of mineral waters were therefore primarily seen as a potential factor for economic development. Nonetheless, it was necessary to understand in detail the existing mineral water springs in Brazilian territory and to develop the science referred to as medical hydrology – which only happened in the late 19th century. In the 20th century, hydro-mineral resorts were recognized as places of healing and tourism, as reflected in the publication of some technical-scientific studies.[15]

The Use of Water in Dermatology

Water comprises about 60% of the skin's weight; the stratum corneum is relatively dry (15-40% water content). The exchange of water between the stratum corneum and the environment is an important function of the skin, and serves as an indicator of the integrity of the skin's barrier. Transepidermal water loss is a measure of this exchange, and is a useful assessment of the state of the skin barrier. In some dermatologic diseases, and with the aging process, the complex that forms the barrier's lipid layer might undergo alterations that contribute to the dryness and itching observed in those conditions. Water plays an important role in dermatological treatment through its hydration and cleansing properties and as a vehicle. [23]

The waters used to treat dermatological conditions contain various chemical products and specific physical properties. Generally rich in sulfur, hydrogen sulfides, and sulfates, they are used in many countries that have a variety of mineral springs and muds – which are considerably different from each other due to their hydrogeological origins, temperatures, and chemical compositions. [1] The main dermatological conditions that are often treated with balneotherapy with high success rate are psoriasis and atopic dermatitis. Nonetheless, many other conditions are also treated (acne, alopecia areata, contact dermatitis, eczema, granuloma annulare, ichthyosis vulgaris, lichen planus, lichen sclerosus et atrophicus, fungoid mycosis, necrobiosis lipoidica, palmoplantar keratosis, pityriasis rubra pilaris, pruritus, rosacea, scleroderma, sebopsoriasis, seborrheic dermatitis, chronic ulcer, urticaria pigmentosa, vitiligo, and xerosis). [1] Thermal water has been proposed as an anti-inflammatory and light hydrating agent. Thermal waters –in natura or dispensed in products or cosmeceuticals – have been indicated in dermatology as an adjuvant in skin hydration; in the treatment of aging skin, acne, rosacea, and other inflammatory dermatoses; and after cosmetic procedures such as chemical peels and laser. [24, 25]

An oligoelements complex composed of sodium, magnesium, zinc, and manganese has been proposed as replicating the effects of thermal waters in the skin. There are reports on the importance of various inorganic ions, such as calcium, sodium, zinc, magnesium, manganese, and potassium in the composition of the stratum corneum. [26] The clinical antimicrobial, keratolytic, and detergent properties of the sulphurous waters have been considered for many centuries. Sulfur can be present in its free or combined form, and there can be several combinations of sulfur ions with other ions. [27,28]

Commercially Available Thermal Waters in Brazil

Avène thermal water (Avène, Paris, France) is an oligomineral water (< 210 mg/L) with a high concentration of silicates and trace elements and a neutral pH. It is very well tolerated, and its dermocosmetic effects, such as its moisturizing action – which is useful for treating dry skin and decreasing the pinching sensation in the skin – have already been demonstrated. 4 Studies carried out with humans have shown that Avène water is capable of reducing erythema, desquamation, and burns in patients with sensitive skin.[29] Many *in vitro* studies aim to understand the Avène thermal waters' mechanism of action, having shown that this silicate-rich oligomineral water reduces the production of IL-4 (inflammatory interleukin) and the degranulation of basophils in atopic patients.[30,31] Such data partially explain why adjuvant therapy with this water is effective in the treatment of atopic dermatitis, rhinitis and conjunctivitis.[4]

La Roche-Posay thermal water (La Roche-Posay, Paris, France) contains low levels of minerals with dermatologic effects (for example bicarbonate, calcium, and silicate) and, in particular, a high concentration of selenium, which is essential for regular cellular metabolism and has a protective effect on human cells, maintaining cell integrity and neutralizing free radicals and organic peroxides, acting on eczema, psoriasis, acne, and burns. Furthermore, its effect against photoaging, due to its antioxidant properties, has been demonstrated.[32,33] A study carried out with cultured human fibroblasts, which compares the effects of mineral water, demineralized water, and demineralized water enriched with selenium, demonstrated that the absorption of selenium, zinc, and copper by fibroblasts was higher in the mineral water culture and that cellular mortality due to oxidative stress (UVA/UVB radiation and hydrogen peroxide) was significantly reduced. Moreover, the superoxide dismutase's activity was greater in cells cultured with mineral water. The presence of selenium increased resistance to UVB radiation through the neutralization of free radicals, and zinc protected

the thiol groups and strengthened the liposomes' and microsomes' membranes. 4 Another study demonstrated that La Roche-Posay water inhibits the migration of sensitized Langerhans cells and reduces the expression of activation molecules (HLA-DR, B7-2, and ICAM-1), increasing their anti-inflammatory activity. 34 The history of La Roche-Posay's water dates back to 1617, when Dr. Pierre Milon analyzed treatment based on it due to the positive outcomes obtained, and subsequently reported the results. Nearly 200 years later, Napoleon built a hospital in La Roche-Posay to treat his soldiers' dermal conditions. Nevertheless, it was only in the 1990s that scientific research began to elucidate that water's mechanism of action. [35]

A bibliographic review showed that Vichy thermal water (Vichy, Paris, France) has also been used for local application in the treatment of certain skin conditions. Based on those data, the effects of Vichy thermal water on the skin were studied using skin enzymatic systems. The results of the first in vitro and in vivo studies suggested a statistically significant increase ($p < 0.05$) in the catalase enzyme's activity in the presence of that thermal water. Considering the role of catalase in the skin's defense against generated oxygen-derived free radicals, its increased activity may explain the beneficial role of Vichy water observed in the treatment of various dermatoses. [36] The main physicochemical differences between the three mineral waters described above are shown in table 1.

SPECIFIC USES IN DERMATOLOGY

Cellular Renewal

Thermal waters are considered a particular type of underground water, which are enriched with minerals such as sodium, magnesium, zinc, boron, and manganese contained in rocks and emerge to the surface via springs.[37] Experimental studies have demonstrated that these oligoelements stimulate the migration of keratinocytes, meaning they may promote cellular renewal. [38]

Hydration

A study has evaluated the stability and influence of thermal waters or their oligoelements in dermocosmetic formulations, as well as the immediate effects of their application on the skin. The results obtained in both subjective and objective evaluations were coincident, suggesting the usefulness of cosmeceuticals containing oligoelements in skin hydration and as an adjuvant in dermatologic treatments. [37]

Healing of Wounds

According to some authors, thermal waters rich in boron and manganese originating from springs in the Saint-Gervais region in France stimulated the migration of keratinocytes in vitro, meaning they can improve the healing of wounds. [38,39] Zinc acts on the skin's physiology by modulating the inflammation, accelerating the re-epithelialization process and stimulating the proliferation of keratinocytes and fibroblasts. [40] Manganese and copper salts can also stimulate the proliferation of keratinocytes, accelerating the recovery of the cutaneous barrier. [39]

Keratolytic Effects

Sulfur's activity in the skin seems to be primarily related to its interaction with cysteine and its catabolites. Sulfur, which reacts with cysteine, interacts with hydrogen sulfide gas (H2S), promoting keratinization in low concentrations – a well-known keratolytic effect that determines the proteolysis of keratin. [4,41,42] Histological alterations in the skin caused by bathing in sulfur waters have been described. They include hyperkeratosis, parakeratosis, and keratolysis, all of which occur in different concentrations of sulfur ions following sulfur baths, when blood vessels in the dermis dilate. [4,43]

Antibacterial and Antifungal Effects

Sulfur can also interact with oxygen radicals in the deeper layers of the epidermis, producing sulfur and hydrogen disulfide, which may in turn be transformed into H2S5O6 – which may be the source of antibacterial and antifungal activity of sulfur water. [4]

Sulfur's antibacterial and antifungal properties can explain why this type of mineral is effective in treating infected ulcers in the leg, tinea versicolor, tinea corporis and tinea capitis. [44,45]

Table 1: Physicochemical differences between thermal waters

Brand of water Location of spring	Avène France	Vichy France	LaRoche France
Temperature (ºC)	25.6		
pH	7.5	7.0	7.0
Conductivity (m/cm at 20°C)	343.1		
Silica (mg/L)	14.00		31.60
Bicarbonates (mg/L)	226.70	4776.30	387.00
SO2-4 (sulfate) (mg/L)	13.10		
Cl (chloride) (mg/L)	5.40	357.00	
NO 3 (nitrate) (mg/L)	1.40		
F (fluoride) (mg/L)	0.10		
PO3-4 (phosphate) (mg/L)	0.30		
Fluoride (mg/L)		8,80	
Ca2 + (calcium) (mg/L)	42.70	150.60	149.00
Mg2+ (magnésio) (mg/L)	21.20	12.30	4.40
K + (potassium) (mg/L)	0.80	99.60	
Na + (sodium) (mg/L)	4.80	1860.00	
Fe2 + (iron) (mg/L)	< 0.1	1.00	
Mn2 + (manganese) (mg/L)	< 0.1		
Sr2 + (strontium) (mg/L)	0.1000		
Li (lithium) (mg/L)	< 0.1		
B (boron) (ug/L)	220.00		
Zn (zinc) (ug/L)	20.00		< 5
Cd (cadmium) (ug/L)	2.00		
Cu (copper) (ug/L)	< 5		
Se (selenium) (ug/L)	< 5		53.0000
Ba (barium) (ug/L)	220.00		
Dry residue at 180oC (mg/L)	207.00	5119.60	595.00

Baths can alleviate many types of pruritus, particularly the senile and chronic forms of pruritus. Lesions in those patients are caused by scratches and benefit from the antiseptic properties of certain waters. [1]

Acne and Oily Skin

The effectiveness of sulfur waters in dermatology has been described in cosmetology and in certain skin disorders. For its detergent property, in particular, it can be used in oily and mixed skin types to remove excess sebum without inducing a reduction of lipids, which entails irritation. In addition, along with their keratolytic and antimicrobial effects, sulfur waters can be used to treat light acne. [4]

Immunological Aspects

Hydro-massage baths containing sulfur have also been successfully used as an adjuvant treatment of moderate cases of so called immune-mediated conditions, such as atopic dermatitis, contact dermatitis, and psoriasis, suggesting that sulfur may play a role in the regulation of the skin's immune response. [46] Sulfur is known to be especially effective in the treatment of psoriasis. Sulfur penetrates the skin and is oxidized, inducing diverse physiological responses in the skin, such as vasodilation of the microcirculation, analgesic effect on pain receptors, and inhibition of immune response. [1] Atopic dermatitis, in its dry phase, can be soothed by local treatment that is aimed at improving skin hydration and protecting it from external irritants. Thermal water baths can prepare skin for the application of moisturizers and are useful for controlling the symptoms of acute exacerbation in the skin in refractory cases of atopic dermatitis.

Magnesium decreases guanylate cyclase activation and hence the production of cyclic adenosine monophosphate in the epidermis, thus reducing excessive cell proliferation, which is an important element of the psoriatic condition. It has also been demonstrated that magnesium inhibits the synthesis of certain polyamines, which are involved in psoriasis' pathogenesis, improving the condition. Magnesium also has a anticarcinogenic effect, since tissues with high concentrations of magnesium have less incidence of cancer (compared to tissues with low concentrations), and cause vasodilation, which decreases arterial pressure. [1] Thermal waters have bactericidal activity and can inhibit the manifestation of *Staphylococcus aureus* in the skin, a common microorganism in acute atopic dermatitis. The bactericidal activity is caused by the presence of manganese and iodide ions in the water. [1] It also improves seborrheic dermatitis, relieving inflammation by suppressing the bacteria residing on the skin and keeping the skin dry. The keratolytic action of the water also facilitates the removal of fat and skin scales. Baths with relatively large quantities of sodium chloride are very useful for that purpose. [1]

Antioxidant and Photoprotective System

A further study looked at protecting skin from UVB radiation-induced lipid peroxidation and carcinogenesis with the percutaneous application of mineral water rich in selenium. This study was conducted in three groups of mice that repeatedly underwent UVB radiation for 25 weeks: Group 1 received the application of a cream formulated with mineral water rich in selenium, Group 2 received a cream formulated with demineralized water, and Group 3 did not receive treatment. There was a significant reduction in the appearance of skin tumors, reduced lipid peroxidation of membranes, and an increase in glutathione peroxidase activity in the group treated with the cream containing mineral water with selenium. Those studies therefore demonstrated that oligoelements (selenium and zinc) contained in mineral waters are effective in strengthening the defense system against free radicals. [47] Selenium is an essential oligoelement. In high doses, it is toxic and inhibits cell growth and DNA synthesis, whereas in small doses it promotes DNA synthesis and cell growth. Selenium also works as an antioxidant and anti-inflammatory, and protects against UVA and UVB radiation. [1] In a study aimed at verifying whether the therapeutic use of mineral water had any influence on the antioxidant system, the volunteers were divided into three groups: Group 1 bathed in alkaline thermal springs, Group 2 bathed in mineral water containing chlorine, and Group 3 bathed in tap water. The levels of catalase, superoxide dismutase, malondialdehyde, and glutathione peroxidase were measured at the beginning and end of the study; the measurements suggested that hydrotherapy with both mineral waters reduced the activity of all enzymes studied. In contrast, the use of tap water did not influence any enzymatic activity. That study concluded that thermal water can have a beneficial effect on the formation of free radicals, inducing changes in the enzymes' activity. [48]

Anti-inflammatory Activity

The anti-inflammatory activity of mineral waters rich in selenium has already been demonstrated in in vitro studies carried out with Langerhans cells. One of the studies examined the effect of mineral waters rich in selenium in the proliferation of mitogens (spontaneous or derived from peripheral blood mononuclear cells (PBMCs)) and the stimulatory capacity of epidermal Langerhans cells in the reaction skin/lymphocyte. A culture medium, rehydrated with Millipore water, was used as a control. The PBMCs did not show significant changes when cultured in the control medium, however they had strong inhibition in the culture medium rehydrated with thermal water. 34,49,50 The stimulatory capacity of Langerhans cells is regulated by diverse cytokines (e.g., IL-1) and tumor necrosis factors (TNF-α), which are released by keratinocytes during the various stages of activation. The suppressive effect observed may be related to the following factors: [50]

1. Direct effect of one or more thermal water components in the functional maturation of Langerhans cells;
2. Indirect effect through the induction of TNF-α secretion, which blocks the Langerhans cells' stimulatory activity;
3. Inhibition of cytokine secretion by keratinocytes, which could support the functional maturation of Langerhans and cells in vitro; and
4. The combined effects of all the above mechanisms.

Magnesium ions proved effective, in both in vivo and in vitro studies, in inhibiting the capacity of Langerhans cells' presenting antigens, contributing to their effectiveness in inflammatory processes in skin diseases. 1 Table 2 compiles the data described by listing the respective biological effects and/or proven therapeutic uses in in vitro and in vivo studies.

FINAL CONSIDERATIONS

Mineral waters have never been cited as agents with proven biological activity. Of course, they do not have side effects and rarely induce inflammatory reactions. More recently, clinical studies have been published that demonstrate such actions not only in dermatology, but also in rheumatology. According to the scientific literature review described in the present study, the authors observed that some clinical studies have shown biological effects that are correlated to the use of mineral waters, either in the form of sprays or vehiculated in dermatological formulations, such as moisturizers and sunscreens, respectively. It is worth noting, however, that there are differences between the mineral waters that are commercially available in the Brazilian market. It is crucial for dermatologists to consider these differences when deciding on the use of those waters. They should analyze their chemical composition and confirm that the claimed biological actions – preventive or therapeutic, or as an adjuvant to other treatments – have indeed been proven by clinical studies. In evaluating those differences, it is possible to infer that waters with high pH or a high mineral salt concentration should not be used in illnesses in which the skin barrier has been compromised, for they could cause a burning sensation or other discomfort. Furthermore, substances such as selenium and zinc showed better effects against oxidation and free radical formation, and others, such as magnesium and calcium, presented greater anti-inflammatory effects.

Table 2: Biological effects/therapeutic uses of the main minerals contained in thermal waters

Mineral	Biological effects/therapeutic uses
Aluminum	Acute dermatitis
Arsenic	Psoriasis
Boron	Cell renewal, wound healing
Calcium	Regulation of epidermal cell growth, anti-inflammatory action
Sodium chloride	Hydration of the keratin layer in hyperkeratotic disorders
Copper	Antioxidant, skin barrier recovery
Sulfur	Anti-inflammatory, antibacterial, antifungal
Magnesium	Dermatitis acute cellular renewal
Manganese	Cell renewal, wound healing, recovery of the skin barrier
Selenium	Seborrheic dermatitis, tinea versicolor, antioxidant action, protecting against UVB
Sodium	Cell renewal
Zinc	Antioxidant, cell turnover, modulation of inflammation

Finally, it is important to highlight that there is still a lack of studies that determine more precisely the biological effects arising from the physicochemical differences among mineral waters, which could entail a more efficient use in the clinical practice. Given that Brazil is one of the countries with the greatest number of water basins and holds one of the largest mineral water reserves in the world, there is great potential for appreciation and investigation of the physicochemical and biological characteristics of Brazilian mineral springs. •

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