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Real World Scenario on Evaluating Various Dietary Salts and Its Metabolic Complications: A Comprehensive Review

Karthick Murugesan¹*, Pooja Rajan², Nila Pari²

¹ Assistant Professor, Department of Pharmacy Practice, KMCH College of Pharmacy, Coimbatore 641-048, Tamil Nadu, India

² Pharm D Intern, Department of Pharmacy Practice, KMCH College of Pharmacy, Coimbatore 641-048, Tamil Nadu, India

Corresponding Author Mail Id: karthickm0403@gmail.com

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Abstract:

Sodium chloride, commonly known as salt, is an essential dietary mineral vital for maintaining fluid balance, nerve impulse transmission, and muscle contraction. Despite its crucial physiological roles, excessive salt consumption is strongly linked to increased risks of hypertension, cardiovascular disease, kidney damage, and metabolic disorders. This review critically examines the chemical composition and clinical implications of various dietary salts, including refined iodized table salt, Himalayan pink salt, sea salt, rock salt, black salt (Kala Namak), and low-sodium substitutes enriched with potassium chloride. A comprehensive literature review was conducted to compare their mineral profiles, physiological benefits, potential risks, and suitability for individuals with specific health conditions. While naturally sourced salts such as Himalayan or sea salt contain trace minerals like magnesium, calcium, and iron, these amounts are too low to offer meaningful health advantages and do not offset the high sodium content. Furthermore, many natural salts lack added iodine, which is crucial for thyroid health and the prevention of iodine deficiency disorders, especially in vulnerable populations. Potassium-enriched low-sodium salts can help lower blood pressure by balancing sodium and potassium intake but must be used cautiously in patients with chronic kidney disease due to the risk of dangerous hyperkalemia. Iodized table salt remains the safest and most effective option for general use worldwide because it provides essential iodine in a stable, controlled form. Ultimately, this review emphasizes that moderating total sodium intake is more important than selecting a particular type of salt, and that salt choice should align with individual health status, medical advice, and nutritional needs.

INTRODUCTION

Salt, chemically known as sodium chloride (NaCl), is an essential dietary mineral that plays a critical role in numerous physiological functions in the human body [1]. It is vital for maintaining fluid balance, transmitting nerve impulses, and facilitating muscle contraction. Historically, salt has been valued not only as a seasoning and preservative but also as a commodity with economic and cultural significance across civilizations [2]. In modern nutrition and medicine, salt continues to be a topic of scientific interest due

to its dual role as both an essential nutrient and a potential risk factor when consumed in excess [3]. The global food industry relies heavily on salt for flavour enhancement and preservation. However, the increasing prevalence of hypertension and cardiovascular diseases has prompted extensive research into the health implications of high sodium intake [4]. This has led to greater consumer awareness and demand for alternatives such as low-sodium salts and mineral-rich varieties like pink Himalayan salt and sea salt [5].



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This review aims to provide a comprehensive and clinically relevant overview of the diverse types of dietary salt, highlighting their chemical composition, physiological roles, and health implications amid the emerging crisis of salt-related disorders [6]. Special emphasis is placed on the clinical impact of naturally sourced salts versus refined table salt, examining their potential benefits, controversies, and evolving dietary recommendations in the context of global health trends [7].

PATHOPHYSIOLOGY:

High dietary salt intake contributes to a cascade of harmful physiological effects beyond just increasing blood pressure. Initially, it causes fluid retention and expansion of extracellular volume, leading to hypertension, especially in salt-sensitive individuals. This mechanical stress damages the vascular endothelium and suppresses nitric oxide availability, resulting in impaired vasodilation [8]. Simultaneously, excess sodium disrupts the renin-angiotensin-aldosterone system and activates the

sympathetic nervous system, further elevating blood pressure. In the kidneys, salt stimulates the expression of pro-fibrotic markers like TGF- β 1 and synergizes with aldosterone to promote glomerular and tubular fibrosis [9, 10]. Additionally, high salt alters the gut microbiome, decreasing beneficial *Lactobacillus* species and increasing proinflammatory microbes, which activate dendritic cells and promote the release of IL-17 and IFN- γ from T cells—exacerbating vascular inflammation [10]. These immune mechanisms operate independently of blood pressure changes. Moreover, dietary salt disrupts hormonal balance by increasing ghrelin and fructose, impairing adiponectin and GLP-1 levels, and inducing leptin and insulin resistance, thereby contributing to metabolic syndrome. In summary, excessive salt intake initiates a multi-system pathophysiological process involving hemodynamic stress, immune activation, renal injury, and metabolic dysfunction—collectively elevating the risk of cardiovascular, renal, and metabolic diseases [10,11] as shown in Figure 1.

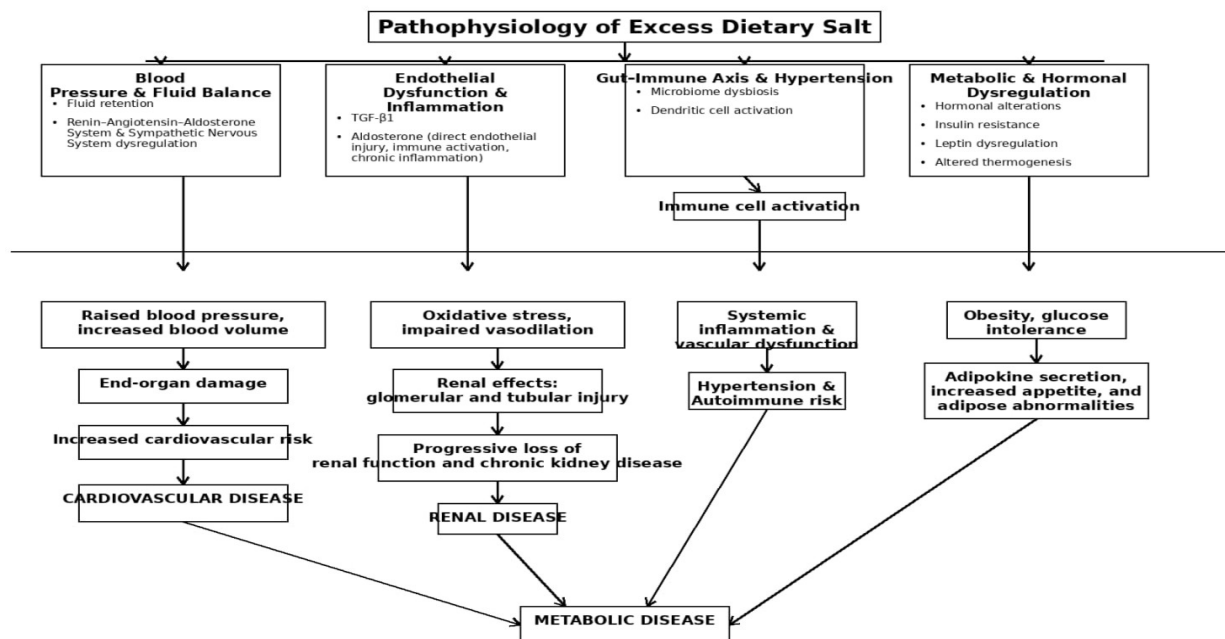


Figure 1. Pathophysiology of Excess Dietary Salt.



TYPES OF SALT:

These variations arise in diverse forms, resulting from their origins, mineral composition, and physical texture. Commonly used for both culinary and industrial purposes are types of salt such as

rock salt, flake lake salt, and sea salt. The table below compares these three basic types of salt based on their origin, main chemical composition, and physical characteristics [12,13].

Table 1: Types of Salt: Source, Composition, and Texture [14]

Type	Source	Main Composition	Texture
Rock Salt	Underground mines	95–98% NaCl	Coarse crystals
Sea Salt	Evaporated seawater	85–95% NaCl + trace minerals	Fine or flaky
Lake Salt / Flake Salt	Salt lakes (inland water bodies)	85–95% NaCl + trace minerals	Light flakes

ROCK SALT:

Sodium chloride, also known as halite, exists naturally as the mineral rock salt and is typically extracted via mining operations from underground salt deposits, as stated by the USGS. These deposits were formed through the evaporation of ancient seawater. Due to its effectiveness in lowering the freezing point of water, rock salt is widely used in industrial applications, food-grade salt products, and especially for road de-icing purposes. It contains natural impurities and is less refined than Table salt [15].

There are several types of rock salt, each of which is distinguished by its color, mineral content, and origin. Himalayan pink salt, renowned for its distinctive pink color, is one of the common varieties, along with halite, the purest form of rock salt, which is typically either clear or white, and black salt, a volcanic salt known as Kala Namak,

popular in South Asian cuisine due to its sulfurous smell. Blue halite, known for its striking blue hue resulting from distinct mineral inclusions, also exist, along with red and gray rock salts, whose colors originate from differing mineral impurities, also exist. These salts are used globally in culinary, industrial, and health-related contexts [16,17].

Himalayan salt:

Primarily sourced from the Khewra Salt Mine in Pakistan, Himalayan salt is a rock salt consisting of 96%–99% sodium chloride, with trace minerals including iron, magnesium, calcium, potassium, and zinc making up the remaining 1%–4%[18]. The object's pink color is derived from these minerals, however, their amounts are insufficient to provide substantial health advantages. Potassium is found in the soil at a concentration of 0.16%–0.28% by weight, which is inadequate to cover an individual's daily requirements [19].



Figure 2. Himalayan salt [23]

Himalayan salt was formed from ancient seabed deposits approximately 600 million years ago and does not contain added iodine but may occasionally have small quantities of heavy metals within allowable limits [20]. Himalayan salt gets its pink color mainly from trace amounts of iron oxide, with other minerals like magnesium and calcium contributing slightly (Figure 2)[21].

Recommended range of Himalayan salt < 2.3g. Consuming Himalayan salt in excess can lead to elevated blood pressure and heightened risks of heart and kidney disease due to its high sodium content. The potassium content is extremely low, insufficient to counteract the effects of sodium and offer any health benefits. The main risk stems primarily from sodium levels [22].

Black salt:

Black salt, also known as Kala Namak, is a kiln-fired rock salt traditionally used in South Asian cuisine and Ayurvedic medicine. It is primarily sourced from the Himalayan regions of India, Pakistan, and Nepal. Black salt, unlike common halite, undergoes a process involving heating with charcoal and herbs, resulting in chemical changes, particularly the formation of sulfur compounds that produce its characteristic strong, egg-like odour and dark violet to black color (which turns pinkish when ground) (Figure 3) [24].

The primary constituents of Kala Namak are sodium chloride (~97–98%), along with smaller

quantities of ferrous sulfate (~0.5–1%), sodium sulfate (~0.3–0.6%), hydrogen sulfide (<0.1%), magnesium (~0.1%), and minor amounts of other elements including potassium and calcium (<0.1%) [25]. Compounds containing sulfur, like sodium bisulfate and hydrogen sulfide, are accountable for distinct taste and digestive effects [26].

Black salt has been traditionally used in the Ayurvedic and Unani systems to aid digestion and as a treatment for constipation due to its effects as a carminative and laxative. Due to its complex flavour, it is also perceived as having a less salty taste, potentially resulting in lower sodium consumption. Sources indicate that its relatively low iron content may not provide substantial hematinic benefit, despite being irrelevant in a clinical context. Despite its low levels in dietary consumption, hydrogen sulfide can be hazardous at high concentrations [27]. Black salt is not iodized, which makes it an unsuitable primary salt source in areas where iodine deficiency disorders pose a problem. Black salt is not iodized, making it unsuitable as the primary salt source in regions where iodine deficiency disorders are a concern [28,29]. Its sodium content, though sometimes perceived as lower due to flavor, is still significant and may contribute to hypertension if consumed excessively [30].

**Figure 3.** Black salt [31]**Table salt:**

NaCl or common table salt, is the most commonly used powder in food. Regular table salt is almost entirely sodium chloride, containing about 39% sodium by weight and typically less than 0.1% potassium. Potassium is usually absent unless it's a specially formulated low-sodium salt substitute [32,33].

Part of the sodium chloride in potassium-enriched or low-sodium salts is replaced with potassium chloride (KCl). These substitutes can contain 20-30% potassium chloride, offering around 520-600 mg of potassium per gram. Individuals with high blood pressure or those seeking to lower their sodium intake are often advised to use such flavour-enhancing formulations [34,35].

Most table salt is produced from rock salt extracted from underground salt reserves. It is relatively uncommon, but it can also be generated through seawater evaporation. Sodium chloride is thoroughly refined to eliminate impurities and guarantee a high level of purity, irrespective of its origin. The majority of table salt originates from rock salt, rather than sea salt [36].

Sodium-Potassium Balance

A diet high in sodium and low in potassium can double the risk of heart attacks and increase overall mortality by 50%. Balancing sodium and

potassium intake is crucial for cardiovascular health [37].

In India, table salt is mainly manufactured by solar evaporation from seawater, with brine being the major method, with Gujarat responsible for more than 75% of the country's total production. Tamil Nadu, Rajasthan, Andhra Pradesh, and Odisha are also major producing states [38,39].

To combat iodine deficiency disorders, India mandates the iodization of all edible salt through the Food Safety and Standards Authority of India (FSSAI). Popular iodized salt brands in the country include Tata Salt, Aashirvaad, and Annapurna [40]. Studies emphasize that iodization has significantly reduced the prevalence of iodine deficiency disorders across the nation [41].

SEA SALT:

Seawater is evaporated to obtain sea salt, a natural product. Unlike refined table salt, it is typically less refined and retains trace minerals from the sea, resulting in a distinct texture, flavour, and mineral profile (Figure 4). It is commonly employed in both culinary and therapeutic contexts and exhibits differences in hue, texture, and mineral composition depending on its place of origin and method of collection [42].

**Figure 4.** Sea salt [43]

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Types of Sea Salt (Figure 5)

1. Celtic Sea Salt comes from the coastal region of Brittany, France. It is gray due to clay-lined salt beds and is moist with a high magnesium content.
2. Fleur de Sel, or "flower of salt," is hand-harvested from the same region as Celtic salt. It forms delicate crystals and is prized as a finishing salt.
3. Red Alaea Salt from Hawaii is infused with volcanic red clay (Alaea), giving it an iron-rich composition and reddish hue. (Figure 6)

4. Black Lava Salt, also from Hawaii, is blended with activated charcoal and used for both culinary and detoxifying purposes.
5. Maldon Sea Salt, from the UK, is known for its clean taste and large, pyramid-shaped flakes.
6. Sicilian Sea Salt, harvested along the coast of Trapani, Italy, is sun-dried and rich in potassium and other trace minerals [44].



a) Celtic Sea Salt

b) Fleur de Sel Salt

c) Black Lava Salt

d) Maldon Sea Salt

Figure 5. various types of sea salt [45-48]**Typical Composition of Sea Salt (by weight):**

About 92%–97% of sea salt is sodium chloride. Trace minerals such as magnesium (0.1%–0.5%), calcium (0.1%–0.3%), and potassium (0.1%–0.2%) are retained, along with sulfates, bicarbonates, and other minerals present in quantities under 1%. The moisture content can differ based on the type of sea salt, usually spanning from 0.5% to 2%. These trace minerals, while present in small quantities, play a key role in the salt's distinct flavour and, in certain instances, its hue, which are reflective of the water sources that the salt is sourced from [49].

Health Advantages of Sea Salt

Consuming sea salt in moderation provides several health-related benefits. The beverage retains essential minerals including magnesium, potassium, and calcium, which contribute significantly to maintaining electrolyte balance, facilitating nerve function, and encouraging

hydration. In contrast to refined table salt, sea salt is usually less processed, resulting in its absence of added chemicals like anti-caking agents or iodine. Alaea salt, among other varieties, also contains iron oxide, and while it may offer a small contribution to iron consumption, it is not a substantial source [49,50].

Health Disadvantages of Sea Salt

In spite of its natural appeal, excessive consumption of sea salt poses potential health risks. Similar to all other types of salt, it contains high levels of sodium, which may lead to high blood pressure, cardiovascular disease, and kidney damage. Beneficial trace minerals like magnesium and potassium are present, but in such small quantities that they have little influence on overall nutrient consumption. Furthermore, many types of sea salt are low in iodine, which could be a problem in communities that often struggle with iodine

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deficiency unless sufficient iodine is obtained from other foods [50].

In India, sea salt is primarily harvested from coastal regions such as Thoothukudi (Tamil Nadu), Kutch (Gujarat), and coastal Odisha, where seawater is evaporated in large open pans under the sun. This traditional method yields unrefined or semi-refined sea salt, commonly known as Marakkaal uppu or simply Indian sea salt [51]. It typically contains 92–96% sodium chloride, along with trace minerals like magnesium (0.2–0.5%), calcium (0.1–0.4%), and potassium (0.1–0.3%), which may contribute marginally to electrolyte balance and nerve function. While Indian sea salt is valued for being less processed and retaining natural minerals, it lacks iodine unless fortified, posing a risk of iodine deficiency disorders (IDD) in vulnerable populations [52]. Additionally, excessive consumption can lead to hypertension and cardiovascular disease due to its high sodium content. The Salt Commissioner's Organisation, Government of India, oversees production standards and has promoted iodization to address nutritional deficiencies. Studies also support these concerns, noting that while sea salt offers minimal

mineral benefits, it should be consumed in moderation like any salt [53].

RED SALT:

Red salt can be either rock salt or sea salt, depending on its origin. Here's a breakdown:

1. Alaea salt, or Red Hawaiian salt, is a type of sea salt.

Alata salt, which is also commonly referred to as red Hawaiian salt, is a type of sea salt that originates from Hawaii. It is composed primarily of sodium chloride (84%–90%), with 5%–100% iron oxide derived from the volcanic Alaea clay, and 1%–3% trace minerals such as calcium, magnesium, and potassium [54]. The sample also includes 11% moisture and organic compounds. This salt is prized for its high mineral content and its naturally occurring origin. The red colour of this item is due to the inclusion of Alaea volcanic clay, which is high in iron oxide (Figure 6). This natural mineral not only lends the salt its distinctive colour but also enriches its flavour and mineral composition, rendering it a highly valued ingredient in traditional Hawaiian cooking.[55].



Figure 6. Red Hawaiian salt [56]

2. Red Rock Salt from India/Pakistan.

Typically, rock salt is mined from regions such as the Himalayas or volcanic areas. The mineral usually comprises 95%–98% sodium chloride, 0.5%–1% iron oxide, and 1%–3% of a combination of calcium, zinc, magnesium, and potassium [57]. It may also contain fewer than 1% insoluble particles or mineral impurities. The natural coloration is red or pink due to the presence of iron oxide and other trace minerals. These minerals contribute to its appearance and

nutritional profile, making it a popular choice for culinary and therapeutic applications [58].

Unrefined Red Hawaiian Salt and Red Rock Salt, akin to Himalayan salt, serve as unrefined mineral-rich alternatives to regular table salt. They provide trace minerals like magnesium and potassium, and are free from synthetic additives. Red Hawaiian Salt has a higher iron oxide content, potentially providing some benefits for individuals with low iron levels, whereas Red Rock Salt boasts a more extensive range of minerals and is more readily

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accessible [59]. Although they are primarily sodium chloride, excessive intake can exacerbate the risk of hypertension and cardiovascular problems. A balanced diet and medical treatment should not be replaced by their modest health

benefits. Red and pink Himalayan salts are essentially the same type of salt, but they differ slightly in colour intensity due to variations in mineral content, especially iron oxide (Figure 7) [60].



Figure 7. Red Rock Salt [61]

SALT DERIVED FROM SALT LAKES OR SALT FLAKES:

Salt obtained from salt lakes or salt flakes (commonly referred to as lake salt or flake salt) usually originates from the natural evaporation of mineral-rich lake water. The composition of these salts differs by source, but they are mainly composed of sodium chloride (NaCl), typically in the range of 85%–95%, with the rest comprising magnesium (Mg^{2+} ~1–4%), potassium (K^{+} ~0.5–2%), calcium (Ca^{2+} ~0.5–1%), and trace minerals including zinc, iron, and sometimes sulfur compounds [62]. The flake texture is achieved through specific drying methods that create thin, crisp crystals (Figure 8).

These salts are commonly used for culinary finishing, offering a delicate crunch and visual

appeal to gourmet dishes. Their mineral content can subtly enhance flavour. Health benefits include providing electrolytes like magnesium and potassium, which aid in nerve transmission, hydration, and muscle function. Some also consider the trace minerals beneficial for maintaining overall mineral balance. Absent iodine - unless the salt is iodized - is a significant health disadvantage due to its crucial role in thyroid function [63, 64]. Excessive salt consumption, if not kept in moderation, can result in high blood pressure, cardiovascular stress, and kidney disease. Salt from salt lakes or salt crystals is neither rock salt nor traditional sea salt. It is often regarded as a natural salt that evaporates, similar to sea salt in its formation, but is harvested from salt lakes rather than the ocean [65].



Figure 8. Salt Flakes [66]

Salt suitability based on various health condition

This table summarizes the clinical suitability of various dietary salts for individuals with chronic

kidney disease (CKD), hyperkalemia, hypertension, and iodine deficiency. It considers



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the sodium, potassium, and iodine content of each salt, along with recommendations and associated risks.

Table 2: Salt type suitability based on health conditions and its composition.

Salt Type	Sodium	Potassium	Iodine	Best For CKD /Hyperkalemia	Best For Hypertension	Iodine Deficiency	Notes / Risks
Table Salt (Iodized)	High (~40% Na)	Very Low	Yes	Safer (due to low K ⁺)	High Na ⁺ risk	Yes	Most refined; recommended for general use
Low-Sodium Salt (KCl mix)	Lower Na ⁺	High (20–30%)	No	Unsafe (causes hyperkalemia)	Good (lowers BP)	No	Only under medical supervision
Himalayan Pink Salt	High (~36–38% Na)	Moderate (0.16–0.28%)	No	Risk due to K ⁺ and lack of iodine	High Na ⁺	No	Contains trace minerals, but clinically insignificant
Sea Salt (Generic)	High (~38% Na)	Low (0.1–0.3%)	No	Caution (low iodine, low K ⁺)	High Na ⁺	No	Slightly better mineral profile, still risky if excess
Saindhava Namak (Rock Salt)	High	Very Low (<0.1%)	No	Preferred for CKD	High Na ⁺	No	Natural, lower K ⁺ than Himalayan salt; needs iodization
Kala Namak (Black Salt)	High (~35–38% Na)	Very Low	No	Caution (low K ⁺ but contains sulfur compounds)	High Na ⁺	No	May aid digestion; not for primary salt source
Red Rock Salt	High	Low–Moderate	No	Not ideal (higher K ⁺)	High Na ⁺	No	Contains more minerals, but no iodine



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Red Hawaiian Sea Salt	High (~35–38% Na)	Low–Moderate	No	Not recommended for CKD	High Na ⁺	No	Rich in iron; still high Na ⁺ and low iodine
Lake Salt / Flake Salt	High (~36–38% Na)	Low–Moderate	No	Limited evidence	High Na ⁺	No	Delicate texture; trace minerals only

CONCLUSION:

The health impacts of various dietary salts are determined by their mineral composition, degree of refinement, and specific medical condition. The main constituent of all salts is sodium chloride (NaCl), but the nutritional and clinical significance of these salts is affected by the presence or absence of minerals such as potassium, magnesium, calcium, and iodine. According to WHO and AHA guidelines, the recommended sodium intake for adults ranges from 1,500 mg/day, particularly for individuals with hypertension, cardiovascular, or renal disorders, to 2,300 mg/day for the general healthy population.

For the general population, iodized table salt is the preferred choice because it contains a consistent amount of iodine, a crucial component in preventing Iodine Deficiency Disorders (IDD). The product is extremely refined and has a very low risk of contamination. Low-sodium salts enriched with potassium may aid in lowering blood pressure in individuals with hypertension by rectifying the imbalance between sodium and potassium levels. They are not recommended for patients with chronic kidney disease (CKD) because of the risk of hyperkalemia, which makes their use unwise without a doctor's supervision.

Rock salts like Saindha salt, which are low in iodine, may be a safer option for patients with chronic kidney disease. Himalayan pink salt and sea salt have slightly higher potassium levels (~0.16–0.28%) than table salt, and are commonly promoted for their trace mineral content. These minerals are present in very small amounts, providing no substantial clinical advantage. Furthermore, these salts can also contain small amounts of heavy metals and are usually in their unionized form. Kala Namak, a type of black salt used for digestive purposes, contains sulfur compounds but is deficient in iodine and may pose toxicity risks if consumed excessively.

From a metabolic perspective, consuming high amounts of sodium—regardless of the type of salt—can contribute to hypernatremia, insulin resistance, and obesity. Moderating sodium intake is more critical than selecting a particular salt type. The choice of salt should be tailored to an individual's renal function, cardiovascular health, and iodine needs. Culinary variety offered by alternative salts is restricted, and at-risk individuals need medical guidance to reap their health benefits.

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