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Review Article

# Baking Soda and the Skin: A Review of Baking Soda in Dermatology

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Sodium bicarbonate (baking soda, SB) has gained popularity as a versatile and affordable skin and hair remedy. With a pH between 8 and 9, it occurs naturally as the mineral nahcolite in the water of naturally occurring springs. While commonly used in baking, cooking, and cleaning, baking soda also offers numerous medical benefits supported by peer-reviewed research. Baking soda has demonstrated efficacy in addressing dermatological diseases such as psoriasis, aquagenic pruritus, and microbial infections. It can also serve as an analgesic and even as a shampoo alternative. Although research on its effectiveness for hair care is limited, there is a growing movement to use in conjunction with apple cider vinegar. While not extensively studied, adverse effects with topical baking soda have been documented in case reports when used in excess, primarily for nontraditional at-home treatments. Side effects have included metabolic alkalosis and local irritation. Findings from our review reinforce that SB is a powerful and safe dermatologic agent- whose efficacy will be highlighted in this review in an effort to bring its diverse dermatological uses to the forefront.

## INTRODUCTION

Sodium bicarbonate ($NaHCO_3$, SB), also known as baking soda, is an alkaline substance readily available to most consumers worldwide. SB is produced using the Solvay process, which reacts sodium chloride (NaCl) with ammonia ($NH_3$) and carbon dioxide ($CO_2$) in water ($H_2O$).[1] SB can be used therapeutically across many healthcare fields and in some instances improves dermatological conditions, as well as bacterial and fungal infections.[2] In recent years, SB has gained popularity as a low-cost, multifaceted skin and hair remedy.[3] Therefore, it is important for dermatologists to understand the evidence supporting its use to properly counsel patients and avoid toxicity. This review will examine the multiple uses of SB's ability to alleviate dermatological conditions, the benefits of SB-buffered lidocaine-epinephrine, SB as an alternative shampoo remedy, and associated adverse effects and limitations of SB.

## METHODS

A qualitative literature review was performed in PubMed using several search terms including sodium bicarbonate; baking soda; baking soda and skin patient satisfaction; and nociception. Included studies were case reports, review articles, original studies, and expert opinions.

## RESULTS

### ANTIMICROBIAL EFFECTS

Several studies have highlighted SB's potential antimicrobial properties. In vitro antifungal activity of SB was studied using 70 fungal strains derived from human skin and nail samples. The strains of fungi responsible for human skin and nail infections, 40 dermatophytes (23 *T. rubrum*, 17 *T. interdigitale*), 12 molds (3 *S. brevicaulis*, 3 *Fusarium* spp., 3 *Acremonium* spp., 3 *A. versicolor*) and 18 yeasts (6 *C. albicans*, 6 *C. parapsilosis*, 2 *C. guilliermondii*, 1 *C. zeylanoides*, 3 *Trichosporon* spp.) were included. Findings demonstrated that a 10 g/L solution of SB inhibited growth of nearly 80% of the isolated fungi cultivated in Sabouraud dextrose agar (SDA).[4] It was further found that the "minimal inhibitory concentration 90" (MIC90) of SB measured on SDA, Sabouraud dextrose broth and potato dextrose broth was 20 g/L for the dermatophytes, 5 g/L for the yeasts, and 40 g/L for the molds.[4]

The next phase of the experiment was a prospective study focusing on ex vivo antifungal activity of SB on 24 fungal strains: 15 dermatophytes (5 *T. interdigitale* and 10 *T. rubrum)*, 7 yeasts (2 *C. parapsilosis*, 1 *C. albicans*, 1 *C. lusitaniae*, 1 *C. guilliermondii* and 2 *Trichosporon* spp.) and 2 molds (2 *A. versicolor*) isolated from 15 human foot nail and 9-foot skin scrapings.[4] Supplementing Sabouraud dextrose–chloramphenicol agar (SDCA) with 10 g/L of SB solution reduced 4 out of 24 specimens (17%) and fully inhibited fungal growth of 19 specimens (79%) after a 7-day incubation period compared to SDCA alone.[4] These findings highlight SB concentrations effective against different strains of fungi responsible for human skin and nail infections. However, it was noted that the mechanism of action of SB remains unexplored.

A study examining the potential mechanism of SB's in vitro inhibition of a plant fungal pathogen, *Botrytis cinerea*, discovered that SB exhibits anti-fungal properties by impeding yeast-to-hyphae transition, also known as hyphae switching in this fungal species.[5] Similarly, opportunistic

pathogenic yeasts such as *C. albicans* have the ability to hyphae switch which can cause superficial skin infections as well as potentially life-threatening systemic infections.[6] The proposed mechanism of hyphae switching involves the expression of agglutinin-like sequence (Als) molecules, particularly Als3, which act as invasins inducing host cell endocytosis by binding to host cell E-cadherin and N-cadherin.[5-7] The effect of several salts such as: ammonium, potassium, and sodium bicarbonates on *B. cinerea* colony growth in vitro revealed inhibition of colony growth even at low concentrations such as 20 mM, with bicarbonate anions playing a primary role in this effect.[5] Comparisons with other salts suggested that those with high pKa values or acting as reducing agents were effective inhibitors of growth. The pH was found to influence colony growth, with bicarbonates and phosphates exhibiting greater inhibition as pH increased, indicating the involvement of pH and buffering capacity in growth inhibition.[5] Furthermore, SB was found to control *B. cinerea* growth in vitro independently of pH, suggesting its potential as an effective control agent against this pathogen. With the addition of SB, the extracellular environment becomes more alkaline, causing the fungal cells to expel more acid to counteract this alkaline effect. This process demands additional energy expenditure from the fungal cell, diverting resources that would typically be allocated to hyphae switching towards maintaining pH balance, ultimately compromising the cell's function, growth, and survival.[5] Further investigation is warranted to delineate the specific mechanism underlying SB's anti-hyphae activity in *C. albicans*.

In the dental setting, SB exhibits antifungal properties against *C. albicans* and antibacterial properties against Streptococcus mutans, the culprit of dental caries and tooth decay. In a study to assess the impact of 5% SB on the adherence of *C. albicans* to denture-based materials, fifty specimens of acrylic resin were prepared and inoculated with *C. albicans* then treated with different disinfectants. The results showed that both 5% sodium bicarbonate and 0.12% digluconate chlorhexidine significantly reduced the number of colony-forming units (cfu/mL) compared to the control group. However, when comparing the effectiveness of disinfecting solutions, only 0.12% digluconate chlorhexidine showed a statistically significant difference in reducing cfu/mL. Nonetheless, the study concludes that 5% sodium bicarbonate also presents itself as a viable alternative for reducing *C. albicans* adherence to thermally activated acrylic resin.[6]

Another in vitro experiment investigated the impact of sodium bicarbonate and hydrogen peroxide on the cariogenic bacteria *S. mutans* by analyzing their effects through spectrophotometric analysis. Seven different environments were created for testing, incubated in multi-well plates and monitored over 42 hours. Results indicated that both sodium bicarbonate and hydrogen peroxide, individually or in combination, effectively prevented bacterial growth of *S. mutans*. Despite hydrogen peroxide being bactericidal and sodium bicarbonate being bacteriostatic, no significant differences were observed among the treatments in terms of optical density readings. These findings suggest that products containing sodium bicarbonate and/or hydrogen peroxide could potentially be beneficial for caries-prone patients, although further studies on patients are necessary to validate these results.[8] Some studies have shown that SB's effectiveness against fungi and bacteria can be time dependent. For example, killing *S. mutans*, may require exposure to SB for 30 minutes or longer.[8] While dermatology and dentistry are distinct specialties, they often intersect in the diagnosis and management of conditions affecting the skin and oral mucosa.

The potential synergistic effect of ascorbic acid, dexamethasone and SB as an in vivo triple therapy to reduce virulence factors in staphylococcus aureus—a gram-positive cocci, highly virulent and persistent bacterial pathogen responsible for various skin infections such as impetigo, folliculitis, furuncles, abscesses, and mastitis was also explored. SB demonstrated a significant reduction of expression in several virulence factors as follows: biofilm formation, *S. aureus* proteases, hemolysin, staphyloxanthin, and lower *S. aureus* resistance to oxidative burst orchestrated by neutrophils.[9] Furthermore, findings from quantitative reverse transcription polymerase chain reaction (qRT-PCR) show reduced expression of several virulence-specific genes in *S. aureus* (*crtM*, *sigB*, *sarA*, *agrA*, *hla*, *fnbA*, and *icaA*).[9]

The concentrations mentioned above were utilized in in vitro and ex vivo studies, and therefore may not be readily translated to clinically applicable quantities for use by clinicians. While these antimicrobial properties have been demonstrated experimentally, the paucity of clinical data precludes making conclusions on its utility in patient care at this time.

## INPATIENT UTILIZATION

The uses of SB extend beyond outpatient dermatological applications into other skin-related hospital settings. Microbial colonization of central venous catheters (CVCs) can lead to intravascular catheter-related blood stream infections (ICRBSI), which have the potential to increase healthcare expenditures, morbidity, and mortality. For skin cleansing, traditional antiseptic solutions such as iodine, chlorhexidine, or alcohol are used, however, their use may induce discomfort in patients, especially those with open wounds. A prospective, randomized, controlled, single-blinded study on patients with CVCs found that pre-treatment with 5% sodium bicarbonate in distilled water at 40-45°C was better tolerated and resulted in higher procedural satisfaction compared to 75% isopropyl alcohol alone. Specifically, 74% of patients (n = 60) reported lower verbal pain scores and higher satisfaction scores compared to 4.5% with alcohol alone. Additionally, nurses reported higher satisfaction levels with CVC cleaning using SB, and no differences in bacterial count were observed after disinfection with iodine in both groups.[10] One proposed mechanism is that the alkaline property of SB counteracts the acidic environment induced by the skin microbiome, balancing the acidic pH and thereby reducing inflammatory processes and irritation. In contrast, alcohol is well-documented to cause mucosal membrane irritation, particularly when in contact with open wounds. Alcohol dehydrates cells and can alter

protein structures; it evaporates quickly, producing a cooling effect that can manifest as a sensation of burning or stinging.[11,12] Despite the unclear mechanism by which SB reduces pain and irritation during CVC cleaning, this study demonstrates that SB is as effective as isopropyl alcohol in inhibiting bacterial growth, while also resulting in lower pain and stress. Therefore, 5% NaHCO3 in distilled water at 40-45°C may serve as an appropriate alternative to 75% alcohol for skin cleaning.[10]

Another study found that, compared to talcum powder, a solution of 5% SB in distilled water (di$H_2O$) offers a wet, alkaline environment that facilitates softening of hair for more efficient preoperative hair removal in patients undergoing coronary artery bypass graft (CABG) surgery.[13] In the control group, patients (40%, n = 24) and nurses (37%, n = 22) reported lower satisfaction rates using talcum powder, compared to patients (95%, n = 57) and nurses (90%, n = 54) in the SB group (both $p < 0.001$). Overall, introduction of 5% SB- di$H_2O$ resulted in a more efficient and time saving preoperative skin preparation (5.58 ± 1.52 vs 9.74 ± 1.23 min, $p < 0.001$), as well as greater satisfaction when compared to talcum powder.[13] By exploring well known properties of SB in various fields, our review aims to present a well-rounded understanding of the versatile nature of topical baking soda.

## BUFFER FOR LOCAL ANESTHETICS

Buffering local anesthetics with sodium bicarbonate has been shown to help mitigate discomfort, contributing to a reduction in pain during various medical procedures. Local anesthetics, such as lidocaine, function by interrupting sodium channels and when combined with epinephrine, the acidity is increased which produces a burning sensation.[14,15] This acidity can be neutralized by adding 8.4% sodium bicarbonate in a ratio of 1 mL to 10 mL which accelerates the anesthetic's diffusion across nerve cell membranes leading to faster sensory blockade.[16] However, as for the long-term storage stability of epinephrine, it is chemically unstable or may go undetected if over 24 h in alkalinized solution thus making it not a good candidate for prolonged storage prior to clinical use.[17] This is relevant not only in dermatology but any specialty that requires the use of local anesthetic.

## PSORIASIS

SB baths have long been studied in the treatment of psoriasis. A study of thirty-one participants with mild to moderate psoriasis, bathing in a solution of 300-500 g SB in an average of 85 liters of water (approximately 0.67- 0.96 cup/tub or bath) on alternating days for twenty-one days resulted in a significant reduction in the psoriasis area severity index (PASI) score, less pruritus and irritation compared to the control group.[18] Two patients (10.5%) experienced near complete resolution of their psoriasis (86.6% PASI reduction). Four (21%) experienced 60.8% PASI reduction, and the remaining reported moderate improvement, with an average PASI score reduction from 5.4 to 3.3 (38.9%).[18] The continued use of SB baths by participants long after the conclusion of the study provides further evidence for its effectiveness.

In a subsequent study, thirty patients underwent balneotherapy by bathing in a solution rich in chlorine-sulfide-bicarbonate from a mineral spring following a mud treatment for twelve days. Researchers observed an improvement in PASI but were unable to determine the exact mode of action. It is hypothesized that the alkaline environment of SB may act on keratinocyte proliferation or on the skin's microbiome.[19]

A randomized, double-blind, intrapatient, controlled study of 30 patients with mild to moderate psoriasis looked at the impact of topical SB in lanette vax (an emulsifying agent used in cosmetic products) which exhibited no significant difference in PASI score compared to vehicle after 28 days. The authors hypothesized that the lack of improvement could be due to a pH shift post-application, or inadequate concentration used in the formulation.[19] Follow up studies are needed to determine if SB acts independently of balneotherapy to diminish cutaneous inflammation in psoriasis.

## AQUAGENIC PRURITUS

Aquagenic pruritus (AP) is a chronic disorder that is not completely understood, making it a challenging condition to treat. Patients with AP develop severe itching or a prickling sensation without primary skin lesions that typically arise within 5-10 minutes after being in contact with water. Variations in AP may be caused by climate, season, and water composition.[20] Pharmacological studies on AP suggest involvement of mast cell degranulation, elevated serum histamine, and increased activation of acetylcholinesterase in the skin.

Observational data on two patients demonstrated symptom relief at various concentrations. One patient experienced symptom relief by adding 25 g of SB to bathwater and applying SB paste and the other required 100-200 g of SB for relief.[21] There were no reported adverse events at either concentration. However, additional investigation is required to ascertain a concentration that is both safe and effective given the sample size of the study.

## SHAMPOO ALTERNATIVE

There is limited research regarding uses and potential benefits of SB for the growing community of individuals seeking shampoo-alternative "no-poo" remedies. Interest in household alternatives such as SB, apple cider vinegar (ACV), and tea tree oil has been sparked by concerns regarding specific shampoo constituents such as cocamidopropyl betaine, propylene glycol, parabens, and formaldehyde-releasing preservatives.[22] Advocates of these alternatives assert that they effectively cleanse the scalp without stripping hair oils. They also report a reduction of greasiness and softer hair strands.[22] There is currently no evidence to support these claims, and there are potential dangers to this practice that are important for dermatologists to understand to counsel patients.

Inadequately diluted SB opens the cuticle layer of the hair shaft allowing penetration of water that leads to the breakdown of hydrogen bonds. This breakdown of hydrogen bonds reduces hair elasticity and increases the negative electrical charge thereby leading to friction and hair breakage.[22] Acidic shampoos with a pH < 5.5 are recommended because they cleanse and balance the pH of the scalp and hair fibers as well as provide protection against microorganisms.[23] Some proponents of the "no poo" method with SB utilize an ACV rinse following cleansing to combat this, however this can also cause irritation if not used correctly.[22] Until research is conducted to determine the safety of utilizing SB for hair cleaning, dermatologists can share the potential hazards of the "no-poo" with patients to ensure they understand the potential risks and make an informed decision.

### ADVERSE EFFECTS

Baking soda is marketed to consumers worldwide for numerous household and personal purposes and is usually considered a safe substance. Most adverse effects reported with SB are associated with metabolic alkalosis after intravenous administration and ingestion. Animal studies of skin irritation with topical baking soda, applying 0.5 g of baking soda under patches to both abraded and non-abraded skin of six rabbits for 24 hours, demonstrated no signs of skin irritation immediately, at 48 hours or 72 hours.[24] Moreover, testing in 109 humans with 0.0025% SB in water showed no evidence of skin irritation.[24] Harmful effects of topical SB, however, have been described in case reports. One case report in particular demonstrated a 4-month-old infant who received excessive and protracted application of SB for a diaper rash. The skin the SB was applied to was diffusely erythematous with denuded areas that extended throughout the diaper region. The infant developed hypokalemic metabolic alkalosis; the condition resolved when the solution was discontinued.[25] Similarly, a metabolic alkalosis was observed in a 69-year-old woman diagnosed with breast cancer after daily application to her breast. While it was not specified if the skin was broken at the time of application, the patient was found with a necrotic and protruding mass greater than 15 cm in size with a yellowish crust and pus-filled discharge on the left breast. Similar adverse events were reported in a 65-year-old man with an open foot ulcer to which he both topically applied and ingested the SB. Symptoms resolved in these cases with supportive care and discontinuation of SB use.[25, 26] Such cases illustrate the dangers associated with excessive SB application.

## DISCUSSION

While sodium bicarbonate is largely known for its role in household cleaning and cooking, it also has potentially impactful dermatological uses. SB has antimicrobial properties, and its efficacy has been highlighted by multiple studies of *C. albicans*, though no studies have been conducted in vivo with humans.[4,27,28] SB can potentially create an unfavorable environment for hyphae switching for *C. albicans* —thus eradicating these microorganisms in vitro, though the clinical application is still untested.

The use of sodium bicarbonate for preoperative skin preparation prior to intravascular catheter insertions offers advantages in terms of efficiency and comfort. Patients report lower pain and greater satisfaction, while nurses also experience higher procedural satisfaction.[10,13] The buffering effect of SB grants a reduction in infiltration pain from lidocaine with epinephrine.[14-17] SB baths and balneotherapy can provide amelioration of psoriasis, as measured by the PASI score.[18,19] In aquagenic pruritus, SB shows potential as an alternative treatment for itch when patients do not respond to conventional approaches of antihistamines and emollients.[20,21] Finally, although more research is needed on its efficacy and safety for hair care, SB and apple cider vinegar for hair cleansing and hydration are growing in popularity.[22,23]

Case reports serve as warnings for potential adverse effects of direct application of topical baking soda in excess, including metabolic alkalosis and irritation. While diluted baking soda has little risk of irritation, the exact safe concentration for topical use is not clear. A 5% concentration has safely been applied directly to the skin.[10,13] When used for treatment of psoriasis, studies have indicated that approximately 3.5 to 6 grams (approximately 0.67 - 0.96 cup/tub or bath), of baking soda per liter of bathwater has been effectively and safely used.[18] To our knowledge, reports in aquagenic pruritus have not indicated specific concentrations of baking soda, however 25-200 grams of SB were added to baths for treatment without any indicated side effects.[21] We suggest future studies be conducted to determine a safe and effective concentration of baking soda in bathwater for managing aquagenic pruritus. We also suggest starting with similar concentrations that studies have indicated in psoriasis treatment and adjusting according to the patient's AP severity.

As for limitations, patient samples were relatively small and did not include patient demographics, impacting external validity. Many studies also did not include the amount or concentration of baking soda used. Additionally, different population groups have different hair textures that might behave differently when in contact with SB solutions. In aquagenic pruritus, other limitations include undefined water compositions and lack of clarification for mode of application of SB treatments—both of which can significantly influence findings. Although the data is limited, this review seeks to equip dermatologists with the knowledge of available data, especially due to increased popularity of SB, and to encourage potential engagement in additional research.

## CONCLUSION

Overall, findings from this review suggest SB may be an effective and safe dermatologic agent in various capacities. SB can be used for its antimicrobial properties in both outpatient and inpatient settings as a preoperative skin prep. Furthermore, SB can be considered for the treatment of psoriasis and aquagenic pruritus, as well as be used as a

**Table 1. Summary of Baking Soda evidence in dermatology**

| Condition | Treatment | Outcomes |
|---|---|---|
| Fungal infection (nail and skin) | **In vitro**<br>- 10 g/L SB in SDA, incubated at 35 °C for 48 h (yeasts) or 7 days (dermatophytes and molds) | - Inhibits 80% of isolated in SDA[4]<br>- Minimal inhibitory concentration 90 (MIC90) of SB:<br>- 20 g/L for dermatophytes<br>- 5 g/L for yeasts<br>- 40 g/L for molds[4] |
| | **Ex vivo**<br>- 10 g/L of SB in SDCA, incubated at 35 °C for 48 h (yeasts) or 7 days (dermatophytes and molds) | - Fully inhibits 79% of fungal growth compared to SDCA alone[4] |
| Skin preparation for intravascular catheter placement | - 75% Isopropyl alcohol alone vs. 5% SB in distilled water, 40 - 45°C pre-treatment | - Reduced pain score in 74% patients ($p < 0.001$)[10]<br>- 78% of nurses reported higher procedural satisfaction[10] |
| | - Talcum powder vs. 5% SB in distilled water, 40-45°C | - Shorter preparation time: 5.58 ± 1.52 vs 9.74 ± 1.23 min, $p < 0.001$)[13]<br>- Higher patients (95%) and nurses' satisfaction (90%)[13] |
| Analgesia | - 8.4% SB at ratio 1 mL:10 mL 1% lidocaine with 1:100,000 epinephrine | - Neutralizes acidity and mitigates burning pain with infiltration[16] |
| Psoriasis | - 300 - 500 g of SB in 85 L of bathwater (approximately 0.67- 0.96 cup/tub or bath) on alternating days for 21 days | - Almost complete clearance: n = 2 (10.5%), PASI 12 to 1.6<br>- Significant improvement: n = 4 (21%), PASI 5.5 to 2.2<br>- Moderate improvement: n = 8 (42.1%), PASI 5.4 to 3.3[13] |
| Aquagenic pruritus | - 25 - 200 g SB in bath–titrate to effective dose.<br>- SB paste applied topically | - Relieve and prevent pruritus[21] |
| Shampoo alternative | - Risk of hair damage with undiluted SB<br>- SB wash could be followed by ACV rinse to help restore pH | - Decreased hair elasticity and increased breakage with undiluted SB[22] |

shampoo alternative with caution. Understanding of the basic mechanisms, current evidence, and potential uses of SB in dermatologic conditions can aid dermatologists in treating specific skin conditions as well as effectively counseling patients seeking home remedies. Further research is needed to discover innovative and safe ways to utilize this ancient therapeutic agent for skin health.

## LEGEND

**SB**: sodium bicarbonate; **SDA**: Sabouraud dextrose agar; **SDAC**: Sabouraud dextrose agar with chloramphenicol.; **MIC90**: minimal inhibitory concentration 90; **PASI**: psoriasis area severity index.; **ACV**: apple cider vinegar

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