Journal of King Saud University – Science 33 (2021) 101329

Contents lists available at ScienceDirect

Journal of King Saud University – Science

journal homepage: www.sciencedirect.com

Review

Biological and therapeutic roles of Saudi Arabian honey: A comparative review

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ARTICLE INFO

Article history:
Received 31 October 2020
Revised 17 December 2020
Accepted 22 December 2020
Available online 30 December 2020

Keywords:
Honey
Modern medicine
Therapeutic roles
Medicinal properties
Saudi Arabia

ABSTRACT

Honey is deeply rooted in Saudi Arabian culture, religion, and trade, and The Holy Quran refers to its medicinal and healing properties several times. Honey is a highly symbolic and well-regarded product in the Kingdom of Saudi Arabia and it is widely used for its medicinal value in addition to its nutritional uses. Saudi Arabia is home to an estimated 2200 flowering plants, and monofloral honey from local plants and trees such as *Ziziphus* (Sidr honey), *Acacia* (Talha and Sumra), *Lavendula* (Seyfi and Dharm), and *Hypoestes forskaolii* (Majra) fetch high prices and are more expensive than imported honey. Natural honey is used in the treatment of diabetes, dyslipidemia, and skin lesions in addition to having a high nutritional value. It was given Food and Drug Administration (FDA) approval as a potent antimicrobial agent for the topical treatment of wounds in 2007. In this review, we explore and highlight the therapeutic roles of different types of Saudi Arabian honey in modern medicine. We propose that natural honey should not be viewed as an "alternative" treatment and that it deserves more attention from scientists for research into its therapeutic potential for clinical applications.

Contents

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.jksus.2020.101329

1. Introduction

Several reports in the literature support the hypothesis that the honeybee (*Apis mellifera* L.) originated and diversified in the Near East (Ruttner, 1988), a region that includes present-day Saudi Arabia. Beekeeping can be traced back to at least 4500 years when the region was considerably wetter and covered with dense vegetation (Al-Ghamdi and Nuru, 2013). Several documents written by Bilons in 79 AD refer to the region as one in which honey and beeswax were the dominant agricultural products (Tarcissi, 1968). Honey has been used for medicinal purposes since the time of the Egyptian civilization by the ancient Greeks and Egyptians. Samples of honey harvested by humans have been found in Egyptian tombs over 4000 years old (Meo et al., 2017). The history of beekeeping in the Arabian Peninsula dates to ca. 2000 BCE. An earthenware painting found in Iraq depicts honey as a remedy for disease (Crane, 1983). In the Arabian Peninsula, faith and interest in the use of honey made by bees were greatly increased after a chapter in The Holy Quran, entitled "Al-Nahl—The Bees," mentioned honey as "a curative for mankind" and described it as one of the foods of Paradise (Purbafrani et al., 2014). There is documentary evidence for the exploitation of honeybees in the country that dates back at least 1400 years. Clusters of the oldest apiaries in the region can be found in Taif in southwestern Saudi Arabia. According to apiary owners, these were built in the mountains ~500 years ago (Alqarni et al., 2011).

Apis mellifera jemenitica is the only subspecies of *A. mellifera* that is indigenous to the country (Alqarni et al., 2011), and traditional beekeeping is predominantly practiced using this subspecies as it is highly adapted to the harsh environmental conditions of Saudi Arabia (Alqarni et al., 2011). Most beekeepers extract honey using a traditional straining method. The types of honey produced in Saudi Arabia are classified according to their seasonal and botanical origins. These include honey made by bees using plant sources such as *Ziziphus* (Sidr honey), *Acacia gerrardii* (Talha), *A. tortilis* (Sumra), *Lavendula* (Seyfi), and *Hypoestes forskaolii* (Majra).

Honey from different botanical sources varies greatly in its chemical composition, physical properties, sensorial attributes, and therapeutic properties (Noori et al., 2013). The association between the qualities and botanical and geographical origin enables the recognition of different types of honey. The major physicochemical properties of honey from different sources have been extensively analyzed and no two types are identical, as honey has a highly complex chemical composition that varies according to the nectar source and other factors such as its geographical and botanical origins. Studies by various authors have shown significant variation among the different types of honey (Alvarez-Suarez et al., 2009).

Honey is a natural product that has been widely used for its therapeutic effects, and it reportedly contains ~200 bioactive substances (Eteraf-Oskouei and Najafi, 2013). Honey is primarily composed of fructose and glucose, and also contains fructooligosaccharides, amino acids, vitamins, minerals, and enzymes (White, 1979). Natural honey contains multiple metabolites (thiamine, biotin, niacin, tocopherol, pinocembrin, apigenin, kaempferol, quercetin, galangin, chrysin, and hesperetin) and the folic, ellagic, caffeic, p-coumaric, and ferulic acids, in addition to various enzymes, co-enzymes, ascorbic acid, tocopherols, catalase, superoxide dismutase, reduced glutathione, Millard reaction products, and peptides. Most of these compounds work together to confer synergistic antioxidant, antibacterial, anti-fungicidal, hepatoprotective properties on honey (Al-Mamary et al., 2002).

In addition to its dietary importance, honey is an essential ingredient of folk medicine and its use against microbial infections and various diseases and ailments dates back to ancient times (Molan, 1992). Honey is used in the management of wounds in patients with chronic diseases, in combating infections (bacterial, fungal, and viral), treating cardiovascular diseases, cancer, cataracts, cough, peptic ulcers, and several inflammatory diseases (burns, skin grafting, etc.) by modern medicinal methods. Further, it is also used for its antioxidant properties (Meo et al., 2017; Al-Waili, 2004). Results from several studies support the medicinal value of different honey types despite the presence of significant variation in their therapeutic properties (Molan, 1992).

The medicinal properties, flavor, color, and odor of each type of honey depend on its nectar source and its botanical and geographical origins (Molan and Cooper, 2000). Variations in honey properties may be responsible for the differing reports on the antioxidant capacity of honey (Mullai and Menon, 2007). Honey has bactericidal and fungicidal effects that result due to its osmotic effects, acidity, hydrogen peroxide content, and the presence of antimicrobial components (phenols and flavonoids) derived from the nectar source (Alvarez-Suarez et al., 2010). Moreover, the non-peroxide content (lysozyme, some phytochemicals, phenolic acids, and flavonoids) of honey reportedly plays an important role in its antimicrobial properties. Honey shows the presence of different amounts of phenolic and flavonoid compounds depending on its botanical and geographical origin (Özkök et al., 2010). Several physical properties (acidity, phenolic content, and antioxidant level) of honey are directly associated with its antimicrobial effects, which may be important when assessing and correlating the physical properties and medicinal value of different honey types.

The spread of antibiotic resistance is a challenging global public health problem (Davies and Davies, 2010). The U.S. Centers for Disease Control and Prevention have described antibiotic resistance as one of the world's most pressing health problems in the 21st century. As a result, there is an increasing demand for alternatives to antibiotics and conventional therapies (Noori et al., 2013), highlighting the importance of screening honey of different floral origins and the identification of varieties with higher antimicrobial potencies.

Honey is acidic, as it predominantly contains gluconic acid and citric acid. Small amounts of vitamins, especially vitamin B complex and vitamin C, are also present. The mineral content of honey depends on the geographical source of the plants. Potassium is the most common mineral nutrient found in honey and accounts for about one-third of the total mineral content. Different phytochemicals are present in honey at low concentrations and in variable amounts, depending on the plant species and the nectar sources visited by the bees, and the climatic conditions of the geographical area. To date, ~500 volatile aromatic compounds have been identified in different honey types, and phenols and flavonoids are the most abundant phytochemicals found in honey (da Silva et al., 2016). The antimicrobial properties of honey result due to its high viscosity, low pH, acidity, H_2O_2, and gluconic acid, which is produced by the conversion of glucose in the presence of the glucose oxidase enzyme and certain phytochemicals (phenols and flavonoids).

2. The antimicrobial properties of Saudi honey

Almost all types of honey have antimicrobial properties. The nectar source and the botanical and geographical variations for the source of the honey are responsible for differences in the type and level of antimicrobial activity (Brady et al., 2004). Different kinds of Saudi honey show a broad spectrum of activity against Gram-positive and Gram-negative bacteria and various fungal pathogens (Hegazi, 2011; Halawani and Shohayeb, 2011; Hegazi and Abd Allah, 2012; Hegazi et al., 2017, 2018; Wadi, 2019; Owayss et al., 2020; Ghramh et al., 2019; Ayaad et al., 2012).

Monofloral and multi-floral honey from Saudi Arabia has been shown to inhibit Gram-positive and Gram-negative bacterial isolates from humans at concentrations of 20% – 30% w/v (Hegazi, 2011; Hegazi and Abd Allah, 2012). In one study, Hegazi et al. (2017) collected 10 different types of Saudi monofloral honey and tested it against five Gram-positive (*Staphylococcus aureus* ATCC 25,923 and *Streptococcus mutans*) and Gram-negative bacteria (*Klebsiella pneumoniae* ATCC 27736, *Escherichia coli* ATCC 35218, and *Pseudomonas aeruginosa* ATCC 27853). The different honey types showed variable antibacterial effects against the different types of bacteria. Halawani and Shohayeb (2011) tested nine widely used Saudi honey types against several bacterial isolates and food spoiling bacteria and found that Shaoka and Sidr honey showed more effective antibacterial activity than the other honey types. Alqurashi et al. (2013) assessed the antibacterial activity of local Saudi Arabian Sidr and Mountain honey against several human pathogens and found that Gram-negative bacteria (*E. coli*) were more sensitive to Sidr honey. A similar study was conducted by Ghanem Nevine (2011) on Sidr honey from the Al-Hasa region of Saudi Arabia.

Owayss et al. (2020) assessed the antimicrobial potential of Sidr (*Ziziphus spina-christi* L.) and Talh (*A. gerrardii* Benth.) honey samples against Gram-positive bacteria (*Bacillus cereus* and *S. aureus*), Gram-negative bacteria (*E. coli* and *Salmonella enteritidis*), and a dermatophyte fungus (*Trichophyton mentagrophytes*). Talh honey showed significantly higher antibacterial activity against all the bacterial species examined, and both honey types showed similar antifungal activity. Ghramh et al. (2019) collected Sidr, Dharm (*Lavandula dentata*), and Majra (*H. forskaolii*) honey from the Asir region of Saudi Arabia and found that Sidr and Dharm honey showed good antibacterial activity at high concentrations relative to Majra honey, which showed low antibacterial activity (Alzahrani et al., 2012; Ghramh et al., 2019). Al-Nahari et al. (2015) screened imported Manuka honey and the *Nigella sativa* and Sidr honey varieties from Saudi Arabia for their bactericidal/bacteriostatic activities against imipenem-resistant and imipenem-sensitive *P. aeruginosa*. All three types of honey inhibited bacterial growth when used at a high concentration (50%) after 24 h of incubation. Noori et al. (2013) found that Saudi honey varieties have a different biochemical composition but show highly similar antimicrobial activity against multi-drug resistant pathogens. Al-Hindi et al. (2011) studied 30 different honey samples (Sidr, Gatad, Handhal, Talh, Korath, Samra, and multi-floral types) with different botanical and geographical origins from Saudi Arabia. They extracted the total phenolic content of the honey and tested its inhibitory activity against *S. aureus*, *Micrococcus luteus*, and *E. coli*. The results of their analysis showed that the samples with the highest total phenolic content corresponded with the highest antioxidant and antibacterial effects and the lowest minimum inhibitory concentrations. Dark-colored honey showed more efficient antioxidant and antibacterial activities. Additionally, monofloral Sidr honey collected from different geographical locations in Saudi Arabia showed different antibacterial activities; that may result due to regional differences in soil factors (Abdallah and Hamed, 2019).

Noori et al. (2012) tested the synergistic effects of Saudi Arabian Sumra honey and propolis against multidrug-resistant *S. aureus*, *E. coli*, and *Candida albicans* isolates in single and polymicrobial cultures. The results showed that Sumra honey alone showed potent antimicrobial activity against the microbes in the single and polymicrobial cultures, and showed synergistic properties when mixed with Saudi Arabian and Egyptian propolis (Noori et al., 2012). Nashawi et al. (2017) observed a synergistic effect of Saudi honey and lemon against several human pathogens and proposed that the addition of lemon juice changes the pH and acidity of the honey and enhances its antimicrobial activity. Further, Al-Brahim and Mohammed (2020) synthesized silver nanoparticles (AgNPs) using Sidr (*Z. spina-christi*) and Sumra (*A. gerrardii*) honey. These biogenic AgNPs showed cytotoxic effects against HepG2 cells and suppressed the growth of methicillin-resistant *S. aureus* (MRSA, Gram-positive), as well as *E. coli* and *P. aeruginosa* (Gram-negative). The IC_{50} of the AgNPs was between 15.8 and 14.1 lg/mL and the antibacterial effect was between 22.8 ± 1.2 and 17.0 ± 0.1 mm.

Several studies have shown that different types of Saudi honey may be effective for the treatment of MRSA infections (Al-Hindi and Shehata, 2014; Alotibi et al., 2018; Hussain et al., 2019; Wadi, 2019). The identification of the mechanisms underlying MRSA inhibition by honey may enable its use as a first-line of treatment against multi-drug resistant bacterial infections. Wadi (2019) collected honey samples from different countries and showed that honey from Saudi Arabia showed strong antibacterial activity against various human pathogens, and MRSA was particularly sensitive to the effects of Saudi honey. Additionally, Al-Hindi and Shehata (2014) found that vancomycin-resistant enterococci and MRSA can be inhibited by locally produced Saudi honey. Alotibi et al. (2018) collected 11 types of Saudi honey with different botanical and geographical origins, isolated several active compounds from these honey samples, and used these for fingerprinting the honey types. MRSA was found to be sensitive to the various honey types tested, although the Rabea Aja, Zaitoon, and Toran samples showed the greatest anti-MRSA effect. The authors concluded that this effect may result due to the high phenolic content of these samples. Hussain et al. (2019) tested the activity of locally produced Sidr, Sumra, Talha, and multi-floral honey against MRSA and methicillin-sensitive *S. aureus* (MSSA). The authors found that Sumra honey showed greater peroxide-dependent antibacterial activity than Manuka honey, and recommended it as a potential therapeutic agent in certain clinical conditions, such as in wound treatment. Manuka honey and Saudi Arabian honey such as *N. sativa* and Sidr honey were tested for their bactericidal/bacteriostatic activities against MRSA and MSSA. The results showed that all three types showed good bacteriostatic effects (Almasaudi et al., 2017). *Nigella sativa* honey was found to be the most effective against *Proteus mirabilis*; a 25% concentration was enough to kill the bacterial colonies after 24 h of treatment (Alzahrani et al., 2011). Lavender honey was the least effective among the Saudi honey varieties against microbial isolates (Alzahrani et al., 2012).

3. The effect of Saudi honey on the formation of biofilms and the treatment of oral mucositis and vaginal candidiasis

Biofilms are widespread in nature and are used by microorganisms to survive harsh environmental conditions. Biofilms can have a beneficial or a negative impact, particularly in industrial settings or when formed on medical devices. Microbial populations can arrange themselves into biofilms in patients with chronic diseases who are suffering from wounds. Ansari et al. (2013) observed the effect of Sidr honey from Saudi Arabia on the growth and biofilm formation of *C. albicans*. The authors analyzed the height and roughness of the biofilm surface using AFM images, and found that Sidr honey inhibited the formation of biofilms by *C. albicans* and disrupted established biofilms.

Oral mucositis is a common complication in cancer chemotherapy. Local Saudi honey was shown to have positive results in the treatment of oral mucositis among patients with pediatric cancer who were undergoing chemo/radiotherapy at the King Abdul-Aziz University Hospital in Jeddah (Al Jaouni et al., 2017). Al Jaouni et al. showed that the incidence of oral mucositis in Grade III and IV infections of *Candida* and aerobic pathogenic bacteria was greatly reduced by the topical application of local Saudi honey. Vaginal candidiasis is common in Saudi Arabia and 70.2% of cases are caused by *C. albicans* (Al-Aali, 2015). Kalakattawi et al. (2019) collected three different types of honey (Markh, Qatad, and Sidr) from Saudi Arabia and tested them against *C. albicans*. All three types were effective against *C. albicans*, though Markh honey showed the highest anti-*Candida* activity and may serve as an effective alternative treatment for vaginal candidiasis.

4. The use of Saudi honey in the treatment of diabetes

Diabetes is a pandemic in the twenty-first century and the fourth leading cause of death in developed countries (Alzahrani, 2013). According to the international diabetes foundation, the global burden of diabetes will be 380 million people by 2025. Saudi Arabia, Kuwait, and Qatar are among the top 10 countries with the greatest prevalence (Al-Nozha et al., 2004). Studies have shown that honey may be an ideal remedy against diabetes (Erejuwa, 2014; Erejuwa et al., 2012). Honey significantly increased the levels of insulin (0.41 ± 0.06 ng/ml) and decreased the incidence of hyperglycemia (12.3 ± 3.1 mmol/L) and fructosamine levels (304.5 ± 10.1 μmol/L). Glibenclamide and metformin when used alone have been shown to significantly reduce hyperglycemia (13.9 ± 3.4 or 13.2 ± 2.9 mmol/L, respectively), but when combined with honey, these drugs significantly lowered blood glucose levels (8.8 ± 2.9 and 9.9 ± 3.3 mmol/L, respectively) (Erejuwa et al., 2010). The use of low doses of honey (equivalent to 25 g of sugar), sugar mixtures (25 g), and glucose mixtures (25 g) did not result in significantly elevated blood glucose levels for up to 3 h in patients with insulin-independent diabetes. However, the same amount of glucose when used alone produced a sharp rise after 1 h, and the value remained relatively higher than that for the honey and sugar mixtures. The authors concluded that low doses of pure honey or ~3 tablespoons can be recommended as a sweetener for diabetic patients, in addition to its nutritional use (Ahmed, 2020). However, as stated by Meo et al. (2017), "The use of honey in diabetic patients still has obstacles and challenges and needs larger sample-sized, multicenter clinical controlled studies to reach better conclusions."

5. The use of Saudi honey in the treatment of wounds in diabetic patients

The use of honey in wound dressing in patients with diabetes is gaining popularity in modern medicine because of its antimicrobial effects (Alzahrani, 2013; Ismail et al., 2015). Adequate foot care in patients with diabetes includes the use of topical agents to treat infections and diabetic wounds. The use of honey has been shown to significantly reduce the rate of amputation and improved healing when used for wound dressing in patients with diabetes that have chronically occurring foot ulcers (Surahio et al., 2014).

Honey is high on the list of complementary and alternative medicines for wound care, particularly in developing countries (Bakhotmah and Alzahrani, 2010). Evidence from animal studies and a few human trials indicates that honey may accelerate wound healing (Jull et al., 2015). However, certified honey (approved and registered by health regulatory authorities) is not easily accessible and is generally expensive. Honey is used for medical purposes due to its antimicrobial properties against various wound pathogens. This activity may be caused by osmosis, high acidity, hydrogen peroxide, or a variety of phytochemicals (Sherlock et al., 2010); however, only a narrow range of medical-grade honey is available for wound management (Jenkins et al., 2011; Simon et al., 2009). The viscosity and hygroscopic nature of honey enable it to spread effectively across the wound bed, creating a favorable environment to dehydrate and kill wound pathogens (Saranraj et al., 2016).

The habits and practices among the people of Saudi Arabia are often influenced by Islamic culture and literature. Honey is one of the most common complementary and alternatives medicine products used for the topical treatment of diabetic foot disorders, which are fairly common among Saudi patients with diabetes. According to the results of one survey, 56.6% of Saudi patients with diabetes treated diabetic foot ulcers with honey, either as a solo topical preparation or in combination with other herbs such as black seeds and myrrh (Bakhotmah and Alzahrani, 2010). Auguskani (2018) isolated three compounds from Saudi honey and tested these on bacterial pathogens isolated from diabetes-induced wounds in patients. Compound 2 showed better antibacterial activity against pathogens such as *E. coli*, *Klebsiella*, *Staphylococcus*, and *S. aureus* than compounds 1 or 3. The author did not observe any antibacterial activity against *Pseudomonas*, but concluded that Saudi honey may be useful as a potential treatment for diabetic foot ulcers caused by pathogens.

Hananeh et al. (2015) treated full-thickness contaminated skin wounds in dogs using Saudi Sidr honey and reported that they healed as fast as wounds treated with iodine. Al-Jaber (2013) collected Sumra, Sidr, Magra, and several other types of indigenous honey during the winter and summer seasons, and reported that the oral administration of different types of Saudi honey before the induction of ulcers significantly reduced the intensity of ulcer scores compared to a control group. Overall, there is significant experimental data to support the antibacterial effects of Saudi honey against a wide range of bacteria, including antibiotic-resistant strains.

6. The use of Saudi honey to alleviate oxidative stress and hepatonephrotoxicity

Liver disease is an important health issue worldwide. According to the world health statistics report, despite tremendous advances in modern medicine, the strategies for the treatment and prevention of liver disease face multiple limitations. The pathogenesis of liver diseases and the causative roles of oxidative stress and inflammation is well established (Canbay et al., 2011). The inhibition of oxidative and inflammatory processes could be one of the most important therapeutic strategies for the treatment and prevention of liver damage. Kidney disease is another important global public health issue (Coresh et al., 2013). Al-Yahya et al. (2013) assessed the protective effects of Saudi Sidr honey on carbon tetrachloride (CCl_4)-induced oxidative stress and liver and kidney damage in rats. Rats fed with honey showed liver protective effects as seen by the reduction in the levels of liver marker enzymes in CCl_4-treated rats. The treatment of rats with CCl_4 increased the total lipid, triglyceride, and cholesterol levels in their serum, and the use of Sidr honey was associated with significant lipid-lowering effects and the elevation of the high-density lipoprotein cholesterol levels in the serum. Further, the histopathological evaluation of the liver and kidney tissues revealed that honey protected both liver and kidney lesions.

7. The immunomodulatory properties of Saudi honey and its potential in cancer treatment

Honey has been shown to have multifunctional immunomodulatory properties and researchers have tried to identify the substances responsible for these effects (Fukuda et al., 2011). Sidr and Sumra honey were shown to have potential antioxidant, anti-inflammatory, and antitumor activity in studies on erythrocyte lysis, erythrocyte membrane protection against oxidative damage, cancer cell growth inhibition, the reduction of pro-inflammatory marker secretion in prostate cancer cells (PC-3), and peripheral blood mononuclear cell cultures. Sidr and Sumra honey showed greater antioxidant potential and comparable anti-inflammatory and antitumor effects (Hilary et al., 2017). Ghramh et al. (2019, 2020) found that the Saudi Arabian Majra and Sidr honey and AgNPs inhibited HepG2 cancer cell proliferation and HeLa cell growth. The immunomodulatory effects of Sidr and Sumra honey were tested in PC-3 cells and peripheral blood mononuclear cells by measuring the interleukin 6 and nitric oxide levels in the cell cultures. Both honey types exhibited superior erythrocyte membrane protection effects. Malondialdehyde levels were significantly reduced by honey treatment, especially by Sumra honey. Both honey types significantly decreased the cell population and viability of PC-3 cells. Further, it has been suggested that polyphenols (including caffeic acid and its phenyl esters) found in honey may be promising pharmacological agents in the treatment of cancer (Jaganathan and Mandal, 2009). These compounds are thought to exhibit a broad spectrum of activity, including tumor inhibition via the downregulation of multiple cellular enzymatic pathways such as the protein tyrosine kinase cyclooxygenase and the ornithine decarboxylase pathways (Rao et al., 1993).

8. The use of Saudi honey as a gastro-protective (anti-ulcer) agent and in the treatment of chronic constipation and intestinal schistosomiasis

Peptic ulcers are a commonly occurring ailment, and honey is traditionally used to treat dyspepsia and peptic ulcers (El-Soud, 2012). Honey is also effective in treating bacterial gastroenteritis (Halawani and Shohayeb, 2011). Elhassan Taha et al. (2015) investigated the anti-ulcerogenic mechanisms of Saudi Arabian Sidr honey on ulcers caused due to ethanol-induced oxidative stress. The authors observed that Sidr honey protects the gastric mucosa against ethanol-triggered damage in a dose-dependent manner. These findings indicate that further research into the effects of Sidr honey as a possible defensive and remedial agent for gastric ulcers may prove to be useful. Osato et al. (1999) used medical-grade Manuka honey and Saudi Arabian Sidr honey against 28 clinical isolates of *H. pylori*. They found that both honey types, with or without catalase, could kill *H. pylori*. The authors concluded that regional differences do not affect the antimicrobial activity of honey against *H. pylori* and that the observed effect was not related to the presence of hydrogen peroxide in the honey samples. Ali (2003) performed *in vitro* experiments to determine the inhibitory effect of honey against 20 *H. pylori* isolates and found that the growth of all the isolates was inhibited by a concentration of 20% of Saudi honey. Of these 20 isolates, some were multidrug-resistant. The author suggested that Saudi honey may be an effective alternative treatment for gastroduodenal ulcers colonized by *H. pylori*.

Chronic constipation is a commonly occurring clinical condition. Lactulose is used in the treatment of chronic idiopathic constipation in patients of all ages as a long-term treatment. Mountain Sidr honey (*Z. spina-christi)* is commonly used in local Saudi communities to treat many health conditions. A prospective comparative study of 1000 patients diagnosed with chronic constipation and treated with either Saudi Sidr honey or Lactulose showed that mountain Sidr honey (*Z. spina-christi*) may be a promising treatment for the long-term control of chronic constipation. Sidr honey was found to be superior to Lactulose in both the short- and long-term treatment of chronic constipation (Shirah and Shirah, 2016). Further, Mostafa and Soliman (2010) studied the effects of Saudi Arabian Sidr honey and black-seed oil, alone or in combination, on the ultrastructure of the tegument, gastrodermis, and testes of adult male albino mice harboring *Schistosoma mansoni*. The authors found that the mixture of Sidr honey and black-seed oil had schistosomicidal effects.

9. Conclusions

Saudi Arabian honey has high nutritional value and shows promising antioxidant, anti-inflammatory, and antibacterial properties. Honey has also been shown to prevent and disturb biofilm formation, has wound-healing characteristics, and acts as an immunomodulatory and gastroprotective agent. There is a need for further study of its composition and the identification of active ingredients to enable the clinical application of honey as an alternative treatment in medical practice. We recommend certain Saudi honey types as valuable dietary supplements, and propose that the use of honey in the treatment of various metabolic and pathogenic disease needs further investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors extend their appreciation to the Deputyship for Research & Innovation, "Ministry of Education" in Saudi Arabia for funding this research work through the project number IFKSURP-2020-128.

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