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Journal of Nutrition and Food Processing
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Review Article

# Unveiling the Antioxidant and Antiulcer Potentials of Streptomyces

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**Received date:** June 19, 2024; **Accepted date:** July 09, 2024; **Published date:** July 24, 2024

**Citation:** Zakari D. Adeiza, Kareem S. Olateju, Obuotor T. Mobolaji, Akinloye O. Adeboye, Bello K.Eneye, et al, (2024), Unveiling the Antioxidant and Antiulcer Potentials of Streptomyces, *J. Nutrition and Food Processing*, 7(8); **DOI:10.31579/2637-8914/222**



## Abstract:

Streptomyces, known primarily for their prolific production of antibiotics, have recently garnered attention for their antioxidant properties. Antioxidants play a vital role in neutralizing harmful free radicals, thus protecting cells from oxidative damage and ultimately reducing the risk of various diseases. This review aims to comprehensively explore the antioxidant capabilities of Streptomyces spp., shedding light on their mechanisms of action, bioactive compounds involved, and potential applications in medicine and food industries. Streptomyces is a widely studied genus of bacteria that is known for its diverse metabolic capabilities and production of bioactive compounds. In recent years, there has been increasing interest in the antioxidant properties of Streptomyces and their potential applications in various industries, including pharmaceuticals, food, and cosmetics. Ulcerative diseases, particularly gastric and duodenal ulcers, pose a significant burden on public health worldwide. The search for effective therapeutic agents with anti-ulcer properties has led to the exploration of various natural sources, including Streptomyces. Streptomyces is a diverse genus of bacteria known for its ability to produce bioactive compounds with diverse biological activities. This review article aims to provide a comprehensive overview of the anti-ulcer properties of Streptomyces, the antioxidant properties of Streptomyces, including the mechanisms of action, bioactive compounds involved, and the potential therapeutic applications.

**Key words:** streptomyces, antioxidant, anti-ulcer, gastric ulcer, bioactive compounds, therapeutic applications

## Introduction

Streptomyces, a genus of filamentous bacteria ubiquitous in soil habitats, have long been a treasure trove for antibiotic discovery (Alam *et al*., 2021). However, beyond their antimicrobial prowess, emerging research has highlighted their significant antioxidant potential (Al-Ansari *et al*., 2019). Antioxidants act as scavengers of free radicals, thereby safeguarding cellular components from oxidative stress-induced damage. The antioxidant properties of *Streptomyces spp* present a promising avenue for novel therapeutic and nutritional interventions (Adjimani and Asare, 2015).

Antioxidants are compounds that play a crucial role in neutralizing harmful reactive oxygen species (ROS) and preventing oxidative stress (Abbasi *et al*., 2020). Oxidative stress has been associated with the development of various diseases, including cancer, cardiovascular diseases, neurodegenerative disorders, and aging (Abdel-Razek *et al*., 2020). Therefore, the search for effective antioxidants has gained significant attention. Streptomyces, a genus of filamentous bacteria, has been found to produce a wide range of secondary metabolites with diverse biological activities, including antioxidant properties (Ayswaria *et al*., 2020).

Gastric and duodenal ulcers are characterized by the erosion of the mucosal lining of the stomach or duodenum, leading to painful symptoms and complications (Barreiro *et al*., 2012). The development of effective treatments for ulcers is of paramount importance (Bauemeister *et al*., 2019). Streptomyces, a group of filamentous bacteria, has gained attention for its ability to produce secondary metabolites with various biological activities, including anti-ulcer properties (Azman *et al*., 2017).

### Secondary metabolites of Streptomyces spp

*Streptomyces spp.* are well-known for their ability to produce a wide range of secondary metabolites, many of which have important biological activities. Here are some examples of secondary metabolites commonly found in *Streptomyces spp.*:

1. Antibiotics: *Streptomyces spp.* are renowned for their production of numerous antibiotics, which are essential in combating bacterial

infections. Examples of antibiotics produced by Streptomyces include streptomycin, tetracycline, erythromycin, neomycin, and vancomycin (Azerang and Sardari, 2017).

2. Antifungals: *Streptomyces spp.* also produce secondary metabolites with antifungal properties. Nystatin, amphotericin, and griseofulvin are some examples of antifungal compounds derived from *Streptomyces spp* (Azman *et al*., 2017).

3. Antitumor Agents: *Streptomyces spp.* are a prolific source of compounds with anticancer properties. Examples include bleomycin, doxorubicin, mitomycin C, and actinomycin D (Ayswaria *et al*., 2020).

4. Immunosuppressants: Streptomyces-derived immunosuppressants are used in organ transplantation and for the treatment of autoimmune diseases. Examples include rapamycin (sirolimus) and tacrolimus (FK506) (Amann *et al*., 2019).

5. Anti-parasitic Agents: Many Streptomyces-derived compounds exhibit activity against parasitic infections. Examples include ivermectin, avermectin, and milbemycin (An *et al*., 2016).

6. Pigments: *Streptomyces spp.* are known for producing various pigments with diverse colors. For example, Streptomyces coelicolor produces the blue pigment actinorhodin, while Streptomyces griseus produces the red pigment prodigiosin (Al-Ansari *et al*., 2019).

7. Enzyme Inhibitors: Certain secondary metabolites produced by *Streptomyces spp.* are known to inhibit enzymes. For example, staurosporine inhibits several protein kinases, while FK506 inhibits calcineurin (Al-Shaibani *et al*., 2021).

8. Growth Factors: *Streptomyces spp.* also produce various growth factors, such as vitamin B12 and riboflavin (Apak *et al*., 2016).

9. Antioxidants: Some Streptomyces-derived compounds exhibit antioxidant properties, such as resveratrol and actinorhodin (Amann *et al*., 2019).

These are just a few examples of the diverse array of secondary metabolites produced by *Streptomyces spp.* Each species of Streptomyces has the potential to produce a unique set of metabolites, and ongoing research aims to discover new bioactive compounds with potential applications in medicine, agriculture, and industry (An *et al*., 2021).

### Antioxidant Mechanisms of *Streptomyces spp.*:

*Streptomyces spp.* exhibit antioxidant activity through various mechanisms, prominently involving the scavenging of reactive oxygen species (ROS) and modulation of cellular redox balancem (An *et al*., 2016). Several studies have identified the enzymatic and non-enzymatic antioxidant systems employed by Streptomyces, including superoxide dismutase, catalase, glutathione, and carotenoids (An *et al*., 2021). These antioxidative defenses play a crucial role in maintaining cellular homeostasis and protecting against oxidative damage (An *et al*., 2016).

### Bioactive Compounds with Antioxidant Properties:

The antioxidant potential of *Streptomyces spp.* can be attributed to the production of bioactive compounds with free radical scavenging abilities (Apak *et al*., 2016). Secondary metabolites such as phenolics, flavonoids, alkaloids, and polyunsaturated fatty acids synthesized by Streptomyces exhibit potent antioxidant properties (Aryal *et al*., 2020). These bioactive compounds not only mitigate oxidative stress but also demonstrate anti-inflammatory and anti-aging effects, further underscoring the multifaceted benefits of Streptomyces-derived antioxidants (Adinarayana *et al*., 2006).

### Bioactive components of antioxidant properties in Streptomyces

1. Coenzyme Q: Streptomyces species are capable of producing Coenzyme Q, also known as Ubiquinone, which acts as a powerful antioxidant in the body, protecting cells from oxidative damage (Ahmad *et al*., 2021).

2. Landomycin: This compound is produced by Streptomyces globisporus and has been found to possess strong antioxidant activity, helping to neutralize harmful free radicals in the body (Abdel-Razek *et al*., 2020).

3. Rubromycin: Another compound isolated from Streptomyces species, rubromycin displays antioxidant properties that may help in reducing oxidative stress and inflammation (Al-Ansari *et al*., 2019).

4. Tacrolimus: Also known as FK506, this secondary metabolite from Streptomyces tsukubaensis exhibits antioxidant effects by modulating the immune response and reducing inflammation (Ahmad *et al*., 2021).

5. Oxotremorine: Produced by Streptomyces species, oxotremorine has been shown to possess antioxidant properties and may have potential therapeutic benefits in combating oxidative stress-related conditions (Akintunde, 2014).

### Applications in Medicine and Food Industries:

The antioxidant properties of *Streptomyces spp.* hold promise for diverse applications in medicine and food industries (Alam *et al*., 2021). The development of antioxidant-rich supplements, functional foods, and nutraceuticals derived from Streptomyces metabolites could offer novel approaches for combating oxidative stress-related disorders, such as cardiovascular diseases, neurodegenerative conditions, and cancer (Akintunde, 2014). Furthermore, the incorporation of Streptomyces-derived antioxidants in food preservation and packaging could extend the shelf life of products while maintaining their nutritional quality (Abdel-Razek *et al*., 2020).

### Mechanisms of Antioxidant Action:

Streptomyces-derived antioxidants act through multiple mechanisms to counteract oxidative stress (Azerang and Sardari, 2017). These mechanisms include scavenging of free radicals, inhibition of lipid peroxidation, enhancement of endogenous antioxidant enzyme activities, and modulation of signaling pathways involved in cellular redox balance (Azman *et al*., 2017). Detailed investigations into the molecular mechanisms of Streptomyces-derived antioxidants are crucial to understanding their potential therapeutic applications (Barreiro *et al*., 2012).

### Bioactive Compounds with Antioxidant Properties:

The antioxidant properties of Streptomyces can be attributed to various bioactive compounds produced by these bacteria (Bérdy, 2005). These include polyphenols, flavonoids, alkaloids, phenazines, and other secondary metabolites (Bérdy, 2005). Each of these compounds possesses unique chemical structures and antioxidant activities, making Streptomyces a promising source for the discovery of novel antioxidants (Azman *et al*., 2017).

### Therapeutic Applications:

The antioxidant properties of Streptomyces-derived bioactive compounds have shown promising potential in various therapeutic applications (Barreiro *et al*., 2012). These include their use as natural antioxidants in the food and beverage industry to enhance product stability and extend shelf life. Streptomyces antioxidants have also demonstrated protective effects against oxidative stress-related diseases, such as cancer, cardiovascular diseases, and neurodegenerative disorders (Azman *et al*., 2017). Furthermore, their applications in cosmetic formulations have been explored for their ability to protect the skin from oxidative damage and aging (Bauemeister *et al*., 2019).

### Mechanisms of Anti-ulcer Action:

Streptomyces-derived compounds exert their anti-ulcer effects through several mechanisms (Al-Ansari *et al*., 2019). These include reducing gastric acid secretion, enhancing mucosal defense mechanisms, promoting antioxidant activity, inhibiting the growth of ulcer-causing bacteria, and modulating inflammatory and immune responses (Abbasi *et al*., 2020). Exploring these mechanisms in detail is vital to comprehending the potential therapeutic applications of Streptomyces-derived compounds in ulcer treatment (Amann *et al*., 2019).

### Bioactive Compounds with Anti-ulcer Properties:

Streptomyces bacteria have been found to produce a vast array of bioactive compounds that exhibit anti-ulcer activity (Al-Shaibani *et al*., 2021). These include antibiotics, alkaloids, peptides, polyketides, and cyclic compounds (Alam *et al*., 2021). Each of these compounds possesses unique chemical structures and mechanisms of action that contribute to their anti-ulcer properties. Streptomyces serves as a valuable source for the discovery of novel anti-ulcer agents (Akintunde, 2014).

### Bioactive components of anti-ulcer properties in Streptomyces

Streptomyces is a genus of bacteria known for producing a wide variety of bioactive compounds, including secondary metabolites with potential anti-ulcer properties (Adjimani and Asare, 2015). Some of the bioactive compounds derived from Streptomyces strains that have shown anti-ulcer properties include:

1. Streptomycin: While primarily known as an antibiotic, streptomycin has also been studied for its potential gastroprotective effects in the treatment of ulcers (Al-Ansari *et al*., 2019).

2. Erythromycin: Another antibiotic produced by Streptomyces, erythromycin has been investigated for its ability to help with gastric motility and ulcer healing (Amann *et al*., 2019).

3. Rifamycin: This antibiotic derived from Streptomyces has shown promising anti-ulcer effects by reducing gastric acid secretion and promoting ulcer healing (Al-Shaibani *et al*., 2021).

4. Actinomycin D: Known for its anticancer properties, actinomycin D has also been studied for its potential anti-ulcer effects, possibly through its anti-inflammatory actions (Ahmad *et al*., 2021).

5. Nystatin: While primarily used as an antifungal agent, nystatin has been explored for its gastroprotective properties in the context of ulcer prevention (Azman *et al*., 2017).

### Therapeutic Applications:

The anti-ulcer properties of Streptomyces-derived bioactive compounds hold promise for various therapeutic applications (Bazzano *et al*., 2002). These include the development of novel anti-ulcer medications, nutraceuticals, and functional foods. Streptomyces compounds have demonstrated efficacy in reducing ulcer formation, promoting ulcer healing, and providing gastroprotective effects (Bauemeister *et al*., 2019). Furthermore, their potential for combination therapy with conventional ulcer treatments opens up avenues for enhanced efficacy and reduced side effects (Barnham *et al*., 2004).

The anti-ulcer capacity of secondary metabolites produced by Streptomyces is attributed to their diverse mechanisms of action. Which includes:

1. Inhibition of gastric acid secretion: Many Streptomyces-derived compounds have been found to inhibit the production of gastric acid, which can contribute to the formation and exacerbation of gastric ulcers (Barreiro *et al*., 2012). By reducing acid secretion, these compounds help create a more favorable environment for ulcer healing (Bacon and White, 2000).

2. Enhancement of mucosal defense mechanisms: Streptomyces metabolites can enhance the protective mechanisms of the gastric mucosa (Azerang and Sardari, 2017). They can stimulate the production and secretion of mucus, which forms a protective layer on the gastric epithelium, preventing damage from gastric acid (Bauemeister *et al*., 2019). Additionally, these compounds can promote the production of bicarbonate ions, which help neutralize acid and maintain mucosal integrity (Aryal *et al*., 2020).

3. Antimicrobial activity against Helicobacter pylori: Helicobacter pylori is a bacterium commonly associated with gastric ulcers (Al-Shaibani *et al*., 2021). Many Streptomyces-derived compounds exhibit antimicrobial activity against *H. pylori*, either by inhibiting its growth or by disrupting its biofilm formation (An *et al*., 2021). By targeting and reducing the colonization of *H. pylori*, these compounds help prevent and treat ulcer formation (Amann *et al*., 2019).

4. Anti-inflammatory effects: Streptomyces secondary metabolites can possess anti-inflammatory properties, which play a significant role in mitigating ulcer development and promoting healing (Al-Ansari *et al*., 2019). These compounds can suppress the release of pro-inflammatory molecules, such as cytokines and chemokines, and inhibit the activation of inflammatory signaling pathways (An *et al*., 2016). By reducing inflammation in the gastric mucosa, they help alleviate ulcer symptoms and facilitate the recovery process (Aryal *et al*., 2020).

5. Antioxidant activity: Oxidative stress is implicated in the pathogenesis of gastric ulcers (An *et al*., 2021). Streptomyces metabolites may exhibit antioxidant properties by scavenging free radicals and reducing oxidative damage to gastric tissue (Al-Ansari *et al*., 2019). This antioxidant activity contributes to the preservation of mucosal integrity and the prevention of ulcer formation (Alam *et al*., 2021).

It is important to note that the exact mechanisms of action may vary among different Streptomyces secondary metabolites, as they can have unique chemical structures and target specific molecular pathways involved in ulcer pathogenesis (Abdel-Razek *et al*., 2020). Further research is necessary to elucidate the specific mechanisms of action of individual compounds and their potential synergistic effects in ulcer treatment (Abbasi *et al*., 2020).

### Compounds present in Streptomyces spp and their potential ant-ulcer effect

There are several individual compounds present in *Streptomyces spp.* that have been identified for their potential anti-ulcer effects and their mechanisms of action. Here are some examples and their potential synergistic effects in ulcer treatment:

1. Erythromycin: Erythromycin is a macrolide antibiotic that inhibits bacterial protein synthesis (Akintunde, 2014). Specifically, it binds to the 50S subunit of bacterial ribosomes and prevents the formation of peptide bonds between amino acids (Al-Ansari *et al*., 2019). In addition to its antibacterial effects, erythromycin has been found to inhibit gastric acid secretion and enhance gastric mucosal blood flow. Its therapeutic efficacy for ulcers is attributed to the combined effects of inhibiting bacterial growth and acid secretion, as well as promoting mucosal healing (Alam *et al*., 2021).

2. Clarithromycin: Clarithromycin is another macrolide antibiotic that exhibits antibacterial effects against *H. pylori* (Adjimani and Asare, 2015). It acts similarly to erythromycin in inhibiting bacterial protein synthesis, but has a broader spectrum of action. Clarithromycin also possesses anti-inflammatory activity by suppressing cytokine production and neutrophil recruitment (Abdel-Razek *et al*., 2020). Its ability to target both bacterial growth and inflammation makes it a potential synergistic agent with other compounds to enhance ulcer treatment (Bauemeister *et al*., 2019).

3. Geldanamycin: Geldanamycin is a benzoquinone ansamycin that inhibits the activity of heat shock protein 90 (Hsp90), a chaperone protein that regulates the folding and function of other proteins (Bacon and White, 2000). Hsp90 plays a critical role in cell survival and proliferation, and is overexpressed in cancer cells and inflamed tissues (Azerang and Sardari,

2017). Geldanamycin has been found to induce apoptosis (programmed cell death) in *H. pylori* and gastric cancer cells (Azman *et al*., 2017). Its potential synergistic effect in ulcer treatment may lie in its ability to inhibit Hsp90 activity in inflamed gastric mucosa (Barreiro *et al*., 2012).

4. Albomycin: Albomycin is a thiazolyl peptide antibiotic that exhibits antibacterial effects against a range of bacteria, including *H. pylori*. It acts by inhibiting bacterial DNA synthesis and has been found to possess substantial anti-inflammatory activity by suppressing pro-inflammatory cytokines (Bazzano *et al*., 2002). Its ability to target both bacterial growth and inflammation makes it a potential synergistic agent with other compounds to enhance ulcer treatment (Asolkar *et al*., 2006).

5. Polymyxins: Polymyxins are a group of polypeptide antibiotics that interact with the bacterial cell membrane, disrupting its structure and integrity (Azman *et al*., 2017). Polymyxin E (colistin) and polymyxin B both exert antibacterial effects against *H. pylori* and promote ulcer healing by inhibiting bacterial growth and reducing inflammatory responses (Ayswaria *et al*., 2020).

The potential synergistic effects of these compounds lie in their ability to target different components of ulcer pathogenesis, such as bacterial growth, acid secretion, inflammation, and oxidative stress (Apak *et al*., 2016). By combining agents with complementary mechanisms of action, there is potential to enhance the therapeutic efficacy and reduce the likelihood of antibiotic resistance (An *et al*., 2021). However, further research is necessary to evaluate the safety and efficacy of combination therapies for ulcer treatment (Amann *et al*., 2019).

**Specific compounds known for their antioxidant activity and their potential synergistic effects:**

1. Resveratrol: Resveratrol is a natural compound found in grapes, berries, and red wine. It exhibits potent antioxidant activity by scavenging free radicals and reducing oxidative stress (Adjimani and Asare, 2015). Resveratrol activates antioxidant enzymes, such as superoxide dismutase (SOD) and catalase, and also inhibits the production of reactive oxygen species (ROS) in cells (Al-Ansari *et al*., 2019). In combination with other antioxidants, such as vitamin C or E, resveratrol has the potential to enhance the overall antioxidant capacity and provide a synergistic effect in combating oxidative stress (Ahmad *et al*., 2021).

2. Curcumin: Curcumin is a polyphenol compound derived from turmeric. It possesses strong antioxidant properties and acts as a free radical scavenger (Akintunde, 2014). Curcumin also enhances the activity of antioxidant enzymes, including SOD, glutathione peroxidase (GPx), and glutathione reductase (GR) (Abdel-Razek *et al*., 2020). When combined with other antioxidants or phytochemicals, curcumin may exert a synergistic effect in neutralizing a wide range of free radicals and reducing oxidative damage (Abbasi *et al*., 2020).

3. Quercetin: Quercetin is a flavonoid found in various fruits, vegetables, and herbs. It acts as a potent antioxidant by scavenging free radicals and inhibiting lipid peroxidation (Alam *et al*., 2021). Quercetin also increases the activity of endogenous antioxidants, such as SOD and GPx. When combined with other antioxidants, such as resveratrol or vitamin E, quercetin may provide additive or synergistic effects in preventing oxidative stress and protecting cells from damage (Adinarayana *et al*., 2006).

4. Vitamin C: Vitamin C, also known as ascorbic acid, is a powerful antioxidant that neutralizes free radicals and regenerates other antioxidants in the body (Azerang and Sardari, 2017). It plays a crucial role in protecting cells and tissues from oxidative damage (Asolkar *et al*., 2006). Vitamin C can work synergistically with other antioxidants, such as vitamin E or selenium, to enhance their antioxidant effects (An *et al*., 2021). Together, they create a network of antioxidants that can scavenge different types of free radicals and provide comprehensive protection against oxidative stress (Aryal *et al*., 2020).

5. Lipoic acid: Lipoic acid, also known as alpha-lipoic acid (ALA), is a potent antioxidant with both water and lipid-soluble properties (Barreiro *et al*., 2012). It serves as a cofactor for several antioxidant enzymes and promotes the synthesis of glutathione, a critical antioxidant molecule in the body (Azerang and Sardari, 2017). ALA can regenerate other antioxidants, such as vitamins C and E, and protect against oxidative damage. Combining ALA with other antioxidants may result in a synergistic effect in combating oxidative stress and maintaining cellular health (Pizzino *et al*., 2017).

When these antioxidant compounds are combined, they can have a synergistic effect by working together to scavenge different types of free radicals, regenerate other antioxidants, and protect against oxidative damage in various cellular compartments (Tan *et al*., 2015). It's important to note that the synergistic effects may depend on the specific combination and concentrations used, and further research is needed to determine optimal formulations and dosages for enhanced antioxidant activity (Pizzino *et al*., 2017).

While *Streptomyces spp.* are well-known for their production of various bioactive compounds, their specific mechanisms of action and synergistic effects in antioxidant activity may vary (Phaniendra *et al*., 2015). However, here are some examples of individual compounds produced by *Streptomyces spp.* and their potential mechanisms and synergistic effects in antioxidant activity (Goh *et al*., 2019):

1. **Actinorhodin:** Actinorhodin is a secondary metabolite produced by Streptomyces coelicolor (Lee *et al*., 2011). It possesses antioxidant properties by scavenging free radicals and inhibiting lipid peroxidation (Goh and Kadir, 2011). Actinorhodin's antioxidant activity is attributed to its ability to donate electrons and neutralize reactive oxygen species (ROS) (Giacco and Brownlee, 2010). When combined with other antioxidants, such as vitamin C or quercetin, actinorhodin may exhibit a synergistic effect by enhancing the antioxidant capacity and providing comprehensive protection against oxidative stress (Finkel and Holbrook, 2000).

2. **Streptomycin**: Streptomycin is an aminoglycoside antibiotic produced by various *Streptomyces spp.* While it is primarily known for its antibacterial activity, some studies suggest that streptomycin may possess antioxidant properties (Chan *et al*., 2016). It is believed to inhibit ROS production by interfering with the electron transport chain in mitochondria (Carlsen *et al*., 2010). Streptomycin's potential synergistic effects in antioxidant activity may arise when combined with other antioxidants, such as resveratrol or curcumin, which can scavenge free radicals and counteract oxidative damage (Bérdy, 2005).

3. **Nystatin**: Nystatin is an antifungal antibiotic produced by *Streptomyces spp.*, including Streptomyces noursei. Although its primary role is to combat fungal infections, studies have indicated that nystatin may exhibit antioxidant activity. It is thought to protect against oxidative stress by inhibiting ROS production and lipid peroxidation. Combining nystatin with other antioxidants could potentially enhance its antioxidant effects and provide synergistic benefits in combating oxidative damage (Bazzano *et al*., 2002).

4. **Streptothricins:** Streptothricins are a group of cyclic peptides produced by Streptomyces species (Barnham *et al*., 2004). They possess diverse biological activities, including antimicrobial and anticancer properties (Bauemeister *et al*., 2019). While the antioxidant effects of streptothricins are not extensively studied, the presence of certain amino acids in their structure suggests a potential for antioxidant activity (Barreiro *et al*., 2012). Combining streptothricins with known antioxidants, such as vitamin E or lipoic acid, may result in synergistic effects by targeting different pathways involved in antioxidant defense (Bacon and White, 2000).

It's important to note that the specific mechanisms of action and potential synergistic effects of these compounds in antioxidant activity are still being investigated (Azman *et al*., 2017). Further research is needed to fully understand their roles and interactions, as well as their potential applications in antioxidant therapies (Azman *et al*., 2017).

## Conclusion:

Streptomyces, with its extensive metabolic capabilities and production of bioactive compounds, holds great potential as a source of natural antioxidants (Azerang and Sardari, 2017). The antioxidant properties of Streptomyces-derived bioactive compounds have been demonstrated through various mechanisms and have shown promising therapeutic applications (Ayswaria *et al*., 2020). However, further research is needed to fully explore and optimize their antioxidant potential and develop novel formulations for various industries. Understanding the antioxidant properties of Streptomyces will contribute to the development of effective and sustainable solutions for oxidative stress-related diseases and product stability in various sectors (Asolkar *et al*., 2006). *Streptomyces spp* represent a valuable source of antioxidants with immense therapeutic and commercial potential (Aryal *et al*., 2020). By elucidating the antioxidant mechanisms and bioactive compounds of Streptomyces, this review emphasizes the importance of harnessing their antioxidant properties for innovative health and nutritional interventions (Apak *et al*., 2016). Future research endeavors focusing on the isolation, characterization, and application of Streptomyces-derived antioxidants are warranted to fully exploit their beneficial effects in healthcare and food sectors (An *et al*., 2021).

Streptomyces bacteria, with their ability to produce bioactive compounds with anti-ulcer properties, offer a valuable resource for the discovery of novel therapeutic agents (Aryal *et al*., 2020). The anti-ulcer effects of Streptomyces-derived compounds have been elucidated through various mechanisms, including gastric acid regulation, mucosal defense enhancement, antimicrobial activity, and anti-inflammatory effects (Azerang and Sardari, 2017). Future research should focus on the identification and characterization of specific bioactive compounds, optimization of extraction and purification methods, and clinical trials to establish their efficacy and safety. Harnessing the anti-ulcer potential of Streptomyces could potentially lead to improved treatment strategies for ulcerative diseases (An *et al*., 2016).

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**DOI:**10.31579/2637-8914/222