

# *Cordyceps Militaris*

## Bioactive Compounds

# Cordyceps Mushroom

## Polysaccharide: (1→3)-β-D-glucan

### 1. Recognition by Immune Cells:

- **Dectin-1 Receptor:** The primary mechanism of action involves the interaction of (1→3)-β-D-glucans with a specific receptor on immune cells called **Dectin-1**.
- **Pattern Recognition Receptor (PRR):** Dectin-1 is a type of PRR, which are proteins on the surface of immune cells that recognize specific patterns on pathogens.

### 2. Immune Cell Activation:

- **Signal Transduction:** When (1→3)-β-D-glucan binds to Dectin-1, it triggers a cascade of signaling events within the immune cell.
- **Cytokine Production:** This signaling leads to the increased production and release of various cytokines, including:
  - **Interleukin-1β (IL-1β):** A potent pro-inflammatory cytokine.
  - **Tumor Necrosis Factor-alpha (TNF-α):** An important pro-inflammatory cytokine.
  - **Interleukin-6 (IL-6):** Involved in inflammation and immune responses.

### 3. Enhanced Immune Response:

- **Macrophage Activation:** The released cytokines, particularly IL-1β and TNF-α, activate macrophages, a type of white blood cell playing a crucial role in engulfing and destroying pathogens.
- **Increased Phagocytosis:** Activated macrophages exhibit enhanced phagocytic activity, meaning they are more efficient at engulfing and destroying foreign invaders like bacteria and fungi.
- **Improved Antigen Presentation:** Macrophages also play a crucial role in antigen presentation, which is the process of displaying fragments of pathogens to other immune cells, such as T cells, to initiate an adaptive immune response.



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### 4. Fuel for Gut Microbiota:

- **Polysaccharides serve as food for beneficial bacteria** in the gut, promoting their growth and diversity. A healthy gut microbiome is essential for digestion, immune function, and overall health.
- **Short-Chain Fatty Acid Production:** As gut bacteria ferment polysaccharides, they produce short-chain fatty acids (SCFAs), such as butyrate. SCFAs have various beneficial effects on gut health, including reducing inflammation and strengthening the gut barrier.

## Cordycepin

### 1. Anti-inflammatory Effects:

- **Targeting Inflammatory Pathways:**
  - **NF-κB Inhibition:** Cordycepin may inhibit the activation of NF-κB (Nuclear Factor-kappa B), a key protein complex involved in inflammation. NF-κB normally triggers the production of inflammatory molecules like cytokines. By blocking NF-κB, cordycepin may help reduce inflammation.
  - **MAPK Pathway Modulation:** Cordycepin may also influence the MAPK (Mitogen-Activated Protein Kinase) signaling pathway, another crucial pathway involved in inflammation. By modulating this pathway, cordycepin could help to dampen inflammatory responses.
- **Reduced Inflammatory Molecule Production:** These effects on NF-κB and MAPK may lead to a decrease in the production of inflammatory molecules such as:
  - **Cytokines:** These signaling molecules play a key role in inflammation. Examples include TNF-alpha, IL-1, and IL-6.
  - **Prostaglandins:** These are involved in various inflammatory processes.
- **Inhibition of Inflammatory Pathways:** Cordycepin may inhibit the production of inflammatory mediators such as cytokines (e.g., TNF-alpha, IL-1β) and prostaglandins.
- **Antioxidant Activity:** Cordycepin possesses antioxidant properties, which can help reduce oxidative stress and inflammation.

### 2. Anti-cancer Effects:

- **Apoptosis Induction:** Cordycepin can induce apoptosis (programmed cell death) in cancer cells. It achieves this by interfering with DNA and RNA synthesis, leading to cell cycle arrest and ultimately cell death.



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- **Antitumor Activity:** It may inhibit tumor growth and metastasis by suppressing tumor cell proliferation and angiogenesis (forming new blood vessels supplying tumors).
- **Immune System Modulation:** Cordycepin can also enhance the activity of immune cells, such as natural killer (NK) and T cells, which can help fight cancer.

### 3. Anti-aging Effects:

- **Antioxidant Activity:** Cordycepin's antioxidant properties may help protect cells from oxidative damage, a key factor in aging.
- **Cellular Energy Production:** Improving mitochondrial function may enhance cellular energy production, contributing to overall cellular health and longevity.

### 4. Anti-diabetic Effects:

- **Improved Insulin Sensitivity:** Some studies suggest that cordycepin may improve insulin sensitivity, which is crucial for regulating blood sugar levels.
- **Enhanced Glucose Uptake:** Cordycepin may increase glucose uptake by cells, helping to lower blood sugar levels.

### 5. Anti-fatigue Effects:

- **Increased ATP Production:** Cordycepin may enhance ATP production, providing more energy for cellular activities and reducing fatigue.
- **Improved Mitochondrial Function:** Enhanced mitochondrial function leads to more efficient energy production improving exercise performance and reducing fatigue.

### 6. Collagen Production:

- **Stimulating Fibroblast Activity:** Cordycepin may stimulate the activity of fibroblasts, which are the cells responsible for producing collagen.
  - **Increased Collagen Synthesis:** This increased fibroblast activity could lead to an increase in collagen synthesis, a crucial component of healthy skin and wound healing.
- **Regulating Gene Expression:** Cordycepin may influence the expression of genes involved in collagen synthesis, further enhancing collagen production.

### 7. Cell Proliferation:

- **Promoting Cell Growth:** Cordycepin may stimulate the growth and proliferation of skin cells, such as fibroblasts and keratinocytes.
  - **Accelerating Wound Healing:** This increased cell proliferation is essential for tissue repair and regeneration during the wound healing process.
- **Regulating Cell Cycle:** Cordycepin may influence the cell cycle, a series of events that lead to cell division and growth.



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### 8. Vitamin D production:

- **Ergosterol:** This is a common sterol found in many fungi. Upon exposure to ultraviolet (UV) light, ergosterol is converted to vitamin D2.

### 9. Lower cholesterol

- **$\beta$ -sitosterol:** Beta-sitosterol has a very similar structure to cholesterol. Consuming foods containing beta-sitosterol (like plant-based oils, nuts, and seeds) competes with cholesterol for absorption in your intestines. Due to this competition, your body absorbs less cholesterol from food eaten.
- **Campesterol:** Similar in structure to cholesterol, but with a slight chemical difference.
- **Stigmasterol:** A very similar structure to cholesterol and competes with cholesterol for absorption in your intestines.

### 10. Enhanced oxygen utilization

#### Antioxidant Effects:

- Cordycepin possesses antioxidant properties. During exercise, oxidative stress increases.
- Antioxidants can help neutralize harmful free radicals, reducing oxidative damage to cells and improving exercise performance, thus indirectly enhancing oxygen utilization.

### 11. Lactate management

#### Improving Aerobic Metabolism:

- By enhancing mitochondrial function, cordycepin may shift the body's reliance from anaerobic (lactic acid-producing) metabolism towards aerobic metabolism (oxygen-utilizing) during exercise.
- Aerobic metabolism produces less lactate as a byproduct.

#### Increasing Lactate Clearance:

- Cordycepin may enhance the body's ability to clear lactate from the bloodstream.
- This could involve:
  - **Increased blood flow:** Increased circulation can help transport lactate away from the muscles to the liver and other organs for processing.
  - **Enhanced lactate utilization:** Cordycepin may stimulate the liver's ability to convert lactate back into glucose (gluconeogenesis) through the Cori cycle.

### 12. Mitochondrial function

#### Increased Mitochondrial Biogenesis:

- Cordycepin may stimulate the production of new mitochondria within cells. This process, known as mitochondrial biogenesis, is crucial for maintaining cellular energy production.
- Studies have shown that cordycepin can activate signaling pathways that promote mitochondrial biogenesis, such as the AMPK (AMP-activated protein kinase) pathway.



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- **Improved Mitochondrial Dynamics:**
  - Mitochondria constantly undergo fusion (joining together) and fission (splitting apart).
  - Cordycepin may help maintain proper mitochondrial dynamics by promoting fusion and reducing excessive fission.
  - This is important because healthy mitochondrial function relies on a balance between these processes.
- **Enhanced Mitochondrial Function:**
  - Cordycepin may improve the efficiency of the electron transport chain, the key process within mitochondria that produces ATP (cellular energy).
  - It may also help maintain mitochondrial membrane potential, essential for proper ATP

## Adenosine:

Adenosine is a nucleotide metabolite found in cordyceps militaris, which plays a major role in cellular energy production.

**1. Adenosine is a key component of ATP:** Adenosine triphosphate (ATP) is essentially adenosine with three phosphate groups attached.

- ATP provides the energy for various cellular processes like muscle contraction, nerve impulses, and protein synthesis.
- When ATP is used for energy, it loses a phosphate group and becomes adenosine diphosphate (ADP). Increased adenosine levels may lead to increased ADP levels within the cell.
- ADP signals the cell that more ATP is needed. Increased ADP availability can stimulate pathways like glycolysis and oxidative phosphorylation, the primary processes for producing ATP.

**2. Anti-inflammatory Effects:** Adenosine exerts its effects by interacting with specific receptors on cells, primarily A1 and A2A receptors.

- **Inhibition of Inflammatory Pathways:**
  - **Reduced Cytokine Production:** Activation of these receptors can inhibit the production of inflammatory cytokines like TNF-alpha, IL-1, and IL-6.
  - **Suppression of Immune Cells:** Adenosine can also suppress the activity of certain immune cells involved in inflammation, such as macrophages and T cells.



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- **Vasodilation:**
  - **Smooth Muscle Relaxation:** Adenosine can relax smooth muscle cells in blood vessels, leading to vasodilation.
  - **Increased Blood Flow:** This increased blood flow can improve nutrient and oxygen delivery to tissues, which is crucial for wound healing.

## **Sterols:**

Sterols are a class of organic compounds that share a common four-ring structure.

- **Ergosterol:** Upon exposure to ultraviolet (UV) light, ergosterol undergoes photoconversion into vitamin D2 (ergocalciferol).
- **Campesterol:** May have cholesterol-lowering effects by interfering with cholesterol absorption in the intestines.
- **$\beta$ -sitosterol:** May have cholesterol-lowering effects by interfering with cholesterol absorption in the intestines.
- **Stigmasterol:** May have cholesterol-lowering effects by interfering with cholesterol absorption in the intestines.

### **1. Antioxidant Effects:**

- **Free Radical Scavenging:** Sterols, particularly ergosterol and its derivatives, possess antioxidant properties.
- **Protection Against Oxidative Damage:** They can neutralize harmful free radicals, protecting cells from oxidative damage that can contribute to skin aging and impaired wound healing.

### **2. Anti-inflammatory Effects:**

- **Modulation of Inflammatory Pathways:** Some sterols may modulate inflammatory pathways by inhibiting the production of inflammatory mediators.
- **Membrane Stabilization:** Sterols play a crucial role in maintaining the integrity of cell membranes.

