The Role of Medicinal Mushrooms in Cancer Therapy

Martin Powell
BSIO Meeting, London – 29/09/14
SHEN NONG BEN CAO
2nd Century AD

- Fu Ling (Poria cocos)
- Yun Zhi (Coriolus versicolor)
- Ling Zhi (Ganoderma lucidum - Reishi)
- Bai Mu Er (Tremella fuciformis - Snow Fungus).

All classified as Superior Herbs, defined as having excellent therapeutic action, few or no side effects, may safely be taken for long periods and of which it is said that ‘prolonged use will lighten the body and confer longevity’!
• In a 15 year study of 174,505 inhabitants of the Nagano area of Japan, mushroom farmers were found to have a much lower rate of death from cancer than the general population (97.1/100,000 cf. 160.1/100,000).¹

• An epidemiological study of 2,000 Chinese women, half with breast cancer and half without, found a reduction in risk of breast cancer in those women who regularly consumed mushrooms (10g/day fresh or 4g/day dried) and drank green tea (1.05g/day dried green tea leaves) with an increased reduction in women who did both. ²

• Two Korean studies comparing women with histologically confirmed breast cancer and an equal number of women without breast cancer also found a strong inverse correlation between mushroom consumption and breast cancer risk. ³

Mushroom-derived anti-cancer agents licensed in Japan

<table>
<thead>
<tr>
<th></th>
<th>KRESTIN / PSK (oral)</th>
<th>LENTINAN (injection)</th>
<th>SIZOFRLAN / SPG (injection)</th>
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<tbody>
<tr>
<td><strong>Trametes versicolor (Coriolus) mycelium</strong></td>
<td>Lentinula edodes (Shiitake) fruiting body</td>
<td>Schizophyllan commune culture medium</td>
<td></td>
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<tr>
<td><strong>May 1977</strong></td>
<td>Dec 1985</td>
<td>Apr 1986</td>
<td></td>
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<tr>
<td><strong>Digestive, lung and breast cancer</strong></td>
<td>Stomach cancer</td>
<td>Cervical cancer</td>
<td></td>
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### PSK CLINICAL TRIALS – STOMACH CANCER

<table>
<thead>
<tr>
<th>Stage</th>
<th>Authors and Year</th>
<th>Survival Duration</th>
<th>Outcome Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach Cancer Stage IV</td>
<td>Kaibara et al, 1976</td>
<td>66</td>
<td>PSK w/chemo doubled 2-yr survival</td>
</tr>
<tr>
<td>Advanced Stomach Cancer</td>
<td>Kodama et al, 1982</td>
<td>450</td>
<td>PSK w/chemo doubled 5-yr survival</td>
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<tr>
<td>Advanced Stomach Cancer</td>
<td>Kondo and Torisu, 1985</td>
<td>144</td>
<td>PSK extended disease-free period and enhanced immunity</td>
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<tr>
<td>Stomach Cancer Stage III</td>
<td>Maehara et al. 1990</td>
<td>255</td>
<td>PSK w/chemo extended 15-yr survival</td>
</tr>
<tr>
<td>Stomach Cancer I-IV</td>
<td>Nakazato et al, 1994</td>
<td>253</td>
<td>PSK extended 5-yr survival and disease-free period</td>
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</tbody>
</table>

# PSK CLINICAL TRIALS – OTHER CANCERS

<table>
<thead>
<tr>
<th>Cancer Type</th>
<th>Study Details</th>
<th>Patients</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorectal Cancer</td>
<td>Kondo and Torisu, 1990 Surgery/no chemo +/- PSK</td>
<td>110</td>
<td>PSK extended 8-yr survival and disease-free period</td>
</tr>
<tr>
<td>Oesophageal</td>
<td>Ogoshi et al, 1995 Surgery + radio. +/- chemo. +/- PSK</td>
<td>158</td>
<td>PSK extended 5-yr post surgery+RT+CT and normalised serum factors</td>
</tr>
<tr>
<td>Lung (NSCLC) Stages I-III</td>
<td>Hayakawa et al, 1993 Radiotherapy +/- PSK</td>
<td>185</td>
<td>PSK extended 5-yr survival 2-4x all stages. &lt;5cm &gt;70yr max benefit</td>
</tr>
<tr>
<td>Breast, ER+/- Stage II, post-surgery</td>
<td>Toi et al. 1992 MMC +/- Tamoxifen +/- Ftorafur +/- PSK</td>
<td>914</td>
<td>PSK extended survival in ER-neg, non-metastasized</td>
</tr>
<tr>
<td>Breast Stages I, II</td>
<td>Iino et al, 1995 FEMP chemotherapy + Levamisole or PSK</td>
<td>227</td>
<td>PSK trend to extend 10-yr survival + disease-free period. HLA B40+ 100%</td>
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</table>
In a systematic review and meta-analysis aggregating and analyzing the efficacy of Coriolus extracts on survival of cancer patients from 13 randomized, placebo-controlled clinical trials, Coriolus was found to result in a significant survival advantage compared with standard conventional anti-cancer treatment alone.

Of patients randomized to Coriolus, there was a 9% absolute reduction in 5-year mortality, resulting in one additional patient alive for every 11 patients treated. In patients with breast cancer, gastric cancer, or colorectal cancer treated with chemotherapy, the effects of the combination of Coriolus preparation on the overall 5-year survival rate was more evident, but not in esophageal cancer and nasopharyngeal carcinoma.

Subgroup analysis could not conclude which type of anti-cancer treatment may maximize the benefit from Coriolus.

MD Anderson Cancer Centre’s Detailed Scientific Review of Coriolus

• ‘Coriolus is a promising candidate for chemoprevention due to the multiple effects on the malignant process, limited side effects and safety of daily oral doses for extended periods of time.’

• PSK and PSP seem to work at multiple steps of the malignant process by inhibiting adhesion, invasion, motility, and metastatic growth of tumor cells in animal models of cancer.

• Adhesion and invasion are inhibited by suppression of cell matrix-degrading enzyme production by malignant cells.

• Motility of malignant cells and subsequent attachment to blood vessels are inhibited by suppression of tumor-cell induced platelet aggregation and anti-angiogenic factors.

• Immune responsiveness of the host does not appear to be affected by PSK under normal conditions, but immune systems depressed by tumor-burden or chemotherapy, have reportedly been restored to normal levels by PSK in animal studies.

• Immune restoration has included antibody and cytokine production and improvement of impaired antitumor activity of natural killer cells, T cells, macrophages and peripheral blood lymphocytes in vivo and in vitro.

• PSK has also been demonstrated to inhibit the decline of immunocompetence during the perioperative period and inhibit the growth of residual tumors following cryoablation.

• PSP has also been shown to reverse tumor-induced immunodeficiencies in sarcoma-bearing mice by increasing immunoglobulin G and C3 complement levels. It has also been associated with increases in white blood cell count, CD4, CD8, B-lymphocytes, and neutrophils, along with a higher survival rate of tumor bearing mice.
Toxicology of PSK

- PSK has been associated with side effects of gastrointestinal upset and darkening of the fingernails, but these effects have been limited and general safety has been demonstrated with daily oral doses for extended periods of time. It does not seem to interact with hepatic drug-metabolizing enzymes involved in the chemical processing of most chemotherapy agents, and no genetic damage has been detected by the Ames test.

- At doses that produced necrotic changes in tumor cells, PSP produced no lesions in the vital organs of tumor-bearing mice after treatment for two months. It has not been associated with teratogenic effects in mice or rats.

- 1994 Gastric cancer trial by the Nakazato and Koike of the Study Group for Immuno-chemotherapy reported in the Lancet (1994;343:1122-1126) concluded that no toxic effects could be observed from PSK “even after meticulous review of all the patient records”.
Meta-analysis of 5 clinical trials with a total of 650 participants showed that the addition of lentinan at 2mg/week to standard chemotherapy offers a significant advantage over chemotherapy alone in terms of survival for patients with advanced gastric cancer, with patients with lymph node metastasis having slightly better results than those with non-lymph node metastasis.  

• Additional trials confirm increased survival, reduced side effects from chemotherapy and improved quality of life in patients with colorectal, hepatocellular, breast cancer and metastatic prostate cancer. In a trial with 69 patients with metastatic prostate cancer the 50% survival length of treated and control patients was 48 and 35 months, respectively while the the five-year survival rate of treated patients was 43% against 29% in the control group\(^1,2\).

• Although usually delivered by injection, Lentinan is also orally bioavailable although the clinical dosage is likely to be significantly higher \(^3,4\).

4. The Medicinal Benefits of Lentinan (β-1, 3-D glucan) from Lentinus edodes (Berk.) Singer (Shiitake Mushroom) Through Oral Administration. Yap AT, Ng MH. Int J Med Mushr. v7.i12.170
Grifola frondosa

*Maitake*

*Hen of the Woods*

D-fraction / MD-fraction

In a non-randomised study of 165 patients with stage III-IV cancer given Maitake D-fraction with Maitake fruiting body tumour regression and/or significant symptomatic improvement was seen in 66% of lung cancer patients, 54% of liver cancer patients, 56% of pancreatic cancer patients and 74% of breast cancer patients\(^1\).

• In a separate study a combination of MD-fraction and whole Maitake fruiting body powder was reported to produce similar improvements: 58.3% of liver cancer patients, 68.8% of breast cancer patients and 62.5% of lung cancer patients¹.

• In vivo studies also showed synergy between D-fraction and chemotherapy (mitomycin C) as well as significant alleviation of side effects from chemotherapy, including loss of appetite, vomiting, nausea, hair loss and leukopenia².

A. blazei polysaccharide extracts show strong in-vitro and in-vivo activity against a range of cancer cell lines, including: lung and ovarian cancer\(^1\).

Clinical studies are limited although Mizuno reports positive clinical results in a number of mainly breast cancer patients at unspecified dosage while Ahn reports increased NK-cell activity and reduced chemotherapy related side effects from A. blazei polysaccharide extract\(^2\).

A 2008 study confirms increases in NK cell activity with A. blazei polysaccharide extract a dose of 3g/day\(^3\).

1-3, 1-6-Beta Glucan

Lentinan - a polysaccharide isolated from Shiitake and licensed in Japan as a pharmaceutical drug.
**Heteropolysaccharides** – as well as Glucose mushroom polysaccharides typically contain other sugars, such as Mannose, Galactose, Xylose, Fucose, e.g.:

- Xylogalactoglucan – Inonotus obliquus (Chaga)
- Glucomannan – Agaricus blazei
- Galactoglucomannan – Lentinus edodes (Shiitake)
- Mannogalactofucan – Grifola frondosa (Maitake)
- Galactoxyloglucan – Hericium erinaceus (Lion’s Mane)
- Glucoronoxylomannans – Tremella fuciformis (Snow Fungus)

Although most research has focussed on β Glucans, especially β-1,3 and β-1,4 linked, α-1,4 and α-1,6 glucans have also shown anti-tumour activity.

It also appears that the most active polysaccharide fractions have bound protein components (proteoglycans).

PSK (Krestin) and PSP from Trametes versicolor

- PSK is a purified hot-water extract consisting of protein-bound polysaccharide molecules with an average molecular weight of 94kDa.
- Protein component ranges from 25-38%.
- The main constituent monosaccharide is glucose with small amounts of other sugar residues, such as mannose, fucose, xylose and galactose. The main chain consists of beta 1-4 linked units with side chains of beta 1-3 as well as beta 1-6 linked glucose residues.
- PSP is similar to PSK but differs in the presence of rhamnose and arabinose.

Immune changes induced by mushroom polysaccharide-based supplementation include:

- Increased NK cell activation
- Increased macrophage activation
- Increased cytotoxic T-cell activation
- Increased IFN-γ, IL-2 and TNF-β production
- Reduced IL-4 production
- Inhibition of prostaglandin synthesis
<table>
<thead>
<tr>
<th>TH1</th>
<th>TH2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Immunity / Cytotoxic</td>
<td>Humoral (Antibody mediated) Immunity / Pro-inflammatory</td>
</tr>
<tr>
<td>Interferon-γ and TNF-β</td>
<td>IL-4, IL-5, IL-6, IL-13</td>
</tr>
<tr>
<td>High NK cell activity and classical (antimicrobial) macrophage activation</td>
<td>Low NK cell activity and alternative (proliferative and collagen producing) macrophage activation</td>
</tr>
<tr>
<td>Infectious diseases</td>
<td>Chronic inflammatory conditions</td>
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Factors promoting the development of Th1 and Th2 phenotypes

<table>
<thead>
<tr>
<th>TH1</th>
<th>TH2</th>
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</thead>
<tbody>
<tr>
<td>Presence of older siblings</td>
<td>Stress / Cortisol</td>
</tr>
<tr>
<td>Early exposure to day care</td>
<td>Chemical and heavy metal exposure</td>
</tr>
<tr>
<td>Infectious diseases in childhood</td>
<td>Multiple vaccinations</td>
</tr>
</tbody>
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Consequences of a TH1 - TH2 Shift

• Lowered resistance to viral and other pathogens.
• Increases in fatigue and incidence of depression.
• Increases incidence of allergic and auto-immune conditions such as asthma and SLE.
• Persistent humoral immune responses exacerbate recruitment and activation of innate immune cells in neoplastic microenvironments where they regulate tissue remodelling, pro-angiogenic and pro-survival pathways that together potentiate cancer development.¹

Dectin-1

- Commonly expressed in macrophages, neutrophil lineages, dendritic cells and some T-cells but not NK-cells.
- Considered the most important receptor for the activation of the innate immune response in macrophages.
- Binds specifically to β-(1→3)-glucans but only those consisting of at least 10 monomers.
- Binding activates phagocytosis, ROS production and induction of TNF-α, IL-2, IL-10, IL-12.

CR3

- Expressed mainly on Neutrophils, Monocytes and NK Cells.
- Two binding sites exist on the CD11b domain. One for β-glucans and the other for iC3b (cleaved component 3 fragment of serum complement system).
- Binding of β-glucans to CR3 increases adhesion to microbial cells and activates the iC3b pathway causing tumour cytotoxicity.

Mushrooms and Chemotherapy

- Lentinan extended survival and reduced the incidence of adverse effects in inoperable or recurrent gastric cancer in conjunction with tegafur as well as S-1-based chemotherapy (tegafur, gimeracil, oteracil).

- Five-year disease free survival in colorectal cancer cases was significantly higher with PSK and oral Tegafur/Uracil (UFT) than with UFT alone (73% vs. 58.8%) and increased five-year disease-free period (70.7% vs. 59.4%) and survival (73.0% vs. 60.0%) in gastric cancer when given together with mitomycin and fluoracil.
• *Agaricus subrufescens* polysaccharide extract reduced chemotherapy related side effects (appetite, alopecia, emotional stability, and general weakness) in 100 cervical, ovarian, and endometrial cancer patients treated either with carboplatin plus VP16 (etoposide) or with carboplatin plus taxol.

• *Grifola frondosa* polysaccharide fractions potentiated the action of carmustine and increased efficacy when given in combination with chemotherapy across a range of cancers, as well as reducing cisplatin-induced nephrotoxicity.
In addition to supporting the immune system and ameliorating chemotherapy-induced immune suppression, there is some evidence that mushroom polysaccharide extracts contribute to the efficacy of the chemotherapeutic drugs themselves through enhanced production of reactive oxygen species (ROS):

• Liu et al. reported an increase in ROS and reactive nitrogen intermediates in peritoneal macrophages of mice given PSP.

• An extract of *A. subrufescens* was shown to induce apoptosis through an ROS-dependent pathway.

• Grifron-D, a polysaccharide extract from *G. frondosa*, has been shown to have a direct cytotoxic effect on cancer cells through oxidative membrane damage leading to apoptosis.
Mushrooms and Radiotherapy

• Reduction in radiation-induced leukopaenia - in a trial with 136 patients undergoing radiotherapy, oral consumption of *T. fuciformis* polysaccharide extract (3g/day) resulted in a 13.2% reduction in WBC compared to a 35.2% reduction in the control group and *T. versicolor* mycelial biomass (6g/day) prevented decreases in red and white blood cells in lung cancer patients undergoing radiotherapy.

• Enhanced treatment efficacy - oral administration of *T. versicolor* extract PSP with radiotherapy significantly increased the percentage of apoptotic cells at 24hr compared to radiation alone and reduced radiotherapy induced reduction in white blood cell count.
Recent research indicates that mushroom polysaccharides have a prebiotic effect on the gut microbiome with increases in *Bifidobacterium* and *Lactobacillus* species and decreases in *Clostridium*, *Staphylococcus* and *Enterococcus* species, together with increased concentration of organic acids (lactate and short-chain fatty acids), decreased pH and increased β-galactosidase and β-glucosidase activity and it has been suggested that this effect may also contribute to their diverse health benefits\(^1,2\).


A 1 year controlled trial using Coriolus versicolor mycelial biomass in 43 LSIL HPV patients reported results including:

- Cytology returned to normal in 72.5% of patients receiving Coriolus supplementation (3g/day) compared to 47.5% in the control group.
- 90% of patients who received supplementation became –ve for High Risk HPV strains compared to 8.5% in the control group.

ACTIVE COMPounds FROM MEDICINAL MUSHROOMS

Immunologically active polysaccharides
- Found in all mushrooms

Secondary metabolites
- Differ from species to species
Lovastatin

Originally isolated from *Penicillium brevicompactum* as an anti-fungal agent (called Compactin), as well as from *Penicillium citrinum* and is widespread in mushrooms and other fungi.

<table>
<thead>
<tr>
<th></th>
<th>Fruiting Body - mg/kg</th>
<th>Mycelium - mg/kg</th>
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<tbody>
<tr>
<td>Porcini</td>
<td></td>
<td>131</td>
</tr>
<tr>
<td>Reishi</td>
<td>68</td>
<td>908</td>
</tr>
<tr>
<td>Oyster (Korea)</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Oyster (Taiwan)</td>
<td></td>
<td>147</td>
</tr>
<tr>
<td>Golden Oyster</td>
<td></td>
<td>930</td>
</tr>
<tr>
<td>Buna-Shimeji</td>
<td>628</td>
<td></td>
</tr>
<tr>
<td>Shiitake</td>
<td>316</td>
<td></td>
</tr>
<tr>
<td>Agaricus subrufescens</td>
<td>184</td>
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</tbody>
</table>

Mushrooms’ Anti-Candida Activity

• Mushrooms produce a wide range of anti-fungal compounds to help them compete with other fungi.  
• Mushrooms help facilitate the immune system’s response to respond candida. 
• Mushrooms do not contain sugars or starches that could stimulate the growth of candida.

Ling Zhi (Reishi)

*Ganoderma lucidum*

*Ling Zhi – Spirit Mushroom*

*Mushroom of Immortality*

*Mannantake – 10,000 Year Mushroom*
Reishi

- Anti-cancer
- Anti-inflammatory
- Anti-histamine
- Anti-allergic
- Sedative
- Anti-hypertensive
- Antioxidant
- Hepatoprotective
- Anti-cholesterol
5 randomised controlled trials met inclusion criteria.

The meta-analysis results showed that patients who had been given G. lucidum alongside chemo/radiotherapy were 1.27 times more likely to respond positively to chemo/radiotherapy compared to those without.

G. lucidum treatment alone did not demonstrate the same regression rate as that seen in combined therapy.

Four studies showed that patients in the reishi group had relatively improved quality of life in comparison to controls. Only one of the studies recorded minimal side effects, including nausea and insomnia.

The results for host immune function indicators suggested that G. lucidum simultaneously increases the percentage of CD3, CD4 and CD8.

Ganoderic and Lucidenic Acids

- Sedative effect on CNS
- 9 lucidenic acids and 4 ganoderic acids showed strong anti-inflammatory activity
- Inhibit histamine release (Ganoderic Acids A,B,C and D, also Oleic Acid and Cycooctasulphur)
- Anti-hepatotoxic (R,S and Ganodosterone)
- Anti-hypertensive (ACE inhibition - B,D,F,H,K,S,Y)
- Anti-viral - 11 lucidenic acids and 5 ganoderic acids showed strong inhibition of EBV. Ganoderma triterpenes also inhibit HIV-1 protease activity and viral binding and showed potent inhibitory activity against herpes simplex virus
- Anti-cancer
Anti-tumour Activity of Ganoderic and Lucidenic Acids

- Suppression of cancer growth and angiogenesis through modulation of AP-1 and NF-kB signalling
- Induction of apoptosis via a mitochondria-mediated pathway
- Inhibition of cancer cell invasiveness
- Inhibition of aromatase activity
- Suppression of steroid 5α-reductase, which converts testosterone to dihydrotestosterone (DHT) and has been shown to play an important role in the development of prostate cancer and benign prostatic hyperplasia (BPH)
- Enhanced chemosensitivity to cisplatin through inhibition of the JAK-STAT3 signalling pathway

Spore Powder of Ganoderma lucidum Improves Cancer-Related Fatigue in Breast Cancer Patients Undergoing Endocrine Therapy: A Pilot Clinical Trial

- 48 breast cancer patients with cancer-related fatigue undergoing endocrine therapy with treatment group given 3g/day shell-broken spore powder.
- Significant improvements in physical well-being and fatigue.
- Reductions in anxiety and depression and improved quality of life.
- Immune markers of CRF were significantly lower.

Inonotus obliquus

*Chaga – Bai Hua Rong*

Widely used as a folk medicine in Russia and eastern Europe to treat cancer and support the immune system. Credited with curing Solzhenitzen of cancer.

Contains high levels of betulinic acid (also one of the key components in mistletoe) derived from the bark of host birch trees, with actions including:

- Anti-retroviral
- Anti-malarial
- Anti-inflammatory
- Anti-cancer
Betulinic Acid and Cancer

• Induces mitochondrial apoptosis in different cancer cell lines and inhibits the enzyme topoisomerase, which is essential for the unwinding and winding of the DNA strands in cell replication.

• In-vitro studies on betulinic acid have shown it to be highly effective against a wide variety of cancer cells: human melanoma, neuroectodermal (neuroblastoma, medulloblastoma, Ewing's sarcoma) and malignant brain tumors, ovarian carcinoma, human leukemia HL-60 cells and malignant head and neck squamous cell carcinomas, including those derived from therapy-resistant and refractory tumors.

Betulinic acid's action against brain tumor cells is particularly interesting and it is noteworthy that in one study it exerted cytotoxic activity against primary tumor cells cultured from patients in 4 of 4 medulloblastoma-tumor samples tested and in 20 of 24 glioblastoma-tumor samples.

It also shows great promise in combination with radiotherapy, exhibiting a strictly additive mode of growth inhibition in combination with radiation in human melanoma cells in one study and acting as a radiosensitizer in head and neck squamous cell cancers in another.

Cordyceps

Ophiocordyceps sinensis

/ Cordyceps militaris
• **Anti-fatigue** – Cordyceps has been shown to increase endurance, efficiency of oxygen utilization and cellular ATP levels. In a trial with 50 asthma patients 81.3% showed improvement with an average of 5 days using Cordyceps compared to 61.1% taking antihistamines with an average of 9 days for symptoms to subside.

• **Hepato-protective** – inhibits hepatic fibrogenesis derived from chronic liver injury, retards the development of cirrhosis, reduces liver enzyme levels and significantly improves liver function.

• **Anti-cholesterol** – decreases plasma cholesterol in rats fed a cholesterol enriched diet and increases ratio of HDL to LDL.

• **Anti-stress** – equivalent to ginseng. Counteracted inhibition of weight gain, increase in adrenal gland weight, increase in glucocorticoid receptors in the liver, spleen and thymus and increased peroxidation in the liver and heart.

• **Immuno-modulatory and anti-cancer** – activates macrophages, stimulates bone marrow cell proliferation through activation of Peyer’s patch cells.
Nucleoside Analogues

Cordycepin

Adenosine

3-deoxyadenosine

2,3-dideoxyadenosine

Forerunner of Didanosine (Videx)
(2) **Cordycepin Halts DNA Replication**

These normal nucleosides have already been inserted into the new molecule of DNA which is being formed.

**Cordycepin**

As the DNA is replicating, each nucleoside gets inserted one after another to its complementary nucleoside. However, when a Cordycepin molecule gets inserted as shown here, there is no 3' oxygen for the next nucleoside to attach to. This appears to halt the replication process in simple cells such as bacteria and virus, and may also be the mechanism by which it halts the replication of tumor cells.

These are nucleosides from the original molecule of DNA which is in the process of replicating. The original molecule has "unzipped" down the middle and these nucleosides are awaiting the attachment of their complementary nucleosides.
Cordycepin

• Inhibits cancer cell replication\(^1\)
• Inhibits invasiveness of cancer cells\(^2\)
• Induces apoptosis of multiple cell lines, including:
  • Leukaemia
  • Multiple myeloma
  • Prostate cancer
  • Neuroblastoma
  • Oral Cancer
• Anti-inflammatory

Current Issues

• Lack of standardisation
• Different formats:
  • Fruiting body
  • Mycelium
  • Hot-water extracts (polysaccharide-rich)
  • Ethanolic extracts (triterpene-rich)
  • Mycelial biomass (rich in anti-microbial secondary metabolites and substrate-breakdown products such as arabinoxylans but low in beta-glucans and related polysaccharides)
• Lack of comparative research
• Single mushrooms vs. combinations
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