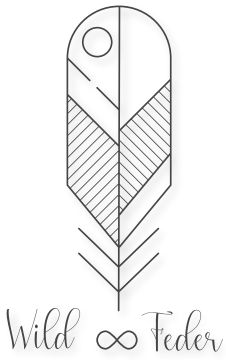
Review of Medical Uses of Chaga
{Inonotus obliquus}
By Arthur Haines



INTRODUCTION

Chaga (Inonotus obliquus; Family Hymenochae- taceae) is a parasitic fungus that frequently occurs on members of the birch family (Betulaceae). It is currently known by the scientific name Inonotus obliquus, but has also been called Polyporus obliquus and Poria obliqua (these latter two names are referred to as synonyms). The genus name (Inonotus) translates as “black fiber” and the specific epithet (obliquus) refers to the fact the pores of the reproductive body are at an angle to the horizon. Chaga has many common names. The name Chaga originated in Siberia (it is the Anglicized version of Czaga). Specifically, it is derived from the name for mushroom in the Komi-Permyak language, which is spoken by natives of the Kama River Basin in the West Uralian region. It is also called true tinder fungus, clinker polypore, sterile conk, cinder conk, cancer polypore, and kabanoanatake (Japan).

Chaga is found in temperate to subarctic forests of North America and Eurasia (Lee et al 2008). Its usual hosts in Eurasia include Asian white birch (Betula platyphylla), European weeping birch (Betula pen- dula), Dahurian birch (Betula davurica), and Erman’s birch (Betula ermanii). In North America, it is most frequent on paper birch (Betula papyrifera) and yel- low birch (Betula alleghaniensis). The portion collect- ed for medicinal use appears as a dark, nearly black, cracked canker on the exterior of the tree. This can- ker is a sclerotium, a sterile mass of hyphae. Though dark on the exterior, it is more or less yellow-brown throughout most of the interior.

Chaga is a parasite of trees, invading the host through a wound. It causes decay of the heartwood and will persist for 10–80 years (or more), producing usually 1–3 sclerotia on the main stem and branches of the tree (Lee at al. 2008). Whereas the sclerotium is perennial, the actual fruiting body occurs only once in the infection cycle and appears as a crust-like layers of pores. The fruiting body is produced on or near the sclerotium after the host or some portion of the host dies. Chaga is connected to the host tree, when the host dies, so does the chaga fungus.

Record of folk use of chaga as a medicinal fungus dates back to the 1500s and 1600s from northern Europe, Poland, and northern Russia (Kahlos and Hil- tunen 1983, 1985, and 1986, Kahlos et al. 1984). The water extracts were used for a variety of ailments, including stomach disorders, tuberculosis, and disor- ders of the heart and liver. This medical review will highlight scientific research that has been undertak- en to determine the efficacy of chaga preparations and elucidate their modes of action. This

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CONSTITUENTS

More than 200 mycochemicals have been identified from chaga (Rogers 2011). These include carbohy- drates (e.g., beta glucans, xylogalactoglucose), lipids (e.g., β-sitosterol, episterol, fecosterol), polyphenols (e.g., 3,4-dihydroxybenzalacetone, inonoblins A, phelligridins D), and terpenes (e.g., p-hydroxybenzoic acid, ferulic acid, foscoperianol D, syringic acid, vanil- lic acid). Some of these chemicals are supplied from the host tree (e.g., betulin, betulinic acid) and contrib- ute to the pharmacological activity of wild-collected specimens (see below). A partial list of the constitu- ent mycochemicals follows:

3β-hydroxylanosta-8,24-dien-21-al, 3β-hydrox- ylanosta-8,24-dien-21-23-lactone, 3,4-dihydroxyben- zalacetone, 4,4-dimethylfecosterol, 4-mehtyl fecoste- rol, 21,24-cyclopentalanosta-3β,21,25-triol-8-ene, 24-methylene dihydrolanosterol, β-sitosterol, p-hy- droxybenzoic acid, beta glucan, episterol, ergosterol peroxide, fecosterol, ferulic acid, foscoperianol D, heteroglucan, hispidin, hispolon, inonoblins A, inon- oblins B, inonoblins C, inotodiol, lanosterol, lupeol, melanin, obliquol, phelligridins D, phelligridins E, phelligridins G, syringic acid, trametenolic acid, vanil- lic acid, and xylogalactoglucose.

GROWTH CONDITIONS

Chaga medicines are now available as wild-collect- ed sclerotia and laboratory-cultured mycelia. Zheng et al. (2007) examined the sterol composition of wild-collected chaga vs. cultured mycelia grown on two different media. Their results indicated that the wild-grown chaga contained a diversity of sterols (they identified 12 total sterols) compared with the cultured mycelia, which contained only three sterols. Not only did the total number of sterols differ, but also did the percent of each specific kind. For exam- ple, lanosterol represented 45.4% of the total sterols in the wild specimens, but only 3.6% in the cultured mycelia. Lanosterol is an important mycochemical and contributes to the mushroom’s antioxidant, anti-cancer,

and immune modulating activity (Kahlos and Hiltunen 1987, Togashi et al. 1998). Zheng et al. (2007) considered the pharmacological activity of laboratory-cultured mycelia to be significantly re- duced compared with field-grown chaga.

Betulinic acid and its precursor betulin, are found in the bark of birch trees (genus Betula) and some other plants. These terpenes have antibacterial, anti-inflammatory, anti-cancer, antiviral, and immune modulating properties (among other actions; Chowd- hury et al. 2002, Yogeeswari and Sriram 2005, Mogh- addam et al. 2012). The chaga fungus extracts these terpenes from the bark of its host trees and concen- trates them in the outer, dark layer of the sclerotium (Spinosa 2006, Marley 2009). Betulinic acid is absent in cultivated strains grown in the laboratory.

MEDICINAL ACTIONS

The chaga fungus contains a host of pharmaco- logically active compounds that beneficially affect human health. A thorough review of its historical use and contemporary medical research would requirea large tome to house this vast amount of informa- tion. The following is a relatively concise treatment of some of the more important, documented actions of this fungus, particularly as they relate to modern health issues.

1. Antioxidant.

Substances that can inhibit oxidation are referred to as antioxidants. When oxidation occurs, electrons (or hydrogen atoms) are transferred from a molecule, creating an unstable molecule with a charge (a free radical). These unstable molecules can borrow elec- trons from or donate electrons to other molecules, which ultimately causes damage to proteins, lipids, and/or DNA. Prolonged elevated levels of oxidizing agents lead to oxidative stress, which is considered to play a role in the development of several diseases and cellular degeneration related to aging. Antioxi- dants are able to donate electrons to stabilize reac- tive molecules, thus they play a critical role in main- taining health. Chaga is a well-known antioxidant and numerous studies support its ability to inhibit free radical damage. Further, as the antioxidants in chaga (including melanin; Babitskaya et al. 2000) are able to protect DNA from damage, this fungus is con- sidered to be genoprotective.

Hu et al. (2009) tested the antioxidant activity of different extracts of chaga. They used alcohol and three different hot-water extractions (differing in temperature) to test chaga's ability to act like super- oxide dismutase (SOD) in scavenging radicals. SOD is an endogenous antioxidant that detoxifies oxygen and hydrogen peroxide anions (an anion is a nega- tively charged version of a molecule). In their study, Hu et al. found that the alcohol extract

displayed the highest SOD-like activity. However, the hot-water extracts also displayed SOD-like activity, with the higher temperature extractions showing greater ability. As part of this study, they also tested the four extract's ability to scavenge 2,2-diphenyl-1-picrylhy- drazyl (DPPH), a commonly used chemical to assay the antioxidant capacity of a substance. In this case, the alcohol extract showed the lowest ability, while the hot-water extracts showed the highest ability to scavenge DPPH. Their study showed that chaga is an effective antioxidant and both alcohol and hot-water extractions contribute to the total free radical scav- enging ability of this mushroom. Supporting this study is the research of Mu et al. (2012) who showed crude extracts of chaga exhibit antioxidant activity against a wide-variety of radicals, indicating it may have a beneficial role in a suite of preventative and disease-healing roles.

Najafzadeh et al. (2007) showed that the antioxidant properties of chaga could have tremendous benefit when dealing with certain gastro-intestinal disorders, such as inflammatory bowel disease (IBD). Conditions such as IBD are partly caused by free radicals and a compromised immune system with an insufficient level of antioxidants. Their data show that chaga extracts reduced DNA damage and oxidative stress, providing a valuable medicine for people suffering from IBD.

In a cognitive function study, Giridharan et al. (2011) examined mice with experimental amnesia. Using the alkaloid scopolamine, the researchers induced cognitive dysfunction and then orally administered extracts of chaga for seven days to examine the effects on the brain and cognition. Chaga restored glutathione and superoxide dismutase levels (two important endogenous antioxidants) and enhanced cognitive function, specifically learning and memory, as measured by two tests. Their results suggest that oxidative stress plays a role in higher brain function and that chaga can improve aspects of cognition.

Oxygen Radical Absorbance Capacity (ORAC) values are a standardised way to compare the antioxidant ability of foods and extracts. An extensive list of val- ues can be observed at www.oracvalues.com. Many ORAC values for chaga can be found on-line, almost all of which are without substantiation (making verifi- cation difficult). Two values do exist that are support- ed by laboratory tests, both performed by Brunswick Laboratories. One test (dated 11 March 2011) provid- ed an ORAC value of 28,200 µmole TE/100 grams (this unit is one standard manner that ORAC values are ex- pressed). This value places chaga sclerotium ahead of many well-known, antioxidant rich foods (e.g., black- berry, blueberry, chokeberry, elderberry). Another test (dated 23 June 2011, Batch #: B-11444) provided a value of 146,700 µmole/ 100 grams. This value plac- es chaga ahead of almost every well-known, high antioxidant food and spice, including açaí, ground turmeric, powdered

chocolate, and rosehip. What is most remarkable about this score is that it represents only the water-soluble fraction. The alcohol-soluble fraction was not tested and would contribute to an even higher score. The reason for the scale of differ- ence between these two tests is unknown.

2. Antineoplastic.

Antineoplastics are agents that prevent the de- velopment, growth, and spread of cancerous cells. Chaga has been used against several types of cancer due to its antineoplastic action. A selection of studies will be presented to demonstrate the efficacy and versatility of chaga preparations.

Lee et al. (2009) showed that hot water extracts have an inhibitory effect against the proliferation
of human colon cancer cells. Chaga produced
an up-regulation of pro-apoptotic proteins and a down-regulation of anti-apoptotic proteins (apop- tosis refers to programmed cell death, a suppressed trait in cancerous cells). Hu et al. (2009) also tested chaga extracts on human colon cancer cells. All the extracts exhibited some antiproliferative effect on the cancer cells. However, they found that alcohol extracts (which contain terpenes, chemicals not abundant in hot-water extracts) exhibited much greater activity against the cancer cells and was the only extract that induced apoptosis.

Youn et al. (2008) demonstrated chaga may have therapeutic benefit regarding malignant hepatoma, the most common form of liver cancer. They showedthat chaga down-regulates critical enzymes (called cyclins) necessary for cell cycle progression in can- cerous cells. Through this action, chaga causes arrest in the cell cycle and induces cell death (apoptosis)in cancer cells. In another study, Youn et al. (2009) showed that water-extracts exhibited antineoplastic activity through inhibiting proliferation and inducing apoptosis.

Chung et al. (2010) showed that various extracts of chaga inhibited proliferation of various human cancer cell lines (four were tested in total). They tested the pure compounds (i.e., single mycochemicals) in their research. Of particular interest is that their work shows that chaga extracts have low toxicity against normal cells.

A final example of chaga's antineoplastic activity involves the research of Kim et al. (2011). They tested individual chemicals extracted from the sclerotium against four different cancer cell lines. Various com- pounds exhibited weak to strong cytotoxic effects against the cancer cell lines. One of the strongest mycochemicals, in terms of its cytotoxic effects, revealed in the study was 3,4-dihydroxybenzalace- tone (DBL), which belongs to a class

of water-soluble compounds called polyphenols. Work by Sung et al. (2008) showed that DBL is able to regulate expres- sion of key genes that promote cancer (i.e., genes that promote inflammation, anti-apoptosis, and cell proliferation). Ultimately, DBL enhances programmed cell death (i.e., apoptosis) and inhibits proliferation of and invasion by cancer cells through suppressing pro-cancer gene expression.

3. Immune Modulator.

The cell walls of fungi contain special kinds of car- bohydrates consisting of long chains of sugars called polysaccharides (Marley 2009). These polysaccha- rides are structural components, providing strength and rigidity to the cells. Many fungi, including chaga, contain a group of polysaccharides called glucans, which are high molecular weight polysaccharides and are well known for their pharmacological activ- ity. Glucans are potent immune system modulators (Lindequist et al. 2005). A modulator is a substance that can exert an influence on a particular system. Immune system modulators can stimulate the im- mune response, suppress the immune response, and/ or increase the tolerance of the immune system to an antigen. In regard to immune system function, Chaga is most often used to beneficially activate the im- mune system to create a stronger, more vital defence against infection, cancer, and immune suppressing pharmaceuticals. Glucans are able to modulate many aspects of the immune system: activate macrophages (which increases scavenging and antimicrobial activ- ity), induce maturation of T-helper cells (which en- hances cellular immunity), stimulate B-cell activation (which make antibodies to antigens), increase release of TNF-α (which up-regulates cell death in tumors), and increase production of interferon-α from white blood cells (which increases viral resistance), among many other actions.

Kim (2005) tested whether water extracts of chaga mushroom could be used to overcome an im- mune-suppressive situation caused by chemical-in- duced damage to bone marrow. The results of the study showed that chaga was a potent immune system modulator that assisted in the recovery of the bone marrow system. The water extracts were able to potentiate the host immune system through the regulation of cytokines, which are signaling mole- cules used in intercellular communication and are critical for cellular immune responses. For example, serum levels of IL-6, a chemoprotective cytokine, were significantly increased over time with continued use of chaga. The data support chaga extracts as being of major therapeutic value for immunocompri- mised individuals (e.g., chemotherapy during cancer treatment).

4. Antidiabetic.

Diabetes mellitus is a group of diseases where reduced production of insulin and/or reduced sensi- tivity to insulin fails to move glucose in the blood into the cells—thus creating a condition of hyperglycemia (i.e., high blood sugar). Diabetes (over the long-term) promotes damage to the blood vessels, contributing to cardiovascular disease, vision problems, damage to the kidneys, and impairment of the peripheral ner- vous system. It is estimated that diabetes reduces life expectancy by 10–20 years.

Chaga functions as an antidiabetic through lowering blood glucose levels. An increased level of glucose in the blood following meals plays a role in the devel- opment of type 2 diabetes (insulin resistance; approx- imately 90% of the diabetes cases are of this type). Polysaccharides in chaga have been shown to inhibit α-glucosidase, a carbohydrate-hydrolyzing enzyme (Chen et al. 2010). Through inhibiting this enzyme, chaga acts as a hypoglycemic agent by retarding glucose absorption in digestive organs, preventing hyperglycemia following meals. Another study, one performed by Lu et al. (2010), also demonstrated antidiabetic effects, in part, through inhibition of α-amylase, an enzyme produced in the pancreas and in saliva to break down carbohydrates into simpler sugars.

5. Anti-inflammatory.

Inflammation is a complex response initiated by the body in reaction to injury and disease. It involves a host of participants, including the vascular system, the immune system, and local, injured cells. Inflam- mation occurs as a result of many different causes (e.g., wounds, burns, infections, stress, free radicals, radiation, allergies, immune system disorders, athero- sclerosis, heart disease). Inflammation is part of the body's innate immunity and serves to destroy, dilute, and/or wall off harmful agents and damaged tissue.

It is (initially) a beneficial response and is part of the healing process, but various factors can cause chronic and perpetual inflammation. Chronic inflammation can depress immune system function, interfere with hormonal balance, create digestive distress, produce chronic pain, and disturb the nervous system.

Medicines that reduce inflammation are called an- ti-inflammatories. They work through many different and often complicated channels to inhibit localized or systemic inflammation. Van et al. (2009) tested several different types of extractions from chagafor their ability to reduce inflammation. All of those tested significantly inhibited inflammation, including a water-based polysaccharide extract and an eth- anol-based extract. Kim et al. (2007) found similar results with ethanol extracts. They showed that cha- ga inhibits key proteins required for nitric oxide and cyclooxygenase-2 pathways(two pathways that promote inflammation). Choi

et al. (2010) demonstrated that extracts of chaga helped ameliorate inflammatory bowel disease, likely through its regulation of tumor necrosis factor-α,a major inflammatory cytokine and a promoter of pro-inflammatory responses.

6. Antimicrobial.

Antimicrobials are substances that directly kill or inhibit the growth of microorganisms, such as bacte- ria, fungi, and viruses (antibacterial, antifungal, and antiviral, respectively). Antimicrobials range in their activity. In other words, these remedies vary in the types and specific kinds of microorganisms they kill or inhibit the growth of. Chaga has been shown to have activity against several different types of viruses, including some viral types with long-term and even lethal effects. For example, lignin-like substances extracted from chaga have been shown to impede Human Immunodeficiency Virus (HIV) by inhibiting HIV-1 protease, an enzyme necessary for replication and infection of additional cells (Ichimura et al. 1999). Through inhibiting HIV-1 protease, chaga disrupts the life cycle of HIV and prevents virus particles from be- ing infectious. Shibnev et al. (2011) documented anti- viral activity of water-based extract of chaga against Hepatitis-C. The extract used in the study reduced the infectious properties of the virus by 100-fold and was shown to have both preventative and therapeu- tic use. Kahlos (1996) performed preliminary tests of the antiviral activity of the chaga sclerotium. They documented up to 100 percent inhibition against two strains of human influenza virus (A and B) utilizing material from the dark, outer crust of the sclerotium.

The chaga sclerotium is known to concentrate bet- ulin and betulinic acid in the dark, outer layer of the sclerotium (Spinosa 2006, Marley 2009). These ter- penes originate from the host tree (members of the genus Betula—birches). Pavlova et al. (2003) showed that betulin and related compounds were active against Herpes Simplex type 1. Also, betulin and bet- ulinic acid inhibited reproduction of the ECHO 6 virus, a highly infectious and sometimes lethal virus that primarily infects the gastrointestinal tract of children. In a review of the medicinal properties of betulinic acid, Moghaddam et. al.(2012) list several studies demonstrating this com- pound's inhibitory effect on the HIV virus. These studies (and many others) demonstrate that wild-col- lected chaga growing on birch trees have potential therapeutic advantages over laboratory cultured chaga mycelium.

SUMMARY AND CONCLUDING REMARKS

The chaga sclerotium has been intensely examined for its prophylactic and healing capabilities with regard to disease. Numerous, independent studies document its valuable role in preventing and healing cancer, beneficially

activating the immune system (in- cluding maintenance of function during immunosup-pressive situations), inhibiting cellular degeneration due to oxidation, suppressing inflammation, killing and/or inhibiting the growth of viruses, supporting diabetes treatment by preventing hyperglycemia, easing symptoms of certain gastro-intestinal disor- ders, and improving cognitive function. Remarkably, this fungus demonstrates virtually no side effects during use in disease treatment (Wasser 2002, Choiet al. 2010). Chaga, like many other wild medicines, presents a wonderful intersection of folk use and modern scientific study. Long history of use helps determine safety and presents anecdotal evidence for efficacy, while scientific research helps validate efficacy and determine mechanisms of action. View- ing medicine through this filter (i.e., the intersection of folk use and modern study) helps paint a confident picture of harmlessness and effectiveness—two criteria a given medicine should possess. Chaga can certainly be regarded as a gift to humankind—it both generates and helps maintain health. Combined with a nutrient-dense diet and beneficial lifestyle, chaga can be part of a foundational strategy that preserves youth, health, and vitality.

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