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# Beneficial and harmful properties of Lectins

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**Abstract**
In food, lectins have been found beneficial for the consumers they were identified in cereals and their germs and seeds, fruits and vegetables and their seeds too, nuts, cocoa, coffee, edible mushrooms, algae, invertebrate including seafood, lectins also exhibited therapeutic responses like antimicrobial and antiparasitic actions, antitumor cells proliferation, immuno-stimulation, inhibition of some viruses replication, including HIV. If it is harmful lectins in foods, that induce disruption of gut mucosa, leptin resistance, an increase of pancreas, thymus, liver, hormonal imbalance, it could be in cooked food, are due to the fact that many of the lectins are resistant to pH and proteases attack during gastrointestinal passage.
Mannose-binding lectin (MBL) may contribute to immunoglobulin-mediated complement activation in both ischemia-reperfusion and rejection. The interaction of MBL with IgM may be of importance to explain some of the conflicting results on beneficial and harmful effects of the lectin pathway. In this present review is focused on the beneficial and harmful properties of Lectins.

**Keywords:** Lectins, immunological response, rheumatoid arthritis, obesity, dietary component, protection

## 1. Introduction
Lectins were located on the surface of cells of all living things lay many thousands of different complex sugar molecules (glycoconjugates) projecting outward from their loose anchors like moving antennae. Genetically unique, these molecules comprise a protective coating for the cell and perform many functions including cell recognition and signaling.
Lectins are a class of protein molecules capable of using these sugar moieties to bind to the surface of cells. Lectins provide the way for one molecule to stick to another molecule without any immunity involved. Lectins play a wide role in health, but their ability to influence the inflammatory process indicates they are involved in inflammatory bowel disease, rheumatoid arthritis and even weight gain.
These lectin abilities promoted interesting results in experimental treatments of immunological diseases, wounds, and cancer. Lectins obtained from virus, microorganisms, algae, animals, and plants were reported as modulators *in vivo* and *in vitro*; these molecules also play a role in the induction of mitosis and immune responses, contributing for resolution of infections and inflammations. Lectins revealed healing effect through induction of re-epithelialization of wounds.
Some lectins have been efficient agents against virus, fungi, bacteria, and helminths at low concentrations. Lectin-mediated bio adhesion was leading for the development of drug delivery systems. Lectin histochemistry and lectin-based biosensors are useful to detect transformed tissues and biomarkers related to disease occurrence; antitumor lectins reported are promising for cancer therapy. Here, we discussed beneficial and harmful properties lectins in the diagnosis and therapeutics [1].

## 2. Lectins - A profile
Lectins are not degraded by stomach acid or proteolytic enzymes, making them virtually resistant to digestion. Microbes carry lectins and use them for attachment to the host cells. The human body contains lectins:

1. On the vascular endothelial linings (selectins) for blood cells to escape into the tissues;
2. In the liver to capture microorganisms, and
3. As opsonin's, substances that coat foreign antigens, making them more susceptible to phagocytosis (the process where immune cells digest and destroy foreign invaders) by the white blood cells. C-reactive protein (CRP) and mannose-binding protein (MBP) are two examples of opsonins.

The important point is that some of the lectins consumed in everyday foods act as chemical messengers that can in fact bind to the sugars of cells in the gut and the blood cells, initiating an inflammatory response.

In wheat, gliadin, a component of gluten and an iso-lectin of wheat germ agglutinin (WGA), is capable of activating NF kappa beta proteins which, when up-regulated, are involved in almost every acute and chronic inflammatory disorder including neurodegenerative disease, inflammatory bowel disease, infectious and autoimmune diseases [2]. WGA needs more recognition as an important dietary problem. Scientific literature shows that dietary lectins can dramatically reduce natural killer (NK) cell activity directly and through disruption of intestinal flora.

Natural killer cells are one of the body's most important defences against viruses and other invaders. Most dietary lectins will also stimulate polyamine production in the gut. Polyamines are important growth factors that may have negative effects if levels become imbalanced. Excess polyamine production initiated by lectins may be the result of an effort to repair the damage to intestinal microvilli caused by lectins. In addition, a high polyamine level may also decrease NK cell populations [3], can contribute to halitosis (bad breath), and is considered an important biological marker for colonic cancer [4, 5, 6, 7]. Several animal studies have shown that an increase in polyamines caused by a high lectin diet resulted in increases in the size of the intestines, liver, and pancreas [8].

**3. Lectin - immunological concern**

There is an abundance of literature from the most prestigious journals that lectins such as WGA initiate allergic reactions in the gut causing the release of IL-4, IL-13, and histamine from human basophils producing noticeable allergic symptoms [9, 10]. WGA has also shown to interfere with protein digestion and increase gut permeability [11, 12]. Peanut lectin, kidney bean and soybean lectins are other examples of lectins that have influences on bodily tissues. On the bright side, the lectins in broad beans (VFA), jackfruit (JAC), and culinary mushrooms (Agaricus bisporus) have been shown to slow the progression of colon cancer [13, 14]. Many food allergies are immune system reactions to lectins [15].

The trend toward consumption of less processed grain foods, although more nutritious in many respects, results in consumption of more lectins. After ingestion, most dietary lectins bind to the absorptive microvilli of the small intestine (the microvilli are the tiny finger-like projections on the epithelial cells). From there lectins may gain access into the blood and lymph system through a process called endocytosis which carries the intact lectin across the microvilli membranes as a vesicle [16]. Then, the lectins may enter the liver, pancreas and systemic circulation.

It is estimated that about 5 percent of ingested lectins enter the body systemically, where, depending on the lectin and depending on the person's unique glycoconjugates, lectin binding occurs on other tissues such as nervous and connective tissue and the bladder, which are very sensitive to the agglutinating effects of lectins. It is a clinical observation that the complete avoidance of wheat lectins will help ameliorate the symptoms of interstitial cystitis. The reactions of lectins in the gut are more potent since the gut is more heavily glycosylated (more sugar receptors). As intestinal cells aged they become less glycosylated due to the loss of glycoconjugates.

The intestinal lining of people with Crohn's disease and IBS (irritable bowel syndrome) appear to be more sensitive to the effects of food lectins because the lining is constantly being replaced by new tissue that is made up of immature cells that are more glycosylated and thus more susceptible to lectin attachment.

Lectins have many other applications in the clinical laboratory from identification of microorganisms to cancer research where lectins serve as probes to investigate the working of the cell through its surface biology. Lectins have been used as carriers for the delivery of chemotherapeutic agents. Mitosis (cell division) can be enhanced with lectins such as pokeweed lectin (PWA).

**4. Lectins - in Rheumatoid Arthritis**

The fact that lectins appear to aggravate existing inflammatory conditions can be seen in the example of rheumatoid arthritis [17, 18, 19]. The RA antibody is different structurally from a normal antibody in that the side-chain sugar, galactose, is replaced with N-acetyl glucosamine, the sugar for which the wheat germ lectin (WGA) is highly specific. This may point to why patients with rheumatoid arthritis feel better on a wheat-free diet. It has been also observed that the pain and inflammation of fibromyalgia may stem from or be contributed to by intolerance to wheat lectins. In fact, lectins are capable of intensifying the effects of autoimmune disorders in general. Nightshade vegetables like potatoes and tomatoes are very high in lectins and are known to trigger the symptoms of arthritis.

**5. Lections - in Obesity**

A very important and interesting feature of some lectins is their ability to mimic hormones. As one can imagine, this could contribute a significant impact on metabolism. The hormone insulin stores excess carbohydrates (glucose) as fat. It accomplishes this by attaching itself to the insulin receptor found on the fat cell. Under stimulation from insulin, the fat cell becomes more permeable to glucose, which would otherwise remain in circulation. With mission accomplished, the insulin hormone then disconnects to its receptor.

In many people, lectins found in lentils, green peas, corn, potatoes but especially wheat germ agglutinin (WGA), are known to bind to the insulin receptor giving the fat cell the same message that insulin gives, namely, to make fat. The lectin, however, due to a lack of feedback inhibition, remains indefinitely attached to the receptor giving the cell a constant message to make fat [20, 21, 22, 23, 24, 25]. This perhaps explains why many weight loss programs that include a moderate-to-high amount of carbohydrate (especially modern grain) fail.

One other point about lectin contribution to weight gain is the fact that lectins have been shown to block digestive hormones. WGA can bind to the receptor for cholecystokinin (CCK), a hormone involved in appetite control, suppressing its function [25, 26].

This essentially leads to an increase in appetite and impairment in the release of digestive enzymes.

**6. In neurological diseases**

The concept of lectin-based therapeutics deploys the specific targets of lectins or the delivery of drugs that interacts with lectins to the target site. For example, Galectin-3 has been implicated in numerous neurological disorders and diseases in the peripheral nervous system. Pharmacological suppression of galectin-3 appears to be a promising approach.

Galectins are a group of pleotropic proteins that recognize both β-galactoside-containing glycans and non- β-galactoside-

containing proteins. The function and regulation of galectins have been implicated in immunomodulation, neuroinflammation, apoptosis, phagocytosis and oxidative bursts. Most Siglecs are expressed at a low level on the plasma membrane and bind to sialic acid residues for immunosurveillance and cell-cell communication [27].

## 7. Detrimental dietary component

Consider the fact that there are many varieties of wheat grown worldwide. Ancient wheat species had much lower protein contents than the modern varieties. Lectins are proteins. Increasing the protein component has also increased the lectin load with the resultant potential for inflammation and metabolic disruption. Genetic altering of grain plants (GMO) has also changed the lectin content.

Interestingly, lectins are destroyed in the sprouting process, which allows for a safer form of grain consumption, not to mention that the sprout is generally higher in overall nutritional value than the seed. Organic, sprouted grain bread products (with no added gluten) appear to be the safest and healthiest way to reap the nutritional benefit of grain without the lectin burdens.

Some lectins are resistant to heating by cooking. As a side note, soaking beans before cooking them reduces the lectin content dramatically. Most people do not know why beans prepared this way makes them easier to digest but it is simply because the water-soluble lectins have been nearly completely removed through the changing of the water during soaking.

## 8. Protecting against Lectins

Because lectins are so prevalent in a typical diet, undertaking a supplement regimen to help combat the damaging effects of lectins can help contribute to optimal health, improve the health of the intestinal tract and contribute to weight loss. Certain seaweeds, especially those high in the sugar fucose (Bladder wrack) and mucilaginous vegetables like okra can bind to lectins in a way that makes them unavailable to the vulnerable cells of the gut. These foods act as sacrificial decoys and attach to the problematic lectins that would ordinarily attach and bind to gut epithelial cells.

A specific glycoprotein, N-acetylglucosamine (NAG), is also a favourite target for dietary lectins and is concentrated in connective tissue. Supplementation with NAG is an excellent strategy for lectin protection. Another sugar with similar activity is D-mannose, which is capable of binding to lectins located on the cells of microorganisms.

Some bacteria responsible for urinary tract infections contain lectins specific for the sugar mannose and use these lectins to bind tightly to mannose-rich tissue in the bladder walls, initiating urinary tract infections (UTIs) (Lenard, *et al*. 2003, Rudiger H, 2000). As with Bladder wrack and NAG, supplementation with D-mannose provides a decoy for these lectins and protects the bladder. Supplementing prior to a meal with these decoy sugars allows for the binding of potentially harmful lectins and protection from attack. This concept of lectin-shielding devices has exciting clinical application now and, in the future [28].

Many known biomarkers established to specific physio- and pathological processes are glycoprotein and glycan detectable in biological fluids and cell surface [29]. Lectin assays developed for glycan analysis attached to circulating glycoproteins or cell surfaces, allowing the detection of diseases and pathogens. Lectin-based biosensors have been developed to detect and quantify glycans [30]. These systems are based on the conversion of lectin-carbohydrate interactions into a measurable signal on a surface, allowing the measurement of biomarkers.

Pisum sativum and Momordica charantia seed lectins showed *in vitro* and *in vivo* inhibitory effects on Ehrlich carcinoma (ascitic tumor) in mice. The growth of tumor inhibited in 63% and 75% with P. sativum and M. charantia lectins, respectively, both administered intraperitoneally at 2.8 mg/kg/day for five consecutive days. The P. sativum lectin caused apoptosis involving activation of caspases while the M. charantia lectin did not induce this cell death mechanism. The proapoptotic gene Bax was expressed intensively in cells treated with P. sativum lectin [31, 32]. The seed lectin from Glycine max caused 82.95% inhibition of Dalton's lymphoma in mice that received it through intraperitoneal injection; induction of autophagy and apoptosis, with activation of ROS production, was detected [33].

Finally, the anticancer potential of lectins also includes antimetastatic properties. Leaf lectin from Viscum album Coloratum showed a preventive effect against lung metastasis caused by B16-BL6 and 26-M3.1cells in mice that received 20–50 ng of lectin through intravenous administration two days before inoculation of cancer cells. This lectin also inhibited liver and spleen metastasis of L5178Y-ML25 cells when administered one day after tumor inoculation [34].

## 9. Conclusion

The involvement of lectins in our health and their relationship to degenerative disease is still an emerging science. Studies performed on animals will continue to be the model in the future for the study of lectins. The glycosylation of the human gut is basically like that of higher animals and it may be confidently predicted that the effects of dietary lectins will have similarities in both humans and animals. In short, dietary lectins, by their chemical reactivity with cell surface receptors on the intestinal epithelium, are metabolic signals for the gut and can modulate immune and hormone functions.

Lectins from diverse sources with distinct carbohydrate recognition events have important roles for many biotechnological applications and disease therapies. *In vitro* and *in vivo* uses showed that lectins have protective effects against virus and microorganisms; they are potent modulators of immune response, mitosis, proliferation, healing, drug delivery therapies, and cancer regression. Altered glycans on cells or tissue surfaces and serum samples can be located using lectin-based techniques, such as histochemistry and biosensors, detecting diseases and infection agents.

Lectin-mediated drugs focused on targeting specific cells could lead to promising anticancer and antimicrobial treatments, which would directly impact areas of economic importance, such as the pharmaceutical and food industries and agriculture.

Domesticated legumes provide an accessible and abundant source of lectins, their effect in modulating the expression of proteins and genes are required to move forward the use of lectins for clinical applications, in near future successful recombinant production of lectins would be a key factor to utilize in a feasible industrial application.

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