by Roger Clemens

Plant Lectins: Toxic or Therapeutic?

The UN General Assembly declared 2016 the International Year of Pulses with the goal of heightening awareness of their potential nutritional benefits and contributions to sustainable food production and global food security. Pulses refer to a spectrum of dry beans, peas, lentils, and more. The world crop production of pulses exceeds 60 million metric tonnes from at least 55 countries (GPF 2016). The majority of this production in 2013 was from dry beans (~39%) and chickpeas (~22%) (FAO 2016).

What is of particular interest are the minor components of ***pulses and their potential impact on human health.***

Pulses have considerable consumer appeal because they provide a source of protein, minerals (especially iron and zinc), and dietary fiber and are low in fat and cholesterol and gluten-free. The most recent economic assessment from the U.S. Dept. of Agriculture indicates that the pulses market will increase to about $500 million by 2024, growing by approximately 3.6% annually (USDA 2015).

Beyond the macronutrient profile of pulses, what is of particular interest are the minor components of pulses and their potential impact on human health. Those minor components include a variety of non-nutritive substances such as phenolic compounds, enzyme inhibitors, phytosterols, phytates, oxalates, and saponins (Champ 2002; Campos-Vega et al. 2010). Among these minor components are lectins. Lectins, sometimes referred to as agglutinins, are glycoproteins that are innate to plants, animals, and microbes. There are three classes of lectins, which are based on their chemistry and functional properties, namely, merolectins, hololectins, and chimerolectins (Peumans et al. 1995). Several hundred lectins have been isolated and identified, yet their biological functions remain the focus of considerable research (Peumans et al. 1996).

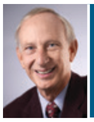
Some lectins are acutely lethal cytotoxins while others exhibit potential health-promoting attributes. For example, ricin, a well-known type-2 ribosome inactivating protein (RIP) and one of the most potent toxins in nature, and possibly abrin, volkensin, and the mistletoe lectin are potent RIP cytotoxins derived from castor beans (*Ricinus communis*), rosary peas (*Abrus precatorius*), roots of *Adenia volkensii*, and *Viscum album*. The LD_{50} of ricin is approximately 22 µg / kg bw if the exposure is from injection or inhalation. The ingestion of 1–2 mg ricin by a typical adult will produce significant adverse responses within a few hours. Ricin from a single castor bean seed may be lethal for a child. Just 4–5 popular red kidney beans (*Phaseolus vulgaris*), if insufficiently cooked, will produce severe gastrointestinal distress due to the lectin phytohemagglutinin (Pusztai et al. 1977; FDA 2012).

Fortunately, most of the untoward effects of lectins and other antinutrients, such as damaging cell walls, compromising immune reactions, and demonstrating cytotoxicity, are marginally reduced during some thermal processes, such as typical autoclave conditions, extrusion, and dry roasting relative to raw materials (Rehman and Shah 2005; Van Der Poel 1990; Ryder et al. 1992). On the other hand, the potential negative health effects of other like substances increase when subjected to heat (Freed 1985). Importantly, soaking pulses in water prior to processing may be the most effective step in removing antinutrients (Ayyagari et al. 1989).

There is evidence from cancer cell cultures of antinutrients such as lectins that some of these substances modulate tumor cell growth. Histochemistry of Merkel cell carcinoma indicated lectins, such as Concanavalin A (mannose/glucose specific) that alters the gut brush border architecture, bind and react with these cells whereas other lectins have poor cell binding properties (Sames et al. 2001). Wheat-derived lectins, when applied at 0.25–1.0 µM concentrations appeared to significantly reduce the viability of human hepatoma (H3B) and human choriocarcinoma (Jar) cells in a dose-related manner (Wang et al. 2000). Many other plant lectins have demonstrated *in vitro* approximately 30%–70% inhibition of numerous malignant cell lines at doses around 15 µg/mL. Similar results with at least eight lectins have been confirmed *in vivo* using classic mouse and rat models for melanoma, non-Hodgkin's lymphoma, colorectal cancer, and breast cancer (De Mejia and Prisecaru 2005). The unique mistletoe lectins, such as ML-I, ML-II, and ML-III, suppress tumor growth of several cell lines by potentiating tumor necrosis factor ($TNF\alpha$) and specific interleukins (e.g., IL-6 and possibly IL-4) and function as mitogens while expanding and activating or mediating cytotoxicity through the induction of the T-cell population and natural killer and lymphokine-activated killer cells at very low doses (e.g., 1 ng/kg bw), depending on the tumor cell sensitivity (Pryme et al. 2006).

Plant lectins may function to protect plants against pathogens such as insects and microbes. These substances may also be toxic to humans if plants are not appropriately processed. Emerging evidence suggests that lectins, one of many antinutrients identified in pulses, may represent future tools for combating diseases such as cancer. **FT**

References are available in the online version of this column via hyperlinked citations.



***Roger Clemens**, DrPH, CFS, Contributing Editor • Adjunct Professor, Univ. of Southern California School of Pharmacy, Los Angeles, Calif. • clemens@usc.edu*