Rice is one of the leading food crops worldwide and the staple food source for more than half of the world's population. Three products traditionally result from the milling of rice: white rice, rice bran, and rice hulls (Table I and Fig. 1). White rice is a carbohydrate source that is gluten-free and has various functional characteristics that are specific to long-, medium-, and short-grain varieties. It is a common source of starches, syrups, and flours. It also cooks faster than brown rice and is stable for extended storage periods. White rice is the most commonly consumed rice fraction. However, during the late 1800s consumption of brown rice increased due to its higher vitamin B content, which helped prevent beriberi, a common disease among sailors of the time.

Following improvements in technology and increased consumer interest in more natural sources of healthy nutrients, researchers have begun investigating the beneficial effects of the secondary constituents of rice milling: rice bran and rice hulls. This article will focus on these two fractions.

Rice Components

Bran. Rice bran, and the germ, is the most nutrient-rich component of the rice grain, containing ≈90% of the nutrients. It is an inherent part of the whole grain and contains phytonutrients such as oryzanols, tocopherols, tocotrienols, phytosterols, and important dietary fibers (10). The complete exploitation of its functional and nutritional potential has been hindered due to problems associated with rancidity resulting from a naturally occurring lipase enzyme. However, stabilization procedures have made it possible to derive an array of health-promoting value-added ingredients from the rice bran. For example, a patented method has been developed for the proteolytic inactivation of lipase in rice bran. Because heat is not used in the process, a separation method is used to concentrate the valuable soluble fractions while separating them from the fiber. The result is a variety of bran-derived ingredients containing minor beneficial constituents that have been identified through research. These new ingredients are giving food manufacturers innovative options for meeting consumer demands for healthier, all-natural products.

Hulls. The rice hull is an often overlooked fraction that consists mainly of fiber and ash. Traditionally, hulls have been used in a variety of nonfood and feed applications. Today, advances in technology are leading to new options and increased interest within the food, dietary supplement, and medical industries.

Unique Rice Characteristics

New research is revealing that there is more to rice than meets the eye. This old and very common grain has unique functional and nutritional characteristics that differentiate it from other grains, particularly its hull and bran fractions.

Hulls. Rice hulls are composed of fiber and ash. The ash found in rice hulls is predominately silica (amorphous), which
is a unique characteristic. When hulls are processed properly, they can be used as a valuable natural alternative to silicon dioxide (SiO$_2$). The rice plant takes up silica from the soil and concentrates it in the hull of the grain. Rice hulls contain more silica than any other grain crop. This fiber and silica material is extremely functional and typically can be used in a 1:1 ratio as an alternative to silicon dioxide and other synthetics, even though the silica content is much lower.

**Bran.** Like most grains, rice bran is very nutritious. However, rice bran contains nutrients that are not common in other grains, such as B vitamins (unique for plants), antioxidants, and phytic acid (a natural plant antioxidant constituting 1–5% of most cereal grains, nuts, legumes, oil seeds, pollens, and spores). Antioxidant levels in rice bran extracts (RBEs) can be as high as 12%. Rice bran also has changed the way we look at saturated and unsaturated fats. Various studies indicate that saturated fats can contribute to heart disease, while unsaturated fats can prevent cardiovascular disease. The major fatty acids found in rice bran oil are palmitic and oleic acids. Despite containing palmitic acid, a saturated fat, rice bran has been found to reduce cholesterol. Although rice bran is a rich source of vitamin E and other nutrients, it does not contain vitamins C, D, or A.

**Rice Applications**

To utilize its unique characteristics, extraction of compounds from the rice bran is necessary. RBEs are not single, isolated molecules, but rather combinations of molecules that occur naturally in the aleurone layer of the rice grain. Water is an excellent extraction fluid for compounds such as tocopherols, tocotrienols, polyphenols, oryzanol, and phytosterols. The potential applications for rice fractions span a wide range products, from food and dietary supplement applications to medical applications.

**Food Applications.** Rice bran is used commercially as a surfactant and emulsifier. By definition, a surfactant is an amphiphilic molecule with a hydrophilic head group that has a high affinity for water and a lipophilic tail group that has a high affinity for oil. In RBEs the protein/carbohydrate portion acts as the hydrophilic head, while the fat portion acts as the lipophilic tail. The principal role of surfactants is to enhance the formation of food emulsions and to stabilize the emulsion once it has been formed. As a surfactant, rice bran reduces the surface tension of water and allows powders to hydrate more rapidly (hydration aid). This characteristic is also valuable in its second function as an emulsifier. Uses range from extrusion processing aid to bakery applications to incorporation in sauces, marinades, and beverages. In many cases rice bran is used as a replacement for mono- and diglycerides or soy lecithin.

Rice hulls are used commercially as an anti-caking agent and flow aid in dry flavors, spices, and hydroscopic powders, providing a natural and potentially organic alternative to silicon dioxide and tricalcium phosphate. The USDA National Organics Program is reviewing a petition approved by the National Organics Standards Board to restrict the use of silicon dioxide in organic products due to the existence of a natural, organic alternative. Implementation could occur as early as the end of 2013.

Hulls are also used as an adsorbent to convert liquids or pastes into flowable powders, without requiring heating or drying. This is commonly done with flavorants or items that are heat sensitive and will be used in systems that do not require full water solubility (hulls are water insoluble).

**Dietary Supplement Applications.** RBEs are used commercially as hydration aids to break the surface tension of liquids and, thereby, allow powdered beverage mixes to hydrate more rapidly. Additionally, tablet and capsule manufacturers can use RBEs to replace magnesium stearate/stearic acid as a lubricant or glidant. The balance of palmitic, oleic, and linolenic fatty acids in RBEs provides functionality similar to magnesium stearate/stearic acid, and they are handled better in the body than stearic acid. This is extremely valuable for companies formulating organic tablets because use of magnesium stearate precludes tablets from being certified as organic.

The rice plant also creates B vitamins and stores them in the rice bran. Thiamin, riboflavin, and niacin can be extracted from the bran using water. Tableters of B vitamins often use rice bran as a natural carrier to maintain the amount of B vitamins throughout the life of the tablet.

**Medical Applications.** The complexity of active ingredients used in medical applications is greater than that of those ingredients used in foods or dietary supplements. A variety of studies have been done by different researchers that demonstrate the unique health benefits of various rice fractions. The benefits being explored by researchers range from cholesterol-lowering properties to treatments to inhibit cancer, Alzheimer’s disease, and obesity.

A study was designed to characterize RBE constituents and evaluate their antioxidant and hypcholesterolemic activities. The antioxidant behavior of RBEs against lipid oxidation was measured in an emulsion prepared with fish oil containing a fatty acid that is very susceptible to oxidation. The emulsion showed stable antioxidant activity, specifically preserving the lipid from peroxidation phenomena and inhibiting the generation of thiobarbituric acid-reactive substances and lipid peroxides. Hypcholesterolemic activity was evaluated in male Wistar rats using two different hypcholesterolemic diet models. A reduction in total cholesterol levels and an

### Table I. Composition of rice fractions

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Bran</th>
<th>Hull</th>
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</thead>
<tbody>
<tr>
<td>Protein (%)</td>
<td>4.5–10.5</td>
<td>11.3–14.9</td>
<td>2–2.8</td>
</tr>
<tr>
<td>Crude fat (%)</td>
<td>0.3–0.5</td>
<td>15–19.7</td>
<td>0.3–0.8</td>
</tr>
<tr>
<td>Available carbohydrates (%)</td>
<td>77–89</td>
<td>34–62</td>
<td>22–34</td>
</tr>
<tr>
<td>Crude fiber (%)</td>
<td>0.2–0.5</td>
<td>7–11.4</td>
<td>34.5–45.9</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.3–0.8</td>
<td>6.9–9.9</td>
<td>13.2–21</td>
</tr>
</tbody>
</table>

increase in HDL cholesterol were found in both models (11).

Bioactive food-derived peptides possess the ability to promote health. Research at the University of Arkansas isolated and characterized fractions of peptides from rice bran for their possible inhibitory effects against cancer, Alzheimer's disease, and obesity. High molecular weight fractions (>10 kDa) exhibited antihypertensive and antioxidant properties, while lower molecular weight fractions (<5 and 5–10 kDa) protected cells from Alzheimer's disease (4).

Palmitic and oleic acids are the major fatty acids found in rice bran oil. When rats were fed diets in which rice bran was defatted and the ratio of saturated to unsaturated fats was kept the same, rats developed characteristic plaques. This indicated there was something among the rice bran lipids that protected the circulatory system against damage and lowered cholesterol. Researchers discovered that γ-oryzanol, a ferulic acid ester, was responsible for lowering cholesterol. The cholesterol-lowering action of oryzanol was similar to that of prescription statin drugs (3,6,7,15).

Another study examined the preventive effect of hydrolyzed rice bran (HRB) against the common cold syndrome in elderly people. Arabinoxylan derivatives of HRB were prepared from water-soluble rice bran through partial processing using a carbohydrate complex and were found to be beneficial in reducing the physical stress associated with acute respiratory tract infection (5). Arabinoxylan extracted from rice bran has been shown to enhance innate and adaptive immunity and has the potential for use in vaccine strategies to fight infection and cancer (1,2).

Through its formation of a unique iron chelate, phytic acid extracted from rice bran (IP₆) suppresses iron-catalyzed oxidative reactions and may function as a potent antioxidant in the preservation of seeds. By the same mechanism, dietary phytic acid has also been shown to have positive nutritional benefits, and there are claims that it is able to prevent cancer through its antioxidant capability. Several studies of phytic acid extracted from rice bran demonstrated that it induced marked growth inhibition in ovary, breast, and liver cancer cells (8,9,12,14).

**Summary**

While rice has fed millions of people for centuries, it provides more than the carbohydrate calories needed to sustain life. Although it is one of the oldest grains, it has not been explored to the same degree as soybeans, corn, and wheat for the potential development of unique and diverse ingredients. Only within the past 20 years have food scientists and technologists begun to explore rice's potential and, most recently, to unlock the health and nutritional benefits of its various fractions. There has been a convergence of consumer trends in food and health research exploring how this well-known grain can provide unique nutrients and functionality. From natural and organic to clean-label and gluten-free trends, formulators have new ingredient options that provide the functionality required to meet consumer demands.

**References**


