New ideas and concepts
Rice bran: A nutrient-dense mill-waste for human nutrition
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Introduction
Rice is the staple food for seventy percent of world population supplying as much as half of its energy needs (Chang TT, 1976). In Asian countries including China, India, Indonesia, Bangladesh, Vietnam, Japan, Thailand, Myanmar and Pakistan, rice is produced and eaten as the predominant source of energy.

Common rice, scientifically called Oryza sativital has more than 8,000 named species that are grown all over the world. Rice is sometimes classified as either short grain, medium grain or long grain. Short grain rice has the highest starch content and is stickiest when cooked as it contains more amylopectin; while long grain is lighter and tends to remain separate when cooked as it contains more amylose. The characteristics of medium grain rice fall between the other two types.

Rice is also classified according to the degree of milling; brown rice is the whole grain with only its inedible outer hull removed keeping its nutrient-rich bran layer intact (Marshall, 1994). In contrast, white rice is both milled and polished, which removes the bran and germ contents along with all the nutrients that reside within these important layers.

White rice is the most popular form for human consumption although brown rice is eaten in some communities.

History
Rice is an ancient crop. It is believed that rice cultivation first began in China around 6,000 years ago, but this period could be as long as 9,000 years according to recent archaeological investigations based on discoveries of primitive rice seeds and farm tools (Plant Rice 2001, Marshall, 1994). Historically, rice is thought to be a staple grain in Asia which was introduced to Greece by the Arab conquest of Asian land and to India by Alexander the Great.

During the Moorist conquest of Spain in the 8th century rice appeared in the Spanish markets while the crusaders brought it to France. In 17th century rice was introduced to South America by the Spanish settlers in this continent. A significant proportion of world production of rice comes from Asian countries where it plays an important role in the food culture of the people. Thailand, Vietnam, India and Pakistan are the three largest exporters of rice worldwide.

Rice bran
Rice bran constitutes the brown covering of the grain beneath the outer husk. It constitutes 8% of the weight of the whole grain and contains most of the nutrients (65%). During milling process rice bran containing nutrients is completely removed. Around 60 million metric tons of rice bran is produced worldwide each year and almost all of it is either thrown away or used as low level...
animal and poultry feed. The cost of rice bran is 0.2 cent per pound in the international market and 0.1 cent (Tk. 5-7) in Bangladesh. Rice bran is a very rich source of nutrients containing vitamins, minerals, oils, wax, trace elements, antioxidants, phytosterols, and phytochemicals. It is also an energy-dense (373 cal/1 cup or 118g), high protein (15.8 g/1cup), high fiber (99%), low sodium, low sugar (1.1g) cereal containing zinc, iron, folic acid and other nutrients but no cholesterol. It is a good source of manganese, magnesium, vitamins B₁, B₂, B₆, and minerals i.e., potassium, calcium, phosphorus, and pantothenic acid. Recent information indicate that its high nutrient contents are hard to ignore.

**Brown rice**

Brown rice is un-milled or partially milled rice with removal of the outermost layer of the rice grain (husk) which becomes rancid more quickly. Parboiling destroys partially or completely the lipase activity of the rice bran thus providing longer shelf life of brown rice and helps preventing development of rancidity. Parboiled brown rice was traditionally and historically been consumed in most part of Bangladesh. With the advancement of industrialization, milled white rice has taken over the place of parboiled brown rice in this setting in past few decades.

The limitations of using brown rice with intact bran are related to its unpalatability due to high fibre content and short shelf life resulting from rapid hydrolysis of its fat content by the grain enzyme lipase (Champagne, 1994). Within 1 hour of separating the bran from the grain during milling the material turns rancid liberating toxic free fatty acids. These shortcomings have now been overcome by reducing the fibre content and destroying the lipolytic activity using an advanced stabilizing technology; the resulting material thus obtained is called "stabilized" rice bran which has a good taste, readily soluble with a longer shelf life of one year.

Rice bran in its crude or stabilized form is a potential dietary source which can be used as a nutritional supplement to replace and prevent nutrient deficiencies in malnourished children. However, no studies have yet been conducted to evaluate its role from the nutritional and metabolic point of view. Nevertheless, stabilized rice bran has been marketed as a popular brand of nutraceuticals for the management of diabetes, hypertension, dislipidemia, and arthritis (Anderson, 2000; Cade JE, 2007; Ensminger, 1983; Erkkila, 2005).

**Nutritional deficiencies and rice bran**

Nutritional deficiency among children is widespread in the developing countries especially in Asia. Of the malnourished children, about 70% live in Asia accounting for the highest concentration of malnourished children in the world. Fifty percent of deaths among these children are attributed to malnutrition which severely affects growth, cognition, motor and social development of young children. A large proportion of hidden burden of malnutrition among children are due to single or multiple micronutrient deficiencies. Factors influencing micronutrient deficiency includes poor body stores at birth, poor dietary intake, and losses from the body during illnesses. Protein energy malnutrition (PEM) along with micronutrient deficiency among young children and pregnant women of developing countries is the most important risk factor for disability and death. Micronutrient supplementation, food fortification, complementary food at home, and several other strategies have been implemented to minimize micronutrient deficiencies in children in many countries including Bangladesh; these interventions have been found to be efficacious and effective although malnutrition remains quite high in these countries.

**Nutrient loss during milling**

Brown rice is an excellent source of energy, vitamins, and minerals (Fortin, 1996). However, the process of milling and polishing
that converts brown rice into white rice destroys 67% of the vitamin B₃, 80% of the vitamin B₁, 90% of the vitamin B₆, half of the manganese, half of the phosphorus, 60% of the iron, and all of the dietary fiber and essential fatty acids. By law in the United States, fully milled and polished white rice is obtained by law in the United States, fully milled and polished white rice must be "enriched" with vitamins B₁, B₃ and iron. But the form of these nutrients when added back into the processed rice is not the same as in the original unprocessed grain, and at least 11 lost nutrients are not replaced in any form even with rice "enrichment".

Locally produced rice bran may have similar nutritional values to those of commercially produced rice bran as commercially produced rice bran does not fortify rice bran with any nutritional ingredients.

**Health benefits of rice bran and brown rice**
The difference between brown rice and white rice is not just color. Brown rice is obtained when only the outermost layer, the hull, is removed from the whole grain (paddy rice) during milling. This process is the least damaging to the nutritional value of the rice and avoids the unnecessary loss of nutrients that occurs with further processing. Further milling of brown rice to remove the bran coat and most of the germ layer will produce white rice which is devoid of the bran-based nutrients. Further milling of rice called 'polishing' will result in more whiter rice we buy from the market. During fine polishing the thin aleurone layer containing important nutrients and oil is removed from the grain. The fat layer is removed to extend the shelf life of the grain since this fat is liable to be decomposed by the grain enzyme lipase to produce free fatty acids and leading to the development of rancidity. Thus the final white rice is simply a refined starch that is largely bereft of its original nutrients. Health benefits derived from consumption of rice containing its bran layer have been described in a number of studies (Erkkila, 2005; Ensminger, 1983).

**Prevention of heart diseases**
Plant lignans are one type of phytonutrient abundantly present in whole grain rice, these are transformed by the resident microflora in the colon into mammalian lignans, such as enterolactone that is known to protect against breast cancers as well as heart disease (Liu, 2004; Lie, 2003). Lignans are present in fruits (nuts, seeds, berries) and vegetables, and beverages such as coffee, tea and wine. Higher levels of protective enterolactone were found in postmenopausal Scandinavian women eating whole grain meals with cabbage and other leafy vegetables.

**Risk of type 2 diabetes**
Regular consumption of brown rice and other whole grains are known to reduce the risks of
developing adult type diabetes (McKown, 2004; Van Dam, 2006). Risk of type 2 diabetes was reduced by 31% in black women eating whole grains compared to those eating the least of these foods. According to the FDA, a food containing at least 51% whole grains by weight is likely to display a health benefit linking lower risk of heart disease and certain cancers. In an 8 years study involving 41,186 black women participants, an inverse association between magnesium, calcium and major food sources relating to type 2 diabetes was documented (Van Dam RM, Hu FB, Diabetes Care). Similar observations were made in white population earlier. Whole grain rice is a rich source of magnesium, a mineral acting as a co-factor for regulating many enzymatic reactions regulating glucose and insulin metabolism.

**Risk of metabolic syndrome**

Refined grains and the foods made from them (e.g., white breads, cookies, pastries, pasta and rice) are now being linked not only to weight gain but to increased risk of insulin resistance (the precursor of type 2 diabetes) and the metabolic syndrome (a strong predictor of both type 2 diabetes and cardiovascular disease), while eating more wholegrain foods is being shown to protect against all these ills.

Common features of the metabolic syndrome include visceral obesity, low levels of protective HDL cholesterol, high triglycerides, and high blood pressure. In one of the most recent studies, which appeared in diabetes care, researchers who analyzed data on over 2,800 participants in the Framingham Offspring study, found that the prevalence of both insulin resistance and the metabolic syndrome was significantly lower among those eating the most cereal fiber from whole grains compared to those eating the least one (McKown, 2004). Prevalence of the metabolic syndrome was 38% lower among those with the highest intake of fiber from whole grains. Conversely, study subjects whose diets had the highest glycemic index and glycemic load, both of which are typically low in whole foods and high in processed refined foods, were 141% more likely to have the metabolic syndrome compared to those whose diets had the lowest glycemic index and glycemic load. The researchers concluded, "Given that both a high cereal fiber content and lower glycemic index are attributes of wholegrain foods, recommendation to increase wholegrain intake may reduce the risk of developing the metabolic syndrome."

It is observed that a way of eating that relies on the healthiest foods from all the food groups-the whole foods that contain the healthiest fats, carbohydrates and proteins-is the most effective, intelligent, and most enjoyable way to not only lower the risk of developing the metabolic syndrome, but to stay slim, vital and attractive throughout a long and healthy life.

**Effects on trace elements**

Magnesium, another nutrient for which brown rice is a good source, has been shown in studies to be helpful for reducing the severity of asthma, lowering high blood pressure, reducing the frequency of migraine headaches, and reducing the risk of heart attack and stroke (Jensen, 2004). Magnesium helps regulate nerve and muscle tone by balancing the action of calcium. In many nerve cells, magnesium serves as nature's own calcium channel blocker, preventing calcium from rushing into the nerve cell and activating the nerve. By blocking calcium's entry, magnesium keeps our nerves relaxed. If our diet is deficient in magnesium, calcium can gain free entry, and nerve cells can become over activated, sending too many messages and causing excessive contraction. Insufficient magnesium can thus contribute to high blood pressure, muscle spasms (including spasms of the heart muscle or the spasms of the airways symptomatic of asthma), and migraine headaches, as well as muscle cramps, tension, soreness and fatigue (Tabak, 2005).
Magnesium, as well as calcium, is necessary for healthy bones. About two-thirds of the magnesium in the human body is found in our bones. Some helps give bones their physical structure, while the rest is found on the surface of the bone where it is stored for the body to draw upon as needed. Brown rice can help keep those storage sites replenished and ready to meet the body's demands. A cup of brown rice can provide 21.0% of the daily value for magnesium.

In addition to niacin it supplies, brown rice may also help raise blood levels of nitric oxide, a small molecule known to improve blood vessel dilation and to inhibit oxidative (free radical) damage of cholesterol and the adhesion of white cells to the vascular wall (two important steps in the development of atherosclerotic plaques). A study published in the British Journal of Nutrition suggests that diets high in rice protein can help protect against atherosclerosis by increasing blood levels of nitric oxide (Ni W, 2003).

In this study, when researchers gave rice bred to mice to be apoliprotein-E deficient a purified diet containing either casein, the principal protein in dairy products, rice protein or soya protein, the mice given casein developed the largest atherosclerotic lesions. In humans as well as animals, apolipoprotein E plays an important role in cholesterol transport, so a deficiency of this protein increases risk for the development of atherosclerosis. Mice given rice or soya protein fared much better. In trying to understand why, the researchers evaluated blood levels of nitric oxide. Mice fed either rice or soya protein diets were found to have increased blood levels of L-arginine (the amino acid that the body uses to produce nitric oxide) and nitric oxide metabolites when compared to those given casein-based feed. However, the L-arginine content of the rice and soya diets was not high enough to explain the amount of protective benefit they conferred, so the researchers concluded that these foods must also contain other cardioprotective compounds.

Manganese-energy production plus antioxidant protection: Just one cup of brown rice can provide with 88.0% of the daily requirements for manganese. This trace mineral helps produce energy from protein and carbohydrates and is involved in the synthesis of fatty acids, which are important for a healthy nervous system, and in the production of cholesterol, which is used by the body to produce sex hormones. Manganese is also a critical component of a very important antioxidant enzyme called superoxide dismutase.

Superoxide dismutase (SOD) is found inside the body's mitochondria (the oxygen-based energy factories inside most of our cells) where it provides protection against damage from the free radicals produced during energy production.

Body weight reduction
A study published in the American Journal of Clinical Nutrition underscores the importance of choosing whole grains such as brown rice rather than refined grain, i.e., white rice, to maintain a healthy body weight. In this study, weight gain was inversely associated with the intake of high-fiber, whole-grain foods but positively related to the intake of refined-grain foods in 74,000 female nurses aged 38-63 years over a 12 year period (Anderson, 2000). Not only did women who consumed more whole grains consistently weigh less but they were also 49% less likely to gain weight compared to those eating foods made from refined grains.

Effects of fiber and selenium
Brown rice is a concentrated source of the fiber needed to minimize the amount of time, cancer-causing substances spend in contact with colon cells, and being a very good source of selenium, a trace mineral that has been shown to substantially reduce the risk of colon cancer (Most, 2005; Ni W, 2003).

In addition to supplying 14.0% of the daily value for fiber, a cup of cooked brown rice
provides 27.3% of the DV for selenium, an important benefit since many do not get enough selenium in their diets. Selenium is an essential component of several major metabolic pathways, including thyroid hormone metabolism, antioxidant defense systems and immune function. Accumulated evidence from prospective studies, intervention trials and studies on animal models of cancer has suggested a strong inverse correlation between selenium intake and cancer incidence. Several mechanisms have been suggested to explain the cancer-preventive activities of selenium. Selenium has been shown to induce DNA repair and synthesis in damaged cells, to inhibit the proliferation of cancer cells, and to induce their apoptosis, the self-destructive sequence the body uses to eliminate worn out or abnormal cells (Liu, 2004).

In addition, selenium is incorporated at the active site of many proteins, including glutathione peroxidase, which is particularly important for cancer protection. One of the body's most powerful antioxidant enzymes, glutathione peroxidase is used in the liver to detoxify a wide range of potentially harmful molecules. When levels of glutathione peroxidase are too low, these toxic molecules are not disarmed and wreak havoc on any cells with which they come in contact, damaging their cellular DNA and promoting the development of cancer cells.

Not only does selenium play a critical role in cancer prevention as a cofactor of glutathione peroxidase, selenium also works with vitamin E in numerous other vital antioxidant systems throughout the body. These powerful antioxidant actions make selenium helpful in the prevention not only of cancer, but also of heart disease, and for decreasing the symptoms of asthma and the pain and inflammation of rheumatoid arthritis.

**Cholesterol lowering effects**
The oil in whole brown rice lowers cholesterol. In one study from Louisiana State University rice bran and rice bran oil were found to reduce cholesterol levels in volunteers with moderately elevated cholesterol levels (Most, 2005).

The study, published in the American Journal of Clinical Nutrition was divided into two parts. First, 26 subjects ate a diet including 13-22g of dietary fiber each day for three weeks, after which 13 switched to a diet that added defatted rice bran to double their fiber intake for five weeks. In the second part of the study, a randomized crossover trial, 14 subjects ate a diet with rice bran oil for 10 weeks. While the diet including only defatted rice bran did not lower cholesterol, the one containing rice bran oil lowered LDL cholesterol by 7%. Since all the diets contained similar fatty acids, the researchers concluded that the reduction in cholesterol seen in that receiving rice bran oil must have been due to other constituents such as the unsaponifiable compounds found in rice bran oil. The scientists suggest that the unsaponifiables present in rice bran oil could become important functional foods for cardiovascular health. But why extract just one beneficial compound from brown rice when you can reap all the cardioprotective benefits supplied by the matrix of nutrients naturally present in this delicious whole food? In addition to unsaponifiables, this whole grain also supplies hefty doses of heart-healthy fiber, magnesium, and B vitamins.

**Cardiovascular benefits for postmenopausal women**
Eating a serving of whole grains, such as brown rice, at least 6 times each week is an especially good idea for postmenopausal women with high cholesterol, high blood pressure or other signs of cardiovascular disease (CVD) (Ysai, 2004). A 3-year prospective study of over 200 postmenopausal women with CVD, published in the American Heart Journal, shows that those eating at least 6 servings of whole grains each week experienced both: slowed progression of atherosclerosis and less progression in stenosis, the narrowing of the diameter of arterial passageways.
women's intake of fiber from fruits, vegetables and refined grains was not associated with a lessening in CVD progression.

Phytonutrients effects better than vegetables and fruits
Research reported at the American Institute for Cancer Research (AICR) International Conference on Food, Nutrition and Cancer, by Rui Hai Liu, M.D., PhD, and his colleagues at Cornell University shows that whole grains, such as rice, contain many powerful phytonutrients whose activity has gone unrecognized because research methods have overlooked them (Liu, 2003). Despite the fact that for years researchers have been measuring the antioxidant power of a wide array of phytonutrients, they have typically measured only the "free" forms of these substances, which dissolve quickly and are immediately absorbed into the bloodstream. They have not looked at the "bound" forms, which are attached to the walls of plant cells and must be released by intestinal bacteria during digestion before they can be absorbed.

Phenolics, powerful antioxidants that work in multiple ways to prevent disease, are one major class of phytonutrients that have been widely studied. Included in this broad category are such compounds as quercetin, curcumin, ellagic acid, catechins, and many others that appear frequently in the health news. When Dr. Liu and his colleagues measured the relative amounts of phenolics, and whether they were present in bound or free form, in common fruits and vegetables like apples, red grapes, broccoli and spinach, they found that phenolics in the "free" form averaged 76% of the total number of phenolics in these foods. In whole grains, however, "free" phenolics accounted for less than 1% of the total, while the remaining 99% were in "bound" form. In his presentation, Dr. Liu explained that because researchers have examined whole grains with the same process used to measure antioxidants in vegetables and fruits-looking for their content of "free" phenolics"-the amount and activity of antioxidants in whole grains has been vastly underestimated.

Despite the differences in fruits', vegetables' and whole grains' content of "free" and "bound" phenolics, the total antioxidant activity in all three types of whole foods is similar, according to Dr. Liu's research. His team measured the antioxidant activity of various foods, assigning each a rating based on a formula (micromoles of vitamin C equivalent per gram). Broccoli and spinach measured 80 and 81, respectively; apple and banana measured 98 and 65; and of the whole grains tested, corn measured 181, whole wheat 77, oats 75, and brown rice 56.

Dr. Liu's findings may help explain why studies have shown that populations eating diets high in fiber-rich whole grains consistently have lower risk for colon cancer, yet short-term clinical trials that have focused on fiber alone in lowering colon cancer risk, often to the point of giving subjects isolated fiber supplements, yield inconsistent results. The explanation is most likely that these studies have not taken into account the interactive effects of all the nutrients in whole grains-not just their fiber, but also their many phytonutrients. As far as whole grains are concerned, Dr. Liu believes that the key to their powerful cancer-fighting potential is precisely their wholeness. A grain of whole wheat consists of three parts-its endosperm (starch), bran and germ. When wheat-or any whole grain-is refined, its bran and germ are removed.

Although these two parts make up only 15-17% of the grain's weight, they contain 83% of its phenolics. Dr. Liu says his recent findings on the antioxidant content of whole grains reinforce the message that a variety of foods should be eaten for good health. "Different plant foods have different phytochemicals," he said. "These substances go to different organs, tissues and cells, where they perform different functions. What our body needs to ward off disease is this synergistic effect - this teamwork - that is
produced by eating a wide variety of plant foods, including whole grains."

**Lignans protect against heart disease**
One type of phytonutrient especially abundant in whole grains including brown rice are plant lignans, which are converted by friendly flora in our intestines into mammalian lignans, including one called enterolactone that is thought to protect against breast and other hormone-dependent cancers as well as heart disease. In addition to whole grains, nuts, seeds and berries are rich sources of plant lignans, and vegetables, fruits, and beverages such as coffee, tea and wine also contain some. When blood levels of enterolactone were measured in over 850 postmenopausal women in a Danish study published in the Journal of Nutrition, women eating the most whole grains were found to have significantly higher blood levels of this protective lignan (Johnsen, 2004). Women who ate more cabbage and leafy vegetables also had higher enterolactone levels.

**Effects of fiber against breast cancer**
Diet rich in fiber from whole grains, such as brown rice, and fruit offered significant protection against breast cancer for pre-menopausal women in 35,972 participants in the UK (Cade JE, Burley VJ, et al., International Journal of Epidemiology, 2007). Pre-menopausal women eating the most fiber (>30 grams daily) more than halved their risk of developing breast cancer, enjoying a 52% lower risk of breast cancer compared to women whose diets supplied the least fiber (<20 grams/day). Fiber supplied by whole grains offered the most protection. Pre-menopausal women eating the most whole grain fiber (at least 13 g/day) had a 41% reduced risk of breast cancer, compared to those with the lowest fruit fiber intake (2 g or less per day).

Fiber from fruit was also protective. Pre-menopausal women whose diets supplied the most fiber from fruit (at least 6 g/day) had a 29% reduced risk of breast cancer, compared to those with the lowest fruit fiber intake (2 g or less per day).

**Table 2: Shows the fibre contents of different grains**

<table>
<thead>
<tr>
<th>Food</th>
<th>Quantity</th>
<th>Fiber (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oatmeal</td>
<td>1 cup</td>
<td>3.98</td>
</tr>
<tr>
<td>Whole wheat bread</td>
<td>1 slice</td>
<td>2.00</td>
</tr>
<tr>
<td>Whole wheat spaghetti</td>
<td>1 cup</td>
<td>6.30</td>
</tr>
<tr>
<td>Brown rice</td>
<td>1 cup</td>
<td>5.30</td>
</tr>
<tr>
<td>Barley</td>
<td>1 cup</td>
<td>13.60</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>1 cup</td>
<td>4.54</td>
</tr>
<tr>
<td>Rye</td>
<td>1/3 cup</td>
<td>8.22</td>
</tr>
<tr>
<td>Corn</td>
<td>1 cup</td>
<td>4.60</td>
</tr>
<tr>
<td>Apple with skin</td>
<td>1 medium</td>
<td>5.00</td>
</tr>
<tr>
<td>Banana</td>
<td>1 medium</td>
<td>4.00</td>
</tr>
<tr>
<td>Blueberries</td>
<td>1 cup</td>
<td>3.92</td>
</tr>
<tr>
<td>Orange</td>
<td>1 large</td>
<td>4.42</td>
</tr>
<tr>
<td>Pear</td>
<td>1 large</td>
<td>5.02</td>
</tr>
<tr>
<td>Prunes</td>
<td>1/4 cup</td>
<td>3.02</td>
</tr>
<tr>
<td>Strawberries</td>
<td>1 cup</td>
<td>3.82</td>
</tr>
<tr>
<td>Raspberries</td>
<td>1 cup</td>
<td>8.36</td>
</tr>
</tbody>
</table>

**Table 3: Full-fat, stabilized rice bran should meet the following specifications for human food quality (by AOAC Standards):**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>Min. 16%</td>
</tr>
<tr>
<td>Protein</td>
<td>Min. 13%</td>
</tr>
<tr>
<td>Total dietary fibre</td>
<td>Min. 20%</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>Max. 9%</td>
</tr>
<tr>
<td>Ash (parboiled rice bran)</td>
<td>Max. 10%</td>
</tr>
<tr>
<td>Moisture</td>
<td>Max. 12%</td>
</tr>
<tr>
<td>FFA (in crude fat extract)</td>
<td>Max. 4%</td>
</tr>
<tr>
<td>SiO₂</td>
<td>Max. 0.1%</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>Max. 2%</td>
</tr>
</tbody>
</table>

Depending on preliminary success, longterm epidemiologic studies need to be conducted to examine the nutritional impact of rice bran and its products in malnourished children in Bangladesh.

**Effects on gallstone prevention**
Preventive effects of insoluble fiber, such as brown rice, on development of gallstones...
were reported in a study published in the American Journal of Gastroenterology.

Studying the overall fiber intake and types of fiber consumed over a 16 year period by over 69,000 women in the Nurses Health Study, researchers found that those consuming the most fiber overall (both soluble and insoluble) had a 13% lower risk of developing gallstones compared to women consuming the fewest fiber-rich foods (Tsai, 2004). Those eating the most foods rich in insoluble fiber gained even more protection against gallstones: a 17% lower risk compared to women eating the least. And the protection was dose-related: a 5-gram increase in insoluble fiber intake dropped the risk by 10%. How do foods rich in insoluble fiber help prevent gallstones? Researchers think insoluble fiber not only speeds intestinal transit time (how quickly food moves through the intestines), but reduces the secretion of bile acids (excessive amounts contribute to gallstone formation), increases insulin sensitivity and lowers triglycerides (blood fats). Abundant not just in brown rice but all whole grains, insoluble fiber is also found in nuts and the edible skin of fruits and vegetables including tomatoes, cucumbers, many squash, apples, berries, and pears. In addition, beans provide insoluble as well as soluble fiber.

**Protection against childhood asthma**

According to the American Lung Association, almost 20 million Americans suffer from asthma, which is reported to be responsible for over 14 million lost school days in children, and an annual economic cost of more than $16.1 billion. Increasing consumption of whole grains and fish could reduce the risk of childhood asthma by about 50%, suggests the International study on Allergy and Asthma in childhood (Tabak C, Wijga AH, Thorax).

The researchers, from the Dutch National Institute of Public Health and the Environment, Utrecht University, University Medical Center Groningen, used food frequency questionnaires completed by the parents of 598 Dutch children aged 8-13 years (Tabak, 2005). They assessed the children's consumption of a range of foods including fish, fruits, vegetables, dairy and whole grain products.

While no association between asthma and intake of fruits, vegetables, and dairy products was found (a result at odds with other studies that have supported a link between antioxidant intake, particularly vitamins C and E, and asthma), the children's intake of both whole grains and fish was significantly linked to incidence of wheezing and current asthma. In children with a low intake of fish and whole grains, the prevalence of wheezing was almost 20%, but was only 4.2% in children with a high intake of both foods. Low intake of fish and whole grains also correlated with a much higher incidence of current asthma (16.7%), compared to only a 2.8% incidence of current asthma among children with a high intake of both foods. After adjusting results for possible confounding factors, such as the educational level of the mother, and total energy intake, high intakes of whole grains and fish were found to be associated with a 54% and 66% reduction in the probability of being asthmatic, respectively.

The probability of having asthma with bronchial hyperresponsiveness (BHR), defined as having an increased sensitivity to factors that cause narrowing of the airways, was reduced by 72 and 88% when children had a high-intake of whole grains and fish, respectively. Lead researcher, Cora Tabak commented, "The rise in the prevalence of asthma in western societies may be related to changed dietary habits." The Standard American Diet is sorely deficient in the numerous anti-inflammatory compounds found in fish and whole grains, notably, the omega-3 fats supplied by cold water fish and the magnesium and vitamin E provided by whole grains. One caution: wheat may need to be avoided as it is a common food allergen associated with asthma.
Meta-analysis explains whole grains' health benefits

In many studies, eating whole grains, such as brown rice, has been linked to protection against atherosclerosis, ischemic stroke, diabetes, insulin resistance, obesity and premature death. A new study and accompanying editorial, published in the American Journal of Clinical Nutrition explains the likely reasons behind these findings and recommends at least 3 servings of whole grains should be eaten daily (Jensen MK, 2004). Whole grains are excellent sources of fiber. In this meta-analysis of 7 studies including more than 150,000 persons, those whose diets provided the highest dietary fiber intake had a 29% lower risk of cardiovascular disease compared to those with the lowest fiber intake. But it's not just fiber's ability to serve as a bulking agent that is responsible for its beneficial effects as a component of whole grains. Wheat bran, for example, which constitutes 15% of most whole-grain wheat kernels but is virtually non-existent in refined wheat flour, is rich in minerals, antioxidants, lignans, and other phytonutrients-as well as in fiber.

In addition to the matrix of nutrients in their dietary fibers, the whole-grain arsenal includes a wide variety of additional nutrients and phytochemicals that reduce the risk of cardiovascular disease. Compounds in whole grains that have cholesterol-lowering effects include polyunsaturated fatty acids, oligosaccharides, plant sterols and stanols and saponins. Whole grains are also important dietary sources of water-soluble, fat-soluble and insoluble antioxidants. The long list of cereal antioxidants includes vitamin E, tocotrienols, selenium, phenolic acids and phytic acid. These multifunctional antioxidants come in immediate-release to slow-release forms and thus are available throughout the gastrointestinal tract over a long period after being consumed. The high antioxidant capacity of wheat bran, for example, is 20-fold that of refined wheat flour (endosperm).

Although the role of antioxidant supplements in protecting against cardiovascular disease has been questioned, prospective population studies consistently suggest that when consumed in whole foods, antioxidants are associated with significant protection against cardiovascular disease. Because free radical damage to cholesterol appears to contribute significantly to the development of atherosclerosis, the broad range of antioxidant activities from the phytonutrients abundant in whole grains is thought to play a strong role in their cardio-protective effects. Like soybeans, whole grains are good sources of phytoestrogens, plant compounds that may affect blood cholesterol levels, blood vessel elasticity, bone metabolism and many other cellular metabolic processes. Whole grains are rich sources of lignans that are converted by the human gut to enterolactone and enterodiole. In studies of Finnish men, blood levels of enterolactone have been found to have an inverse relation not just to cardiovascular-related death, but to all causes of death, which suggests that the plant lignans in whole grains may play an important role in their protective effects.

Lower insulin levels may also contribute to the protective effects of whole grains. In many persons, the risks of atherosclerotic cardiovascular disease, diabetes and obesity are linked to insulin resistance. Higher intakes of whole grains are associated with increased sensitivity to insulin in population studies and clinical trials. Why? Because whole grains improve insulin sensitivity by lowering the glycemic index of the diet while increasing its content of fiber, magnesium, and vitamin E.

Bangladesh data

Rice production in Bangladesh has remarkably increased in recent years, mostly due to cultivation of high yielding variety of rice supplemented with irrigation, fertilization, and pest control. Current production of paddy is 40 million metric tons (MT) in Bangladesh which yields around 27 MT of white, polished rice along with 3 MT of crude rice bran. Most of the bran is not well utilized although some are used in making low quality poultry feed or fed to the

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cattle unprocessed. It is the cheapest of all grain products in Bangladesh, selling at 5-6 taka per kilogram. There is a great potential of agro-industrial development using rice bran and bran-based products. However, there is little interest and almost no activity in this potentially rewarding areas. The difficulties of using rice bran as industrial raw material is related to its short shelf life (due to fat decomposition) and the logistic problems of collecting rice bran from a large number of mills scattered all over the country. These problems can be overcome by appropriately designed technical and logistic operational procedures.

If the total amount of rice bran is used for extracting rice oil there would be 0.5 MT of edible oil produced annually to meet almost 50% of national demand in Bangladesh (12,000 MT crude oil, mostly imported palm oil and soybean oil). It is to be noted that only 150,000-200,000 MT of edible oil is produced locally in Bangladesh which meets only 10%-20% of national demand.

Table 4: Annual rice production in Bangladesh

<table>
<thead>
<tr>
<th>Rice Variety</th>
<th>2006-07 Metric Tons x 000</th>
<th>2007-08 Metric Tons x 000</th>
<th>2008-09 Metric Tons x 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aus Rice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>516</td>
<td>408</td>
<td>447</td>
</tr>
<tr>
<td>HYV</td>
<td>996</td>
<td>1099</td>
<td>1448</td>
</tr>
<tr>
<td>Total Aus</td>
<td>1512</td>
<td>1507</td>
<td>1895</td>
</tr>
<tr>
<td>Aman Rice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>2467</td>
<td>1660</td>
<td>NA</td>
</tr>
<tr>
<td>HYV</td>
<td>7867</td>
<td>7715</td>
<td>NA</td>
</tr>
<tr>
<td>Total Aman</td>
<td>10481</td>
<td>9662</td>
<td>NA</td>
</tr>
<tr>
<td>Boro Rice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>256</td>
<td>226</td>
<td>NA</td>
</tr>
<tr>
<td>HYV</td>
<td>14709</td>
<td>13984</td>
<td>NA</td>
</tr>
<tr>
<td>Hybrid</td>
<td>-</td>
<td>3552</td>
<td></td>
</tr>
<tr>
<td>Total Boro</td>
<td>14965</td>
<td>17762</td>
<td></td>
</tr>
<tr>
<td>Total Rice</td>
<td>27318</td>
<td>28931</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: Bangladesh Bureau of Statistics, Govt of Bangladesh

Table 5: Proximate composition of rice bran from parboiled rice (minicade variety) in Bangladesh

<table>
<thead>
<tr>
<th>Sample</th>
<th>Particle Size</th>
<th>Moisture%</th>
<th>Tot Ash%</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Fibre %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st polish</td>
<td>40 mesh</td>
<td>8.2</td>
<td>9.5</td>
<td>12.8</td>
<td>23.1</td>
<td>8.9</td>
</tr>
<tr>
<td>1st polish</td>
<td>60 mesh</td>
<td>10.0</td>
<td>10.3</td>
<td>13.2</td>
<td>23.6</td>
<td>8.6</td>
</tr>
<tr>
<td>1st polish</td>
<td>80 mesh</td>
<td>8.2</td>
<td>10.5</td>
<td>13.1</td>
<td>24.2</td>
<td>8.8</td>
</tr>
<tr>
<td>2nd polish</td>
<td>40 mesh</td>
<td>7.7</td>
<td>10.0</td>
<td>13.1</td>
<td>26.3</td>
<td>8.9</td>
</tr>
<tr>
<td>2nd polish</td>
<td>60 mesh</td>
<td>6.6</td>
<td>10.6</td>
<td>12.6</td>
<td>26.7</td>
<td>--</td>
</tr>
<tr>
<td>2nd polish</td>
<td>80 mesh</td>
<td>6.2</td>
<td>10.4</td>
<td>13.3</td>
<td>26.5</td>
<td>9.49</td>
</tr>
<tr>
<td>3rd polish*</td>
<td>Total</td>
<td>6.9</td>
<td>9.8</td>
<td>12.6</td>
<td>26.7</td>
<td>--</td>
</tr>
<tr>
<td>Silky polish*</td>
<td>Total</td>
<td>8.5</td>
<td>7.3</td>
<td>13.8</td>
<td>22.5</td>
<td>2.8</td>
</tr>
</tbody>
</table>

* These samples are too fatty to pass through sieve and could not be meshed.

Assayed by methods of AOAC (Association of Official Agricultural Chemists, USA

Source: Dr. Umme Ara, BCSIR Laboratory, Dhaka, Bangladesh

Storage conditions
Since brown rice contains an oil-rich germ, it is more susceptible to becoming rancid due to enzymatic conversion of its oil contents by the enzyme lipase than the white rice and therefore should be stored in the refrigerator. Stored in an airtight container, brown rice will keep fresh for about six months.

While white rice varieties should also be stored in an airtight container, they can be kept in a cool, dry place rather than the refrigerator. Stored properly, they will keep fresh for about one year. The storage of cooked rice is controversial. Most organizations commend 4-7 days of storage in the refrigerator at most. From all of the available evidence, however, and to err on the safe side, we believe it’s best to cook only the amount of rice one can consume during the day it is cooked, or at most, the following day. Several potential toxins can be produced in rice under certain conditions involving time, temperature, presence of moisture, bacterial spores, or fungi. It appears that some fungi can turn one of the amino acids (tryptophan) in rice into alpha-picolinic acid, and that this substance, when excessive, can
cause hypersensitivity reactions to rice in some persons. Another mycotoxin (fungus-triggered toxin) called T-2 can also be produced in rice by the fungus fusarium. About 300 mycotoxins are commonly found in many grains, not only rice, when these grains are allowed to become moldy. All of the research we've see on these potential toxins involves cultivation and harvesting of rice at the agricultural level rather than cooking and storage of rice at home.

**Stability of rice bran and brown rice in Bangladesh**

One of the important problem of storing brown rice or rice bran was associated with their rapid deterioration due to hydrolysis of bran oil by the enzyme lipase forming free fatty acids (FFA). Oxidation of rice bran fat also occurs after milling and prolonged storage, specially in moist conditions. Most rice millers in Bangladesh is unable to store their bran products and brown rice more than 18 months because of development of hydrolytic rancidity. With technological advancement the problem of fat decomposition has been largely overcome by destroying lipase activity either by application of heat or chemical treatment.

Fortunately, for Bangladesh these problems can be of limited concern cause long term storage is not needed for commercial marketing; almost all of the season's harvested is usually consumed before the next crop of the season comes to the market (usually within 3 months). Moreover, almost all rice grain consumed by the people of Bangladesh are parboiled, i.e., boiled before milling. This process effectively destroys most of the lipase contents of the grain thus extending its self-life during storage.

**Rationale and expected benefits**

Rice bran is widespread and affordable - this makes a powerful value proposition for bolstering scientific, humanitarian, and business opportunities for its supply and use in promoting human health. Therefore, with proper treatment of rice bran for human consumption, significant reduction in prevailing malnutrition can be accomplished through the use this simple, low-cost, culture-friendly local products.

**Recommendations and conclusion**

*Need for Basic Research:* Rice bran available in Bangladesh need to be characterized in the laboratory determining its macronutrient contents and physicochemical properties by proximate analysis. Attempts should be made to develop a useful and simple method of stabilizing rice from the damaging effects of hydrolytic rancidity; simple heating or boiling could be an important tool to accomplish this goal. Effects of cooking, storage, palatability, and digestibility of rice bran and its products also need to be determined by conducting appropriate studies.

*Product formulation by local industries:* Rice bran itself or a modification of it can be used to formulate confectionery products (cookies/biscuits/cakes) for feeding malnourished children through school feeding programmes in Bangladesh. Different preparations can be developed using different percentages of stabilized rice bran to establish a definite, acceptable, and useful recipe/formulation for this purpose by conducting trial feeding studies in children.

These products should be acceptable to and consumed by the local population depending on their food habit and preferences. These could be manufactured locally and marketed through the government, NGO or international donor agencies for supplying to the school feeding programmes. Leptogenic studies also need to be conducted.

**References**