# LOUISIANA AGRICULTURE

THE MAGAZINE OF THE LOUISIANA AGRICULTURAL EXPERIMENT STATION

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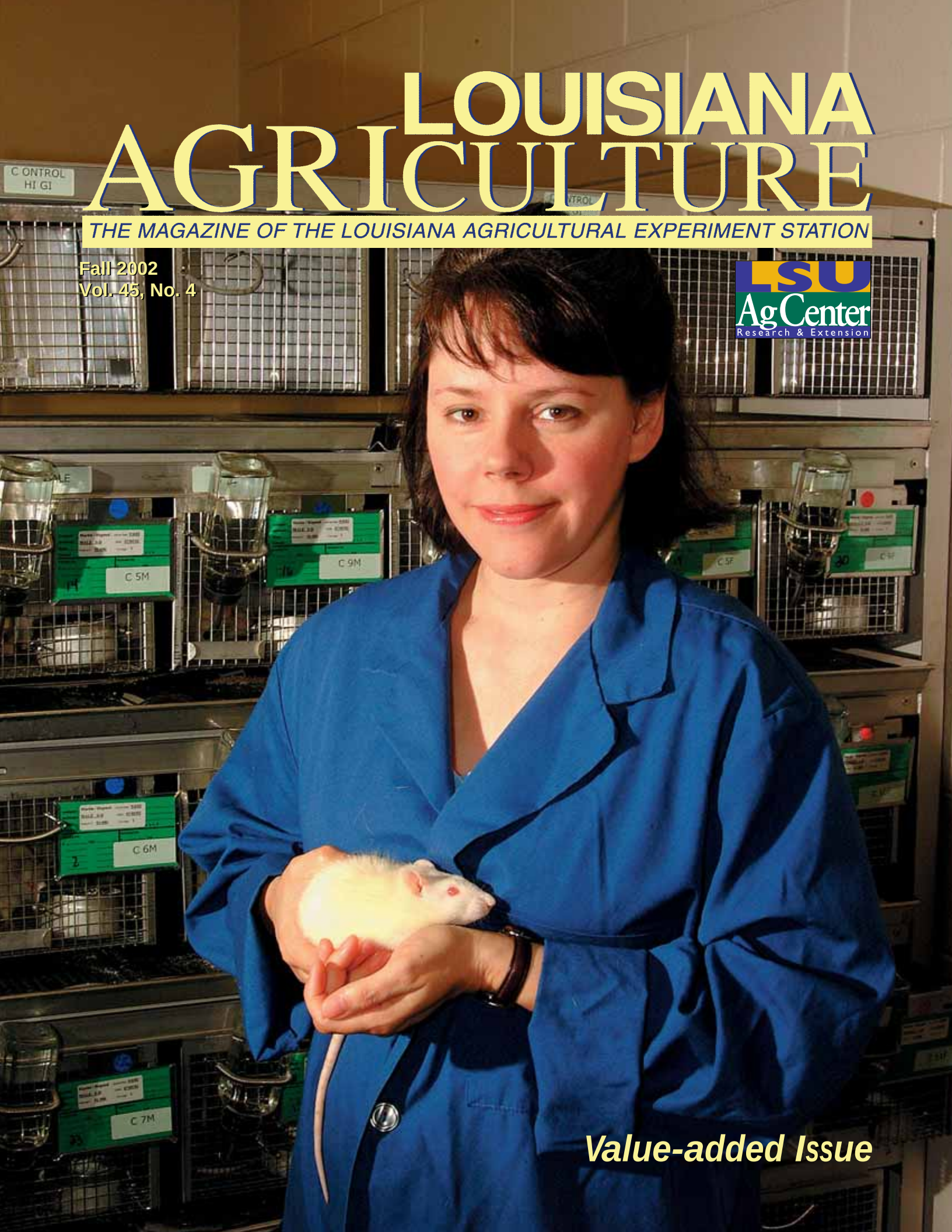


*Value-added Issue*

**ON THE COVER**

*Mary May, a 2002 LSU graduate, wrote her senior honors thesis on her research on the role that soy protein can play in reducing bone loss in rats. Her thesis won the award for best thesis in science. Her adviser was Maren Hegsted, an LSU AgCenter researcher and the author of an article that describes this research on page 6. May is continuing her nutrition studies at LSU as a graduate student. Photo by John Wozniak.*

# New food that's functional

Just as Popeye's spinach gave him extra power, today's "functional foods" can give us a boost for disease prevention.

Functional foods are those in which some ingredient has been added or modification has occurred that provides health benefits beyond basic nutrition, such as a bread spread that lowers cholesterol.

Creation of a functional food requires intensive research. And LSU AgCenter researchers are right in the middle of it. They are looking at the roles that various food components play in disease prevention as well as how to extract these components and incorporate them into foods we would find acceptable to eat.

Jack Losso, for example, is studying lutein and the possibility of adding it to grits. Lutein can help prevent cataracts, glaucoma and irreversible blindness in diabetic patients.

High amounts of lutein occur naturally in kale. But there is not enough kale in the world to help the population who can benefit from increased lutein in their diets.

Lutein is also in corn but not in sufficient quantities for us to get enough just by eating it. However, during the processing of corn byproducts, lutein can be extracted and added to other foods, thereby bringing more value to that corn crop.

And that's another benefit of this relatively new phenomenon of functional foods' creation. It offers more ways to use Louisiana agricultural commodities, including waste products.

For example, Joan King is investigating resistant starch, which can be extracted from rice, even the broken kernels that have little value in the marketplace.

Resistant starch is in high demand as a functional food ingredient because it acts like soluble fiber in our digestive system and can reduce the risk of colon cancer and help us lose weight.

Other functional food ingredients being studied include protamine, which can be extracted from seafood waste. Protamine has been shown to inhibit the growth of salmonella, *E. coli* and listeria in foods.

Some of the functional foods in the market include Benecol, which is a spread similar to margarine but with the ability to lower our cholesterol levels, and Silk, which is a milk-like product that incorporates the health-giving properties of soy protein.

Down the road functional foods mean more money in the pockets of Louisiana agricultural producers and more business opportunities for food processing. ■ **Linda Foster Benedict**

*Assuring Our Future Through Scientific Research*

LOUISIANA AGRICULTURE
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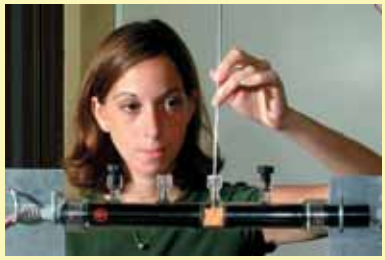

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# LOUISIANA AGRICULTURE

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# Value-added Products Provide Broader Base for State's Economy

**Leo J. Guedry**

Value-added industries and activities are fundamental to agriculture's viability, stability and contribution to economic development of the state. In general, value-added means any activity or process that increases the market value or utility of a product to consumers. In 2001, the value-added activities in Louisiana associated with selected agricultural products for which data are maintained was $3.9 billion and the level of farm income for these products that year was also $3.9 billion. That is, for every dollar of farm income last year, an additional dollar of value-added activity occurred in the state. Over the last five years, the value-added activities have averaged about $4.8 billion, while farm income averaged $4 billion. Agricultural production is what gives rise to the value-added component of the agricultural sector, and this component contributes significantly to the state's economy.

*Vision 2020*, a document developed by Gov. Mike Foster's administration outlines a plan for economic development in Louisiana focusing on the use of industry clusters. These clusters include groups of businesses that complement, compete and have similar needs for technology, human resources and infrastructure. Two sets of clusters have been identified, traditional and seed. Traditional clusters are based on existing industries and represent the state's industrial core. They include shipbuilding; oil and gas; petrochemical; tourism; transportation; health care; agriculture and food products; wood, lumber and paper; and entertainment. Seed clusters have a strong foundation in university-based research and are expected to serve as engines of growth to transform the traditional clusters. The identified seed clusters include environmental technologies, food technologies, advanced materials technologies, medical and biomedical technologies, microsystems technologies and information technologies. Three clusters are directly related to value-added research and extension programs of the LSU AgCenter. They are 1) agriculture and food products, 2) wood, lumber and paper and 3) food technologies. Particularly critical to the success of the latter cluster is university-developed technology expected to serve as the engine for innovation.

Value-added also represents a major component of the delivery system for newly developed products emerging from research. Given the investment involved in bringing new technologies to the consumer, most companies are looking for exclusive licenses before committing to the production of new and improved products. Therefore, a role for value-added industries in the state is to ensure that new technologies and products are accessible to the end user.

A more subtle value-added activity that the LSU AgCenter is involved in is the maintenance of a coastal wetland area through the management of a watershed which results in the maintenance of an estuary. The value-added as a result of this activity is not as easily defined in terms of monetary or market value but is more appropriate when viewed from the foregone loss that might have occurred. The point is that while value-added takes on specific meaning in the market, there are numerous research and extension programs that would fall into the category of value-added activities where value is something other than market determined.

The most recognized use of the value-added term relates to the enhancement of the value of products. Why these activities are important to producers and consumers alike is at least partially due to the incidence of economic activity. For any given product, the more of the processing, packaging and distribution functions occurring within a state, the greater the level of economic activity and job creation. Economic activity and job creation lead to the ripple effects of new or additional sales leading to enhanced incomes, increased tax base, community services and standard of living. ■

Photo by John Wozniak

*Leo J. Guedry*

***Leo J. Guedry, Executive Vice Chancellor, LSU AgCenter, Baton Rouge, La.***

# Value-added from Agricultural and Aquacultural Byproducts and Wastes

**Witoon Prinyawiwatkul and Michael Moody**

The term "value-added" broadly means "adding value to a product." For food items, adding value implies a degree of innovation that makes a product more desirable to consumers, perhaps in terms of shelf stability, improved functionality, better color, texture, flavor and more convenience. Adding value to agricultural and aquacultural byproducts or wastes, however, implies "total resource use," meaning that the byproducts or wastes are used as raw materials subjected to further processing into edible food items or functional ingredients. For value-added forestry or wood products, they are commonly thought of as being high-value products such as furniture, flooring or specialized paneling. Value, however, can be added to wood and wood products at various levels during processing. Development of more durable termite- and decay-resistant engineered wood products is an example.

Louisiana has several high-value agricultural, fishery and aquacultural commodities including crawfish, catfish, soybeans and rice that lend themselves to further processing and development of value-added industries. The dollar value for value-added for animal, fisheries, wildlife and plant commodities in 2001 was $3,853,788,970 compared to the gross farm income of $3,901,187,329. Louisiana may not be highly competitive in the high-technology industries, but we can compete in high-value and value-added agricultural production and processing.

Seafood and aquaculture production has a potential to offer an immediate payoff and has a potential to become Louisiana's highest dollar impact in the animal commodities; however, the problem is disposal of processing wastes, which remains a huge problem for the processors. Additional cost on top of further processing is from disposal of processing byproducts and wastes. Louisiana seafood processors generate millions of pounds of wastes. It is no longer practical to discard byproducts and wastes, especially when a significant amount of valuable raw materials can be recovered and used to produce value-added new products and functional ingredients. The magnitude of raw material for value-added products in Louisiana suggests a strong economic potential with major impact on the Louisiana seafood and aquaculture industries.

The outlook for more innovative and effective processing technology for byproduct recovery is promising. Value-added new product development using processing byproducts can convert an often negative or low-value byproduct into a product capable of covering the original processing and disposal costs, reducing the environmental damage and perhaps expanding the world's food supply. Research on value-added is critical and challenging. In the long run, adding values to byproducts and processing wastes will affect the growth and economy of Louisiana tremendously.

This issue of *Louisiana Agriculture* provides a snapshot of research efforts under way in the LSU AgCenter to add value to agricultural and aquacultural byproducts and processing wastes. These include a concept of product development process of value-added products from processing wastes, the new value-added food processing tool, development of value-added from agricultural, seafood and aquacultural processing wastes, novel white beef products from undesirable cuts, development of valuable functional and health-promoting ingredients (chitosan, lutein, oryzanol from rice bran and beta-carotene), value-added forestry products and bioconversion of processing wastes from sugar industry. ■

Photos by John Wozniak

*Witoon Prinyawiwatkul*

*Michael Moody*

***Witoon Prinyawiwatkul, Associate Professor, and Michael Moody, Professor and Head, both with the Department of Food Science, LSU AgCenter, Baton Rouge, La.***

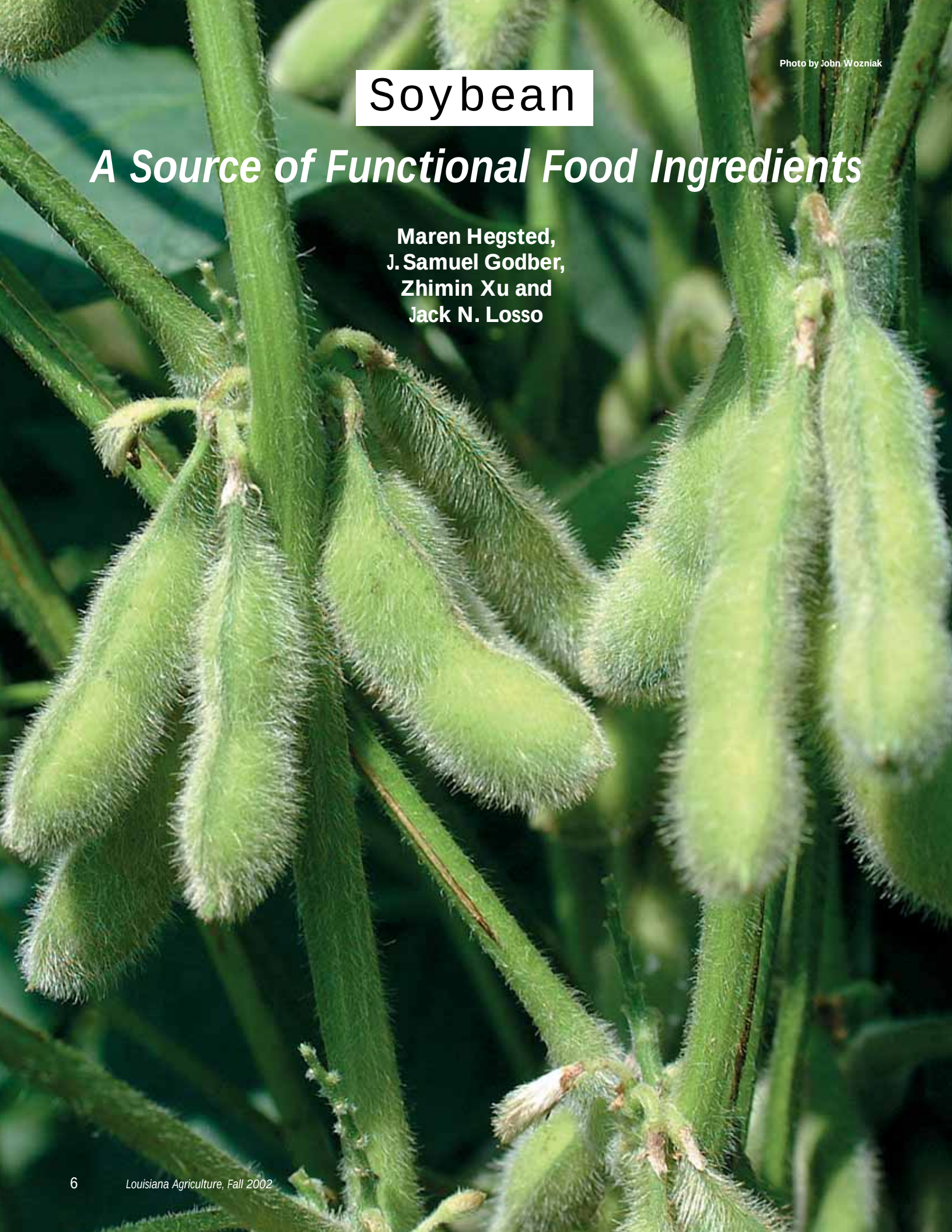

Photo by John Wozniak

# Soybean

# *A Source of Functional Food Ingredients*

**Maren Hegsted,
J. Samuel Godber,
Zhimin Xu and
Jack N. Losso**

Soy flour and more highly purified soy proteins contain a number of constituents that can be used in combating a variety of diseases. Soy isoflavones may prevent diseases associated with post-menopausal women such as osteoporosis and coronary heart disease. A peptide found in soy flour is a potential anti-carcinogen. LSU AgCenter research has been directed at extraction, purification, stability testing and functional activity of these compounds.

Soybeans have been a major food source in Asian cuisines for centuries. Soybean cultivation as a crop began in northern China more than 5,000 years ago and slowly spread into southern China, Korea, Japan and Southeast Asia. Early Chinese writings by the Emperor Sheng-Nung in 2838 BC include a description of soybeans as one of the five sacred crops along with rice, wheat, barley and millet. Later poets celebrated the benefits of soybeans and their service to humanity in China. Soybeans were processed into many food items such as tofu, miso, tempeh and soy sauce, which were part of the daily diet. Fermented soy products were used medicinally in many parts of Asia, and moldy soybean curds have been used for more than 3,000 years to treat skin infections.

Today, soybean consumption is still much higher in Asian countries than in the United States. Because lower rates of heart disease, some cancers and osteoporosis are associated with higher intakes of soy products, scientists have started to examine soy as a functional food. The relationship between soy intake and heart disease was the first focus of research because heart disease rates are much lower in soy-consuming countries. Because of evidence supporting the benefits of soy in lowering cholesterol, the Food and Drug Administration has approved a nutrition health claim on soy-containing food products stating that "foods rich in soy protein as part of a low-fat diet may help reduce the risk of heart disease."

## Isoflavones

Soy contains many phytochemicals, and scientists are just now identifying the roles they may play in human health. Among these phytochemicals are the isoflavones—genistein, daidzein and glycitein—which may act as estrogen analogs in the body, affecting cells that contain estrogen receptors. LSU AgCenter researchers are studying the purification and characterization of soy isoflavones.

The chemical structural differences of soy isoflavones may result in variable bioavailability in biological systems. The structures of soy isoflavones are not consistent during routine food processing. Factors induced in the food processing, such as enzymes in raw soy flour, heating and additives, can affect the stability of soy isoflavones. The isoflavones genistein, daidzein and glycitein, as found in soy foods, are usually bound to a glucose molecule forming the glucosides—genistin, daidzin and glycitin. In LSU AgCenter research, high purity genistin, daidzin and glycitin were prepared from soy flour and observed for their stability during heating. The results are useful in understanding the thermal stability of soy isoflavones. Overall, the stability of daidzein was found to be higher than that of glycitein or genistein.

Many reports have indicated that soy isoflavones lower plasma cholesterol and may reduce the risk of cancer. The detailed mechanism for this capability is not fully understood. Oxidation products of cholesterol are harmful to many cells in the vascular system, which contribute to plaque formation and cancers. Because soy isoflavones contain phenolic groups, they may possess antioxidation properties that offer protection against oxidation of cholesterol and oxidative damage to blood vessel cells. In LSU AgCenter research, both genistein and daidzein demonstrated significant antioxidant activity in the inhibition of cholesterol oxidation. Since soy contains both genistein and daidzein, the combined antioxidant benefits of both isoflavones could be important in reducing oxidative damage to body tissues.

## Bowman-Birk inhibitor

Another health benefit of soy intake may be through inhibition of angiogenesis by a peptide found in many soy products, referred to as Bowman-Birk inhibitor (BBI). Angiogenesis is the formation of new blood vessels to supply blood and nutrients and to remove metabolic wastes from living tissue. Physiologic angiogenesis is a tightly regulated process important to embryonic development, reproduction and wound healing. Pathologic angiogenesis is a feature of many inflammatory diseases and contributes to the spread of several chronic diseases and may involve excessive or inadequate angiogenesis. Prevention of excessive angiogenesis involves using drugs that inhibit the enzymes required for new blood vessel formation. Stimulation of new blood vessel growth with growth factors is being considered for therapeutic treatment of insufficient angiogenesis for patients with poor wound healing of skin ulcers.

Data from animal models and cell culture show that angiogenesis can be

# Functional Foods

**The functional food area is the largest and fastest growing segment of the food industry, with a market estimated at $29 billion a year in the United States alone. Functional food ingredients are naturally occurring bioactive compounds isolated from plant sources, dairy products, animal byproducts, fishery waste and aquatic resources that may enhance health by providing a physiological benefit beyond the provision of the basic nutrients in the food.**

**The proliferation of functional foods has developed from the critical link between diet and optimal health, increased consumer demand from aging baby boomers for healthy food products to augment a healthy lifestyle, the staggering health care costs driven in part by diet-related diseases, and advances in food research and market opportunities.**

***Maren Hegsted, Professor, School of Human Ecology; J. Samuel Godber, Professor; Zhimin Xu, Postdoctoral Researcher; and Jack N. Losso, Assistant Professor, Department of Food Science, LSU AgCenter, Baton Rouge, La.***

inhibited by naturally occurring physiologically active compounds, such as BBI. BBI is stable to gastrointestinal digestion and maintains biological activity even after boiling for 10 minutes. BBI is used in the soybean as a defense mechanism against insects, predators and bacterial and viral infections. BBI is a natural inhibitor of several metalloprotease enzymes that lead to the onset and progression of angiogenesis and diseases related to excess production of new blood vessels.

LSU AgCenter research has shown that BBI at concentrations found in a cup of soymilk can completely prevent the activation of metalloproteinases by binding to the enzymes. These enzymes can be maintained in an inactive form by the presence of low concentrations of BBI. The prevention of metalloproteinase activation preserves the integrity of the basal membrane and other tissues and may delay the onset and progression of diabetes complications, periodontal diseases, cancer, arthritis, osteoporosis, psoriasis and AIDS complications. Because treatments for many of these conditions may be costly and ineffective, good nutrition may be the key to prevention. Two advantages for promoting BBI as an inhibitor of angiogenesis are 1) BBI is not perceived as a medicine and has no known side effects in Asian populations who have consumed soy products for generations and appear to have low rates of chronic diseases and 2) food fortification with soybean BBI would be a relatively inexpensive way to deliver BBI over a lifespan.

BBI is a protein with health-enhancing properties that encompass a wide range of human ailments. Consumption of soymilk by the general population may provide health benefits in the intestinal tract and should be encouraged. A cup of soymilk a day may help keep the doctor away.

## Soy and osteoporosis

The incidence of osteoporosis in this country is increasing as the population ages, leading to more hip fractures, pain, disability and death. One commonly recommended treatment is hormone replacement therapy for women at menopause. However, many women choose not to use hormone replacement because of the potential for side effects such as increased risk for breast cancer and leg thrombosis. Asian populations with a high soy intake have a substantially lower incidence of osteoporosis, suggesting that increasing our soy intake may be a beneficial alternative to hormone replacement therapy. Soy isoflavones are phytoestrogens and may bind to estrogen receptors to maintain bone integrity after menopause without the detrimental side effects seen with hormone replacement treatments. Ovariectomized rats are being used as a model for postmenopausal women to study the potential of soy protein for maintaining bone mineral.

Several studies in the LSU AgCenter's School of Human Ecology have confirmed that soy protein containing natural soy isoflavones can reduce the vertebral bone loss that normally occurs in ovariectomized rats. This research has shown that the protective effect of soy is dose responsive to the level of soy protein in the diet and is most beneficial when soy is part of a low-fat diet. In the most recent soy study, ovariectomized rats were fed a low-fat diet with 5 percent, 10 percent or 15 percent soy protein and compared to casein-fed rats with and without ovariectomy. The density of the vertebrae was measured at the end of the study. The benefits of soy protein on vertebral bone density were clearly seen in 10 percent and 15 percent soy fed rats. As the level of soy protein increased in the diets from 5 percent to 10 percent to 15 percent, the vertebral bone mineral density increased by 3 percent, 15 percent and 18 percent respectively, when compared to the ovariectomized control rats. This confirms the benefits of soy in reducing bone loss and osteoporosis.

In summary, soybeans are a powerful functional food that contains phytochemicals that can reduce the risk of chronic diseases. Work at the LSU AgCenter has focused on purifying and describing the characteristics of the active components of soybeans that can benefit health. Researchers are continuing to study soy products and the isolation of active components that can benefit all of us. Throughout history, people living in Asia have relied heavily on soybean products to prevent or fight disease. It is time for the western world to learn how to use soybeans effectively in our diets to maintain a healthier life. ■

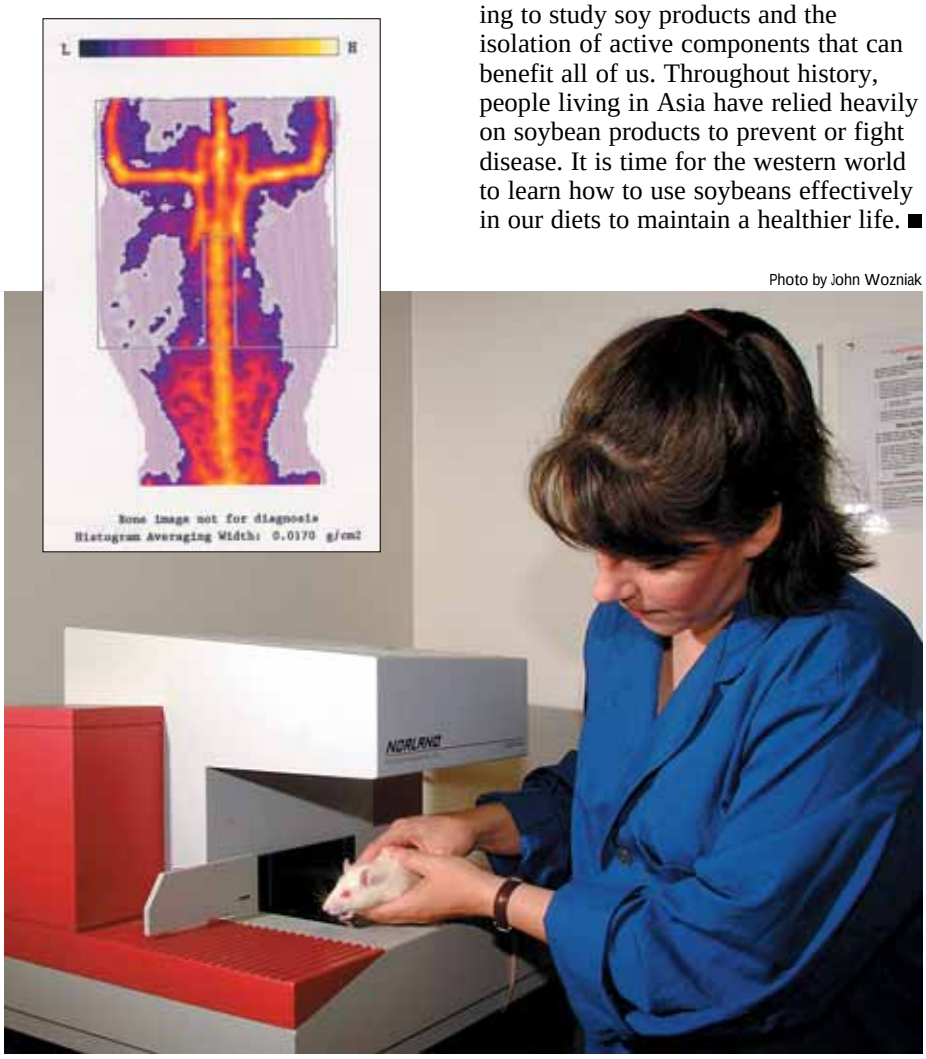


Photo by John Wozniak

*Several LSU AgCenter studies have confirmed that soy protein can reduce the vertebral bone loss that normally occurs in ovariectomized rats. The diagram shows an image of bone mass. The student researcher is Mary May.*

Photo by John Wozniak

*Zhimin Xu uses a high performance liquid chromatograph for analyzing components of rice bran oil including oryzanol, which has been of particular interest in functional food development.*

# Rice Bran and Rice Bran Oil *In Functional Foods Development*

**J. Samuel Godber, Zhimin Xu, Maren Hegsted and Terry Walker**

Rice bran and its oil contain large concentrations of several compounds that could potentially prevent chronic diseases such as coronary heart disease and cancer. The LSU AgCenter has been actively engaged in identifying, extracting, purifying and evaluating the functionality of several of these compounds. The focus has been on vitamin E, especially the tocotrienols, and oryzanol, which contains a high proportion of phytosterols. Recent efforts have included an evaluation of the potential of supercritical carbon dioxide as a more appropriate extraction medium, use of cell culture to evaluate cellular antioxidant activity, and an evaluation of the potential of oryzanol to reduce bone loss in rats whose ovaries had been removed as a model of postmenopausal women.

Functional foods are defined as foods, or food components, that provide health benefits beyond their nutritional value. Functional foods may reduce chronic diseases such as coronary heart disease or cancer. One of the most well-recognized functional foods is garlic, which has been found to reduce serum cholesterol and possibly prevent certain types of cancer. Oat bran, soy protein and red wine are also viewed as functional foods, to name just a few. For several years, ongoing research in the LSU AgCenter has focused on rice bran as a potential human food ingredient.

## Rice bran and antioxidants

Our initial studies with rice bran focused on stabilizing it against lipid degradation that leads to flavor problems. During these studies, we realized rice bran had high levels of both tocopherols and tocotrienols, which comprise vitamin E and act as antioxidants in our body, and also had high levels of a mixture of compounds

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referred to collectively as oryzanol. Oryzanol components are complex compounds that can act as an antioxidant and can improve solubility in cell membranes and potentially lower cholesterol by competitive inhibition of absorption and synthesis. Our recent efforts have focused on recovery of these compounds from rice bran, especially oryzanol.

Conditions were optimized for the extraction of oryzanol using a process called supercritical fluid extraction (SFE) with carbon dioxide as an extraction solvent. This state-of-the-art extraction process has been suggested as a means to obtain high-value functional components from low-value agricultural byproducts such as rice bran. We demonstrated the viability of this approach because we were able to obtain a highly concentrated extract of oryzanol. We now have a pilot scale extractor that will allow us to scale up the extraction process to demonstrate the commercial potential of this approach.

To evaluate individual components of the oryzanol mixture, we employed a sophisticated separation process using a preparative scale chromatograph. We were able to purify the three major fractions of oryzanol: cycloartenyl ferulate, 24-methylene cycloartanyl ferulate and campesteryl ferulate. Separation conditions were developed that would permit economical purification of these three components.

## Rice bran components reduce cholesterol oxidation

The possibility that rice bran components could reduce the effects of oxidation both in food and in our bodies is one of the most exciting aspects of rice bran as a functional food. The causes associated with almost all chronic disease can be traced to the effects of oxidants, both in the environment, including food, and in our bodies. Cholesterol oxidation products have been suggested as a major cause of heart disease. The antioxidant activities of four of the vitamin E and three oryzanol components purified from rice bran were investigated in a chemical model of cholesterol oxidation. All components exhibited significant antioxidant activity in the inhibition of cholesterol oxidation. All three oryzanol components were higher than any of the four vitamin E components.

A second approach to the potential effect of these components on oxidation and cholesterol dynamics has been initiated using cell culture techniques. Cell membrane integrity of living cells was used to test the protective effect of oryzanol compared with the vitamin E component alpha-tocopherol against an oxidizing agent. Oryzanol was found to maintain greater cell survival than alpha-tocopherol, and both were considerably higher than the untreated control.

Photo by John Wozniak

## Rice bran and osteoporosis

Osteoporosis affects more than 20 million older Americans, with the number increasing every year. This bone loss can be greatly reduced with hormone replacement therapy for postmenopausal women. Unfortunately, many women do not to use hormones because of side effects such as increased risk for cancer. This has led to great interest in identifying functional foods that can reduce bone loss naturally.

Ovariectomized rats are used as a model for postmenopausal osteoporosis and typically lose substantial bone mineral density after an ovariectomy. The addition of a 7 percent oryzanol rice bran oil concentrate to the diets of ovariectomized rats was slightly protective in reducing bone loss at several bone sites. This protective effect was strongest for the tibia, where the bone density was 5 percent greater for rats fed rice bran oil concentrate than the control rats. The beneficial effect of the rice bran oil concentrate appeared to be primarily on cortical bone in the long bones, not on the trabecular bone in vertebra. Crystalline oryzanol and crystalline oryzanol dissolved in corn oil had no effect on bone mineral density. This suggests that either the oryzanol as it occurs naturally in rice bran oil is more biologically active than crystalline oryzanol or that something else in the rice bran oil is affecting bone density positively.

## Rice bran as a functional food

Rice bran and its oil may be among the most important sources of functional food components available in the world today, considering rice bran's vast worldwide production and the fact that it is poorly used for human food consumption. Our efforts are revealing potential functional applications for rice bran in human foods. The importance of these efforts is becoming more critical because of the introduction to U.S. markets of margarine and other products, such as Benecol, containing compounds reputed to lower serum cholesterol that are similar to the oryzanol components under study. Thus, the establishment of the therapeutic potential for specific oryzanol components could lend credence to similar applications with rice bran oil or concentrates.

The potential role of rice bran components in bone health is a critical area of research and expands our potential for reducing osteoporosis with functional foods. More study is needed to identify the active elements in rice bran oil beneficial in reducing bone loss and determine their mode of action. The rice bran oil concentrate appears to act primarily on preserving the slow turnover cortical bone in the long bones. Other functional foods such as soy protein act on the rapid turnover trabecular bone in vertebrae. This leads to the possibility that the two in combination could provide even greater bone benefits in preserving both cortical and trabecular bone in the elderly to reduce osteoporotic fractures. ■

# Protamine and Collagen

# *Two Value-added Products from Louisiana Seafood Processing Facilities*

**Jack N. Losso, Masahiro Ogawa, Michael W. Moody, Ralph J. Portier, Kenneth W. McMillin, Donal F. Day, Jon Bell and Mark Schexnayder**

The United Nations Food and Agriculture Organization has estimated that by 2025 global aquaculture will provide more than half of the world's seafood supply. Now it is about 35 percent to 40 percent. With a growing industry comes growing waste. Louisiana seafood processors alone generate millions of pounds of aquatic-based food processing waste annually. Disposal of fisheries waste in Louisiana is a huge problem. Many processing facilities have a waste load of 1 million to 2 million pounds per year. Current disposal rates in the New Orleans area are $30 per ton, and a large plant may spend $2,000 to $3,000 per month in disposal fees. Several local landfills have already refused fisheries wastes because of the nitrogenous runoff that may be produced and the contamination of their truck weighing scales.

One traditional use of seafood waste has been low-value feeds and fertilizers. However, there is growing interest among seafood processors to obtain higher value from byproducts such as by recovering health-enhancing products. Fish byproducts include fish frames (bones), viscera, skin, roe, eyes, head and testes. Fishery waste is a mixture of many biologically active components that can be extracted to isolate different compounds. Functional foods, biochemicals and pharmaceuticals can be refined and used as anti-inflammatory agents, antimicrobials, antioxidants, enzymes, proteins, nucleic acids, calcium, oil, enzyme inhibitors, colors, pigments, dyes and caviar.

Researchers at the LSU AgCenter are developing commercially viable recovery methodologies for bioactive compounds such as protamine and collagen from Louisiana seafood waste products. The development of a biochemical industry that will help solve the waste disposal problem associated with fishery byproducts and generate more profit for seafood processors requires a scientific information base.

Photo by John Wozniak

*Many seafood processing facilities have a waste load of 1 million to 2 million pounds per year.*

## Protamine and Collagen

One of the products that can be extracted from seafood waste is protamine, a small cationic peptide that shows potential as an antimicrobial agent. Its antimicrobial property, stemming from its ability to create cavities in microbial cell membranes, is similar to other cationic peptides such as defensins and nisin produced by organisms as a defense against microbial invasion.

Researchers at the LSU AgCenter are developing antimicrobial systems containing protamine for use in meat products and fresh produce. Initial studies have shown that protamine inhibited salmonella, *E. coli* and listeria in soy broth. In ground beef, protamine resulted in a reduction in salmonella, and reduction was observed for *E. coli* at refrigeration temperature.

Protamine also has applications in the control of fat intake and is a potential candidate for the control of food intake in diabetes.

Another product that can be extracted from seafood waste is collagen. This product is unique among body

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proteins because it contains hydroxyproline amino acids. It is the single most important protein of connective tissue and serves as the matrix on which bone is formed. It is found in the ligaments and tendons, forms scars to hold separated tissue faces together and is the strengthening glue between the cells of artery walls that enables them to withstand the pressure of surging heartbeats. Successful medical and pharmaceutical applications of commercially available collagen include the treatment of hypertension, urinary incontinence and pain associated with osteoarthritis and inhibition of cancer spread in the body. The cosmetic industry uses collagen in personal care products. Food applications of collagen include clarification of alcoholic beverages and the preparation of gelatin. There is a large market for gelatin as an ingredient in food, pharmaceuticals, photographic and personal care products.

The predominant source material for commercially available gelatin is animal tissue (skin, bone). Use of collagen and collagen-derived products from warm-blooded animal byproducts, however, has been called into question because of concern that bovine spongiform encephalopathy ("mad cow" disease) may be transmitted to humans.

## Marine Sources of Collagen

This concern is giving rise to new markets for marine sources of collagen. Marine collagen is considered a safer alternative to bovine or porcine skin materials. No evidence suggests that viral or sub-viral particles adapted to cold-blooded organisms can be transmitted to humans. Marine gelatin and collagen, especially those from some warm-water species, have physical and chemical properties similar to the gelatin and collagen from warm-blooded animals. This is not always true for gelatin from cold-water species.

Marine products can easily be certified as a Kosher quality product because there is no mixing of porcine and bovine tissues as occurs in red meat byproduct recovery. This designation is an important marketing element to many companies using gelatin or collagen as an ingredient. A marine collagen production facility would use only a limited number of species available from local processors in one given geographical area, so the sorting of species allowed as Kosher could be easily accommodated.

Scientists at the LSU AgCenter have received funding from the National Sea Grant to prepare collagen from Louisiana seafood processing waste for pharmaceutical and food applications. Collagen has been purified from finfish skins and scales. The collagen recovered was similar to bovine and porcine collagen in physicochemical properties (molecular size, viscosity, solubility and color). The molecular size of the collagen has been determined acceptable as a food ingredient. ■

# Dried Shrimp Processing in Louisiana

Louisiana has the nation's most productive commercial shrimp fishery, landing about 100 million pounds a year with a dockside value of $150 million. White and brown shrimp make up most of Louisiana's harvest. Pink shrimp and sea bobs (small brownish shrimp, more than 100 per pound, with many antennae and a long curved and spiny head) are also caught and sold, but in much smaller quantities.

Although fresh, frozen and canned shrimp dominate the market, there is still a demand for dried shrimp. Dried shrimp is an intermediate moisture and shelf-stable product normally used as a snack or as a food ingredient and flavor enhancer in Asia, Africa, South and Central America, and in the United States, especially Louisiana, California and Hawaii. Dried shrimp are categorized by processing types into freeze-dried and sun-dried shrimp. Freeze-dried shrimp are normally sold as fish food, and sun-dried shrimp are for human consumtpion.

The shrimp drying process, using hot-air indoor dryers, is energy and time consuming and normally takes five to eight hours for dried shrimp to reach an internal water activity required for product shelf-life stability and safety. Additionally, the product may not have a uniform moisture content, which may result in poor quality and short shelf-storage life. After shelling, low-value byproducts consisting of small pieces of separated heads and shells are generally sold as byproducts.

According to our studies, drying times and temperatures and ratios of surface air/above air and drier air temperatures could be used to indirectly monitor critical limits if processors could control: (1) uniform shrimp size, (2) shrimp weight per dryer bin, (3) dryer bin size (length, width and depth), and (4) forced air temperatures and air flow rates of dryers. Finally, we evaluated changes in visual appearance and sensory characteristics of sampled shrimps during drying. Our research provides guidance on how science-based principles can be practically applied and implemented not only in Louisiana's small and less developed dried shrimp businesses but also worldwide.

Although dried shrimp has a limited market and is produced in smaller amounts than frozen shrimp products, dried shrimp processing is still a viable industry for the preservation of shrimp products in South Louisiana and represents a viable and traditional Louisiana shrimp product. Dried shrimp is still another source of revenue for Louisiana shrimp processors. The development of an effective drying process, which maintains short drying time with less energy consumption, would be economical and beneficial to producers. Moreover, the feasibility of protein recovery from boiled shrimp water and the use of dried heads and shells as a source of high quality protein, calcium and minerals for value-added human foods would make Louisiana dried shrimp processing even more cost effective. ■

***Voranuch Suvanich, former Postdoctoral Research Associate, and Michael Moody, Professor and Head, Department of Food Science, LSU AgCenter, Baton Rouge, La.***

# Lutein

# *In Corn and Sweet Potatoes*

**Jack N. Losso, Don LaBonte, J. Samuel Godber, Joan M. King and Witoon Prinyawiwatkul**

Macular (a region of the retina) degeneration is a physiological process that involves the formation of excessive new blood vessels in the retina and is the leading cause of cataract formation, glaucoma and irreversible blindness in diabetic patients and the elderly. The exact cause of age-related macular degeneration (AMD) is not yet known. There are few effective treatments, little prevention and no real cures for these debilitating conditions. Because potential cures are limited and costly, the role of nutrition in preventing these chronic diseases is receiving significant scientific scrutiny.

Lutein has been identified and recognized as one of the dietary strategies (natural sunglasses) that can delay the onset and progression of macular degeneration. The human body easily absorbs lutein and deposits it in the region of the retina called the macula and in the lens of the eye where lutein is able to filter light and prevent oxidation of proteins or lipids within the lens. Epidemiological evidence that supports the inverse relationship between lutein and AMD is consistent. Studies have shown 20 percent to 50 percent lower risk of cataract extraction in people with lutein intake. Lutein also has been shown to be inversely related to the risk of colon cancer in men and women diagnosed with the disease at a younger age. Epidemiological observations have shown that individuals with high levels of serum lutein had a significantly reduced risk of developing coronary heart disease or ischemic stroke. Lutein also binds to aflatoxin and reduces the toxicity of aflatoxin in grain crops like corn.

## Eat Green Vegetables

Lutein is an orange-colored pigment, which is highly concentrated in marigold flowers. High levels of lutein are found in kale and spinach, and low levels are found in many other green vegetables. The human body does not synthesize lutein, so it has to be absorbed from external sources. Ingested lutein deposits in the macular region, where it contributes to the density of macular pigment and may prevent macular degeneration. The denser the pigment, the more protection there is from damage caused by natural light in the blue spectrum. Lutein is more effective than other carotenoids in preventing lipid oxidation, a deteriorative process that occurs in the human serum and in the eye.

Researchers have reported that consuming 6 milligrams of lutein a day was associated with a 43 percent lower risk of macular degeneration and increasing the consumption of foods rich in certain carotenoids, in particular dark-green, leafy vegetables, may decrease the risk of developing AMD. A concentration of 6 milligrams lutein represents about 30 grams of kale or 60 grams of fresh spinach. Other foods containing smaller amounts of lutein include summer squash, green peas, corn and tomatoes.

## Potential Lutein Sources

LSU AgCenter research has focused on commodities grown in Louisiana as potential sources of lutein that could add value to Louisiana crops. Corn is an economically viable source of lutein, because during lutein isolation, other value-added products such as oil, proteins and starch can be extracted. Corn varieties are being screened for lutein content. To date three corn samples from varieties DK 697, DKC 68-70 and AP 9843 have been analyzed. More varieties are being screened.

## Grits with Lutein

Adding lutein to food is more appealing than using lutein as pills. AgCenter research has demonstrated that lutein can be added to a food product and remain stable during processing. One study involves adding lutein to corn grits and analyzing lutein content after microwave cooking the grits. Lutein was added to corn grits at concentrations reported to reduce the incidence of macular degeneration (cataract formation) by 43 percent. A lutein concentration equivalent to 6 milligrams per serving size was added to corn grits. Lutein was dissolved in ethanol or corn oil and added to corn grits in water. After microwaving the grits, the lutein remained stable.

AgCenter researchers are trying to formulate minimally processed food products that contain high levels of lutein so consumers can obtain their daily intake of lutein.

## Sweet Potatoes

AgCenter scientists in the Food Science and Horticulture departments are examining sweet potato leaves and roots as potential sources of lutein. To date, research shows that sweet potato leaves contain more lutein than sweet potato roots. Sweet potato roots are well known for their high content of beta-carotene, and this work shows additional health benefits in sweet potatoes. Bienville, a 2002 LSU AgCenter release, shows particularly high levels of lutein in comparison to other varieties. The high lutein content in sweet potato leaves offers a further possibility of value-added. Additional research is needed to understand the economic feasibility of extracting lutein from sweet potato leaves. ■

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# Resistant Starch from Rice
# *A New Source of 'Fiber'*

**Joan M. King, Maren Hegsted and Carol E. O'Neil**

Resistant starch is chemically not a fiber; however, there is an effort to have it declared so because it acts like soluble fiber in the gastrointestinal tract, thus providing the health benefits of fiber. Resistant starch and soluble fiber ferment in the small intestine—conferring their health effects. Not surprisingly, resistant starch is in high demand as a functional food ingredient. LSU AgCenter researchers are conducting a variety of studies on resistant starch, including the effect it has on properties of rice and rice flour, which will add value to this Louisiana commodity, and the effect it has on weight gain and body fat in rats, with the goal of understanding the role resistant starch plays in obesity.

Resistant starch can occur naturally in foods, including raw potatoes and bananas, or in processed foods and starches. Although some raw foods have resistant starch, cooking can destroy it, so it is important that the method used to process the starch makes it heat-stable. One way to enhance resistant starch in a food product is to heat the starch to a gel and cool it quickly. This process is called retrogradation and is what happens to bread when it cools after cooking—the process is accelerated by storing bread in the refrigerator.

Another way to increase the level of resistant starch in foods is to modify the starch by the addition of fats, which bind inside the spiral of the starch molecule to stabilize it and make it resistant to attack by enzymes. LSU AgCenter researchers are conducting studies on the use of enzymes and additives on rice flour and starch to enhance resistant starch content.

The modification of corn starch to produce functional food ingredients has resulted in driving the selling price of native corn starch from 20 cents per pound to $2.50 per pound for modified corn starch. There is a potential of a 10-fold increase in the value of rice flour, from the development of rice starch-based ingredients, such as resistant starch, through the same technology. The low protein content makes rice hypoallergenic; thus, it is often a better choice for people with allergies to wheat or other cereal grains.

Broken rice kernels, which make up 15 percent of milled rice in the United States, can be used to produce value-added food ingredients. Rice varieties that may have excellent agronomic traits but may lack acceptability by consumers because of negative cooking or other characteristics may also be used for value-added food ingredient development. This research will benefit everyone in the rice industry by providing an expanded use of rice and an increased demand for rice and rice products, as well as providing a healthy choice for consumers.

Photo by John Wozniak

Clinical health research with resistant starch is exciting because there are so many potential health benefits associated with its use. These include:

1) improved glucose regulation and better weight control,
2) reduced constipation,
3) reduced colon cancer risk,
4) and reduced blood cholesterol and triglycerides.

Resistant starch has a low glycemic index because of the slow release of glucose. This may lower the insulin response by the body after eating resistant starch, thus helping people with diabetes normalize their blood sugar. The better blood sugar levels can be controlled, the fewer the long-term complications of diabetes that may occur. The lowered insulin response may also reduce the subsequent drop in blood sugar that triggers hunger for the next meal. This could result in a lower energy intake at the following meal and better body weight regulation. In a study using rats as a model for human obesity, AgCenter researchers found that when they replaced regular starch with high amylose cornstarch (60 percent resistant starch), it reduced body fat in rapidly growing male and female rats. Blood insulin levels were also lower in the rats fed resistant starch.

Resistant starch can also help improve colon health. As resistant starch moves through the intestinal tract, it decreases constipation by increasing fecal moisture, bulk and transit time. The non-digested starch in the large intestine is fermented by bacteria producing short chain fatty acids, primarily acetate, butyrate and propionate. Butyrate is the preferred energy source for colon cells, resulting in healthier colon cells. Resistant starch encourages the growth of beneficial bacteria in the large intestine and lowers the pH of the intestinal contents, all of which may reduce the development of colon cancer. Diets high in resistant starch can reduce blood cholesterol and triglyceride levels because of higher excretion rates of cholesterol and bile acids.

Overall, increasing resistant starch content in the diet has the potential to provide several significant health benefits and add value to rice, an important Louisiana commodity. ■

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# Novel Beef Products from Undesirable Cuts

**Voranuch Suvanich, Ingrid Maciel-Pedrote and Witoon Prinyawiwatkul**

Processed beef products in the U.S. market include sausages and cured, canned, dehydrated and convenience meat items. The convenience and snack meat products make up about 2 percent of the total meat production. The demand for these items continues to increase. According the Snack Food Association, meat had the largest percentage growth in the snack food industry with an increase of 31 percent in sales between 1999 and 2000, and a projection of a profitable future.

Beef cuts from the shoulder and neck tend to be inferior in quality, to darken quickly and to cost less. The rough cuts are trimmed immediately and often sold as stew and ground meat items. These cuts can be further processed into new convenience meat products that are tasty, ready-to-eat, portable and unique in style with added value and acceptable quality. Such alternative products may potentially lead to higher revenues for Louisiana beef producers and processors.

## Crispy Beef Chips

LSU AgCenter researchers have developed two new Cajun-style crispy beef chips from beef cuts for stew (shoulder and neck). Beef cuts were trimmed to remove fat, tumbled with salt and sodium tripolyphosphate and mixed with beef plasma, sodium nitrite, dried herbs and spices. The meat was then stuffed into stainless steel cylinder molds and frozen. The frozen product was sliced thin and oven-dried. The beef chips were packed in polyethylene bags.

Two products (4 percent sugar and 6 percent sugar with spices) were mailed to 100 consumers in Louisiana for them to evaluate. Consumers rated product acceptability of appearance, color, aroma, texture and overall liking. Purchase intent was also asked.

Results indicated no differences between the two beef chips in overall liking, acceptability and purchase intent. Seventy percent of the consumers found the products acceptable, and 37 percent would purchase the products if available. Aroma and taste differentiated the two products. Appearance, color and overall liking were most critical to overall acceptance, while aroma and overall liking were most critical to purchase.

## Surimi-like Beef Products

Surimi-like beef products contain a high concentration of myofibrillar protein and form strong, elastic gels when cooked. The gel-forming property is essential for manufacturing products such as meat snacks, low-fat cold cuts, sausages and seafood analogs. Making beef surimi is challenging because the fat content from undesirable cuts (shoulder and neck) is high, and the meat has more pigment, connective tissue and collagen. However, we successfully developed a process to produce white beef (surimi-like) from ground beef. The process involves washing ground beef with iced water, draining and mixing with cryoprotectants. Yield was up to 35 percent of the original weight of ground beef, depending on the ground beef's particle size. The white beef has low fat content (1.2 percent). Whiteness of the white beef prepared using three washing cycles was not different from that of the commercial Alaska pollack surimi. The white beef exhibited desirable functionality and can potentially be used as an ingredient in various reduced-fat meat products and seafood analogs. Based on its color and textural properties, white beef can be further processed into seafood-flavored imitation products targeting consumers allergic to seafood. Because consumers are more health conscious and often associate the "red" color of meat with unhealthy consumption, white beef and its derivative products may be alternatives.

Based on its color and textural properties, white beef can be further processed into seafood-flavored imitation products targeting consumers allergic to seafood.

## New Beef Cold-cuts

LSU AgCenter researchers have developed a low-fat, colorless cold-cut. Two formulations (spicy and bland) were prepared. White beef was tempered and chopped to fine particles, and all ingredients and ice water were added. The mixture was then stuffed into casings, cooked in the smokehouse, cooled, thinly sliced and vacuum packaged.

Louisiana consumers evaluated the two cold-cut products for acceptability of sensory quality: appearance, color, flavor, texture and overall liking. They also evaluated intensity of whiteness, aroma and hickory smoke strength, saltiness, hotness, sweetness, juiciness and toughness. Purchase intent was also determined.

There were no differences in overall liking, acceptability and purchase intent between the two products. Eighty-four percent of the consumers accepted the products, and 60 percent would purchase if available. Texture, flavor and overall liking were discriminating attributes. Some consumers were concerned about the whiteness of the products. The misconception from consumers was that chemicals were used to produce the white beef cold-cut. The white beef cold-cut product has market potential. Further product optimization and a market-test study are the next steps to commercialization. ■

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***Voranuch Suvanich, Research Associate; Ingrid Maciel-Pedrote, Graduate Student; and Witoon Prinyawiwatkul, Associate Professor, Department of Food Science, LSU AgCenter, Baton Rouge, La.***

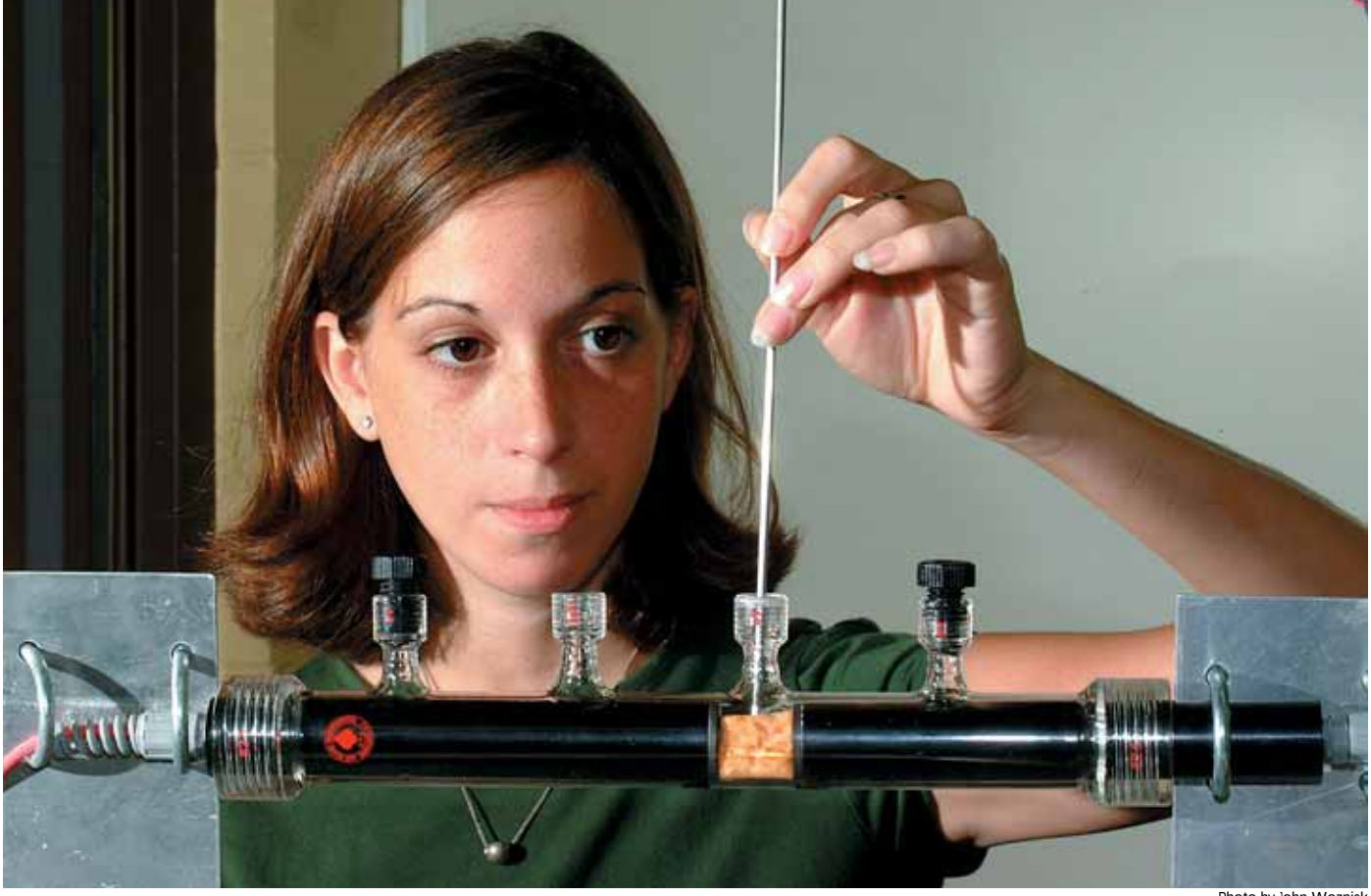


Photo by John Wozniak

*Julianne Forman, a senior in biological engineering, uses a thermocouple to check the temperature of sweet potato tissue during ohmic heating.*

# Ohmic Heating: *A Value-added Food Processing Tool*

**Marybeth Lima, Tuoxiu Zhong and N. Rao Lakkakula**

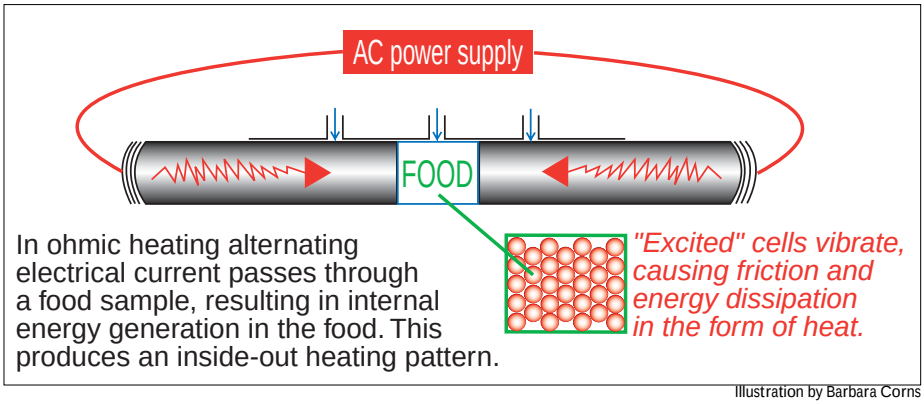
Ohmic heating is a food processing method in which an alternating electrical current is passed through a food sample. This results in internal energy generation in foods. This produces an inside-out heating pattern, which is much faster than conventional outside-in heating. Ohmic heating is somewhat similar to microwave heating but with very different frequencies. The advantage of ohmic heating is that it uniformly heats foods with different densities, such as chicken noodle soup, for example.

Ohmic heating technology has been around since the early 1900s, but it was not until the late 1980s that food processing researchers began investigating the potential of ohmic heating for food quality, and cost and energy savings in food processing.

Most initial research on ohmic heating has been conducted on heat transfer and thermal processing of food mixtures. Recently, issues involving mass transfer of components in foods during ohmic heating have been studied. Potential applications for ohmic heating include blanching, evaporation, dehydration, fermentation and extraction. LSU AgCenter researchers are investigating ways to use ohmic heating in food processing.

## Freeze-drying sweet potatoes

Sweet potato samples were ohmically heated and freeze-dried, and their freeze drying rate was measured and




In ohmic heating alternating electrical current passes through a food sample, resulting in internal energy generation in the food. This produces an inside-out heating pattern.

Illustration by Barbara Corns

***Marybeth Lima, Associate Professor; and Tuoxiu Zhong and N. Rao Lakkakula, former Graduate Students, Department of Biological and Agricultural Engineering, LSU AgCenter, Baton Rouge, La.***

compared with a control (no heating). Ohmic heating increased the rate of freeze-drying up to 25 percent, a significant time and energy savings for processing. Freeze-drying is a time- and energy-intensive process, thus any method that cuts drying time significantly is important. Additionally, freeze-drying is one step in the supercritical fluid extraction process, which shows promise as a fast, environmentally friendly way to extract beta-carotene and other high value components from sweet potato tissue.

## Extracting oil from rice bran

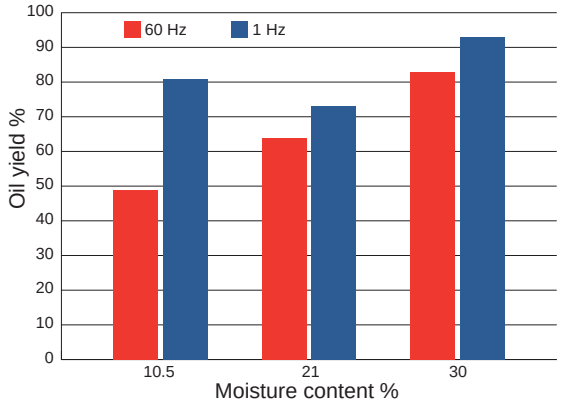
Rice bran oil can be extracted from rice bran and used as cooking oil. Although rice bran oil has outstanding nutritive, sensory and cooking characteristics, it is relatively expensive to produce. Ohmic heating could enhance the extraction of rice bran oil from rice bran, with the ultimate goal of making the production of rice bran oil economically feasible. Ohmic heating is a fast process (on the order of seconds) that enhances the extraction of apple juice from apples, sucrose from sugar beets and soy milk from soybeans. LSU AgCenter researchers conducted studies to determine if ohmic heating could enhance the extraction yield of rice bran oil from rice bran.

Rice bran was ohmically heated and the oil subsequently extracted. Ohmically heated samples yielded more total lipids from rice bran (Figure 1). Researchers also determined that lowering the frequency of alternating current during ohmic heating resulted in enhanced extraction yields.

## Ohmic heating saves time

Ohmic heating saves significant time and energy in hot air and freeze drying of foods and enhances extraction yields in some processing operations. The parameters used during ohmic heating, such as frequency of alternating current, applied voltage and the temperature to which the sample is heated, have a significant effect on its success. The electrical conductivity of the food or food mixture is a significant factor, too. Ohmic heating is a useful tool for value-added processing, and it has great potential for use in a wide variety of food processing operations involving heat and mass transfer. ■

**Figure 1. Percent oil yield as a function of moisture content and frequency of alternating current for the ohmic heating process. Adding water to the bran (10.5% bran has no moisture added) results in better ohmic heating and better oil yields. Decreasing the frequency of alternating current increases the oil yield due to electroporation, which causes the formation of small pores in the cell walls and enables oil to diffuse across the cell walls, where it is easier to extract.**




***Acknowledgments***
*Vicki Lancaster and Terry Walker contributed to this research; James Finney, Tom Bride and the late Malcolm Gaspard provided technical assistance.*

# Microbes and Food

The overwhelming majority of microbes in the world are not harmful to humans. Food processing researchers have established two kinds of microorganisms that are undesirable in food: spoilage microorganisms, which spoil the food but are not toxic to consume, and pathogenic microorganisms. Pathogens are harmful to consume, or they produce toxins that are harmful or fatal if consumed.

Researchers can identify which types of pathogenic and spoilage microorganisms are likely to be in a food based on its biological, chemical and physical properties. A processing method is then designed to ensure that these microorganisms will not grow or proliferate in the food; this can be "guaranteed" for only a certain period. For example, pasteurization is a mild to moderate heat treatment designed to kill spoilage microorganisms. The consumer has 10 to 14 days to consume milk (if refrigerated) before spoilage microorganisms or yeasts sour the milk. In most other parts of the world, milk is subjected to heavy heat treatment (sterilization) using aseptic processing. This milk lasts at least eight weeks and does not need to be refrigerated, even after being opened. Worldwide, most people drink milk warm or at room temperature. ■


***Marybeth Lima, Associate Professor, Department of Biological and Agricultural Engineering, LSU AgCenter, Baton Rouge, La.***


# A Multidisciplinary Approach to New Product Development

**R. Wes Harrison, Alvin R. Schupp and Jeffrey M. Gillespie**

In recent years, many large food and beverage companies have adopted team approaches to new product development. The approach typically involves both a marketing department and a research and development department generating product ideas, concepts and ultimately prototypes, which are subsequently tested in selected target markets. Production engineers and advertising experts are brought in later. The development process takes anywhere from 18 months to several years before a product is launched. Because of short life cycles for many products and stiff competition, the time between product conception and product launch must move as fast as possible. Many companies take an approach that uses all departmental expertise at the earliest stages of product development. This has cut the time it takes to develop and launch new products to less than one year. Food Processing magazine reports that Coors, Hershey Foods, Planters, ConAgra, Taco Bell, H.J. Heinz, General Mills and Ore-Ida all attribute the success of new product launches in the 1990s to well-organized, multifunctional product development teams.

Successful new product development involves matching buyer preferences with the desired physical and perceived attributes of products or services. This is particularly true for foods developed from processing byproducts, because traditional markets for these products do not yet exist. Subjective perceptions of a food's physical attributes, such as visual appeal, texture, aroma and taste, play a major role in consumer acceptance. Consumer perceptions also are affected by numerous socio-economic factors including cultural, social, personal and psychological attributes of the individual. The design of new foods also requires that domestic and international regulations for safe processing and handling, sanitary practices, packaging and labeling requirements be considered. Production and distribution costs and procedures must be evaluated to determine if the new products could be produced profitably in quantity. The complex task of developing these products requires a multidisciplinary team that includes food scientists and engineers, food marketing and economic specialists, and food safety specialists.

The LSU AgCenter has developed a consumer-driven, multidisciplinary approach to new product development in the agro-food industry. The framework includes these sequential steps: 1) identifying new product ideas, 2) analyzing economic and financial aspects of product ideas, 3) testing product concepts, 4) developing product prototypes, 5) conducting consumer taste tests, 6) following food safety considerations and 7) establishing production protocols (Table 1).

Four types of new product development in the food industry include extending or repositioning existing food products, reformulating or developing new forms of existing products, repackaging existing products and developing innovative value-added products. Research institutions, such as the LSU AgCenter, are well suited for this work. Examples of these products include crawfish minced meat, crawfish nuggets and crawfish sausages produced from the byproducts of traditional crawfish processing. These products are currently being developed by multidisciplinary teams from the departments of Food Science and Agricultural Economics and Agribusiness. Other potential prototypes include medicinal products and nutraceutical ingredients being developed by the LSU AgCenter's Agricultural Biotechnology Laboratory.

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## Food Product Development

A product idea can be defined as any possible product that might be offered to a particular market. This broad definition allows food product ideas to come from many sources, including food industry experts, food scientists and marketing specialists. Idea sources may include information gleaned from trade shows, research symposia, trade literature and government publications. Key industry players include managers of processing facilities, restaurant and grocery store managers, salespeople and industry consultants.

Regardless of how product ideas are generated, a method for preliminary screening of those ideas is necessary before the next stage of development can begin. Screening eliminates product ideas with low potential according to four specific criteria: marketability, technical feasibility, manufacturing feasibility and financial feasibility. For example, before the crawfish nuggets were developed and tested, numerous ideas were explored. These included crawfish stuffing, crawfish sticks and crawfish soup base. These ideas were generated and refined in discussions with food scientists and marketing specialists as well as restaurant chefs and crawfish processors.

Next, a preliminary economic analysis is needed. This involves collection and analysis of secondary data intended to determine customer trends and the potential market size and growth prospects. Market analysis provides the basis for initial screening of product ideas. The question of technical feasibility requires input from food technologists. The goal is to determine the probability that the product idea can be successfully transformed into a physical product and to estimate the time and cost required to develop the actual product. Product ideas clearing these hurdles advance to the next stage of development, which involves formation and testing of specific product concepts.

Photo by Witoon Prinyawiwatkul

*These crawfish sausages are produced from the byproducts of traditional crawfish processing.*

## Product Testing

The testing of product concepts leads to the development of prototype products by food scientists. Different ingredients, spices and cooking processes are investigated. Food scientists have developed numerous formulations for crawfish nuggets. Technical experiments are performed in LSU's Muscle Foods Laboratory to develop prototype nuggets under various processing conditions. These prototypes are then tested for sensory qualities of taste, texture, smell and appearance by consumers. Sensory analysis has been conducted on a number of products, including various formulations of minced crawfish meat. These analyses can be used to determine whether a product has acceptable sensory characteristics and how well the product compares with potential competition. Packaging prototypes may be developed for testing, too.

Once product prototypes have been tested and refined, food safety specialists provide input. The costs of developing and implementing appropriate quality control and HACCP systems must be assessed. Food engineers provide the primary input into the question of manufacturing potential. The time and cost required to manufacture the proposed product under commercial conditions is determined. The final criterion of product development is an assessment of the financial feasibility of the new products. This involves input of economists and financial experts of the team. The goal is to access the capital requirements necessary to launch the product idea commercially and to estimate the potential payoff.

**Table 1: New Food Product Development Process**

| Stage | Type of Analysis | Output |
|---|---|---|
| **1.** Product Idea Generation | Opportunities/Need for New Products & Technical Feasibility | Ideas for Product Concepts |
| **2.** Preliminary Market & Economic Study | Analysis of Markets, Prices Production Costs, Investment | List of Product Ideas with the Highest Likelihood of Success in Market |
| **3.** Testing of Remaining Product Concepts | Focus Groups & Consumer Surveys | Important Product Attributes, Hypothetical Product Designs |
| **4.** Prototype Development | Evaluation of Technical Success and Costs | Product Prototypes |
| **5.** Prototype Testing | Consumer Sensory Tests | Refinement of Product Designs |
| **6.** Food Safety | HACCP & Quality Control | HACCP Plan |
| **7.** Production Protocols | Analysis of Pilot Plant Production | Plan for Commercialization |

## Potential Economic Impact

New product development using processing byproducts can change an often negative or minimum value byproduct into a product capable of covering the original processing costs or more. Since processing costs for many meats can represent 5 percent to 10 percent of the products' costs at the packer level, using one or more of the byproducts for human food can greatly improve a producer's net return. Use of processing byproducts for food or other uses has also generated savings in waste disposal and environmental damage. Efforts in new product development such as those of the LSU AgCenter can extract more dollars from byproducts and expand the world's food supply. ■

# Value-added from Crawfish and Catfish

**Witoon Prinyawiwatkul, Voranuch Suvanich, R. Wes Harrison, Joan M. King, Subramaniam Sathivel, Karoline Pacheco, Sandeep Kumar Rout, Kandasamy Nadarajah and Sirisha Sonti**

Because of declining natural fishery resources and increasing consumer demand for fishery and aquacultural products, it is no longer practical to discard undersized crawfish and byproducts and wastes from crawfish and catfish processing plants, especially when a significant amount of valuable raw materials can be recovered and used to produce value-added new products and functional ingredients. The magnitude of this resource as a raw material for value-added products suggests a strong economic potential with major impact on the entire catfish and crawfish industries.

Photo by Mark Claesgens

*Louisiana is the world's largest producer of crawfish with an average annual harvest exceeding 100 million pounds.*

## Crawfish

Louisiana is the world's largest producer of crawfish with an average annual harvest exceeding 100 million pounds. Along with edible crawfish tailmeat, about 85 million pounds of peeling waste is generated in Louisiana annually. The peeling waste is used as animal feed with low economic value, although it is an inexpensive source of the valuable orange-red pigment, asthaxanthin, and the biopolymer, chitosan.

Before processing, crawfish are typically sorted into three grades: large/export, medium/restaurant and small/manual processing. The grading process results in a notable volume of undersized crawfish too small for manual peeling—more than 20 million pounds in some years. Lack of satisfactory markets for overabundant undersized crawfish can be economically devastating for processors and remains one of the problems facing the Louisiana crawfish industry. LSU AgCenter researchers have demonstrated that by using a meat-bone separator located at the Food Processing and Technology Laboratory, they can mechanically recover minced meat from cooked, undersized crawfish. With this recovered crawfish mince, formed seafood products can be created.

Because availability of crawfish is highly seasonal, thorough understanding of storage conditions, shelf-life quality and microbial safety of mince recovered from undersized crawfish are critical for effective development of value-added seafood products safe for human consumption. Crawfish mince has 14.4 percent protein, 80.4 percent moisture, 2.1 percent fat and 1.3 percent ash. Even after six months of storage at minus 20 degrees C, the mince maintains an appealing orange-reddish color. Furthermore, this frozen mince resembles fresh mince, having no apparent offensive odor. LSU AgCenter studies show that formed seafood products made from crawfish mince, which required further heat treatment during cooking, were free of pathogens and safe for consumption. The shelf stability of crawfish frozen mince, which is up to six months without added preservatives, is attributed to its low fat content and the presence of the natural antioxidant, astaxanthin.

## Consumer Survey

A survey was conducted with 1,600 seafood restaurants in Louisiana, Mississippi and Texas to evaluate desirable quality attributes of crawfish mince. Mince freshness was identified as the most critical attribute affecting end-product quality and purchase intent. Minced meat from cooked, undersized crawfish was successfully used as a base for several new formed seafood products such as nuggets, patties and sausages. These products were acceptable to consumers and more than 80 percent of the consumers participating in the tests indicated that they would purchase the products if commercially available. Flavor was most critical to overall acceptance and purchase intent of the crawfish mince-based products from the consumers' point of view.

## Chitosan

Crawfish shell waste is a good and inexpensive source of chitosan. Chitosan is a biopolymer having numerous food applications. Traditional chitosan production involves four steps: demineralization, deproteinization, decoloration and deacetylation. AgCenter researchers successfully simplified the process, which also reduced some chemical waste.

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The fat-binding capacity of chitosan has made it a potential weight-reduction food supplement. We discovered that crawfish chitosan has more than 750 percent fat-binding capacity.

Chitosan is a natural antimicrobial and antifungal substance and may be used to produce an edible film coating. We are currently studying the filmogenic properties of crawfish chitosan. Coating whole or fresh-cut fruits and vegetables with chitosan film may prolong shelf life. The market demand for fresh-cut fruits and vegetables has undergone rapid expansion in recent years. We are investigating the effect of chitosan coating on shelf stability of fresh-cut apples. Our preliminary study indicated that the coated fresh-cut apples lasted at least one week without surface browning.

## Catfish

Most catfish processed in the United States is sold as fresh or frozen fillets and whole-dressed fish. The yield from dressed-out catfish from traditional processing is only 45 percent, while offal (including catfish frames, viscera, skin and trimmings) derived from the filleting process, which often ends up in landfills or rendering plants, amounts to 55 percent of the total live catfish weight. Up to 75 percent of usable mince can be recovered from a catfish frame. The mince can be directly used in formed seafood products or further processed into surimi. Crude fat can be extracted from the viscera and head, purified and potentially used as seasoning oil or functional food supplement.

## Surimi Production

Catfish processors have increasingly shown interest in converting byproduct or waste into edible value-added food products. At the LSU AgCenter, we successfully developed the process to recover minced meat from filleted catfish frames. The mince was furthered processed into surimi. Our surimi production process requires less wash-water volume than the traditional process, yet provides quality comparable to that of the commercial surimi products. Furthermore, all significant potential human pathogens were reduced to a non-detectable level as a result of our controlled processes used during production of minced meat and surimi. Reducing the required wash-water would lower the production cost and reduce the space required for wastewater treatment. Lower production costs would encourage catfish processors to further invest to extend the production line to include surimi. Catfish surimi has little or no flavor of the original fish and therefore can be used as an intermediate raw material for various seafood-based products. Surimi produced from catfish frame mince has inferior whiteness compared to commercial surimi. Our studies show that significant improvement of whiteness of catfish surimi can be achieved with addition of 0.1 percent titanium dioxide. Consumer acceptability of catfish surimi is increased when at least 0.5 percent titanium dioxide is added.

Photo by John Wozniak

*Most catfish processed in the United States is sold as fresh or frozen fillets and whole-dressed fish.*

Catfish frame mince and surimi, alone or in combination, were successfully used as major ingredients for various seafood-based products such as nibblets, fingers, chips and sausages. Product acceptability, opportunity and market potential for nibblets, fingers and seafood sausage were investigated. Flavor and texture were most critical to product acceptance. Since safety is critical to the success of any new products, we developed the generic model Hazard Analysis and Critical Control Point (HACCP) for raw frozen catfish mince, catfish surimi and derived value-added products.

As demand for surimi products continues to grow and a global natural fishery catch declines, byproducts from the catfish filleting operation may serve as an alternative for surimi production. Potential exists for the commercial-scale development of both catfish mince-based and surimi-based products, which may in turn form new market niches that will be beneficial to the catfish industry.

## Catfish Viscera

There has been little interest to add value to catfish viscera, a processing waste. A whole viscera, which includes the liver, gallbladder, digestive tract (intestine and stomach) and storage fat, weighs about 10 percent of a live catfish. Our study indicated that catfish viscera contains about 30 percent to 35 percent fat. Docosahexaenoic and arachidonic acids in natural fish oil have been touted as helping maintain heart and vascular health in humans. We found that catfish viscera contain these two health-promoting fatty acids. Recovery, extraction and purification processes for catfish visceral oil were developed, and the oil quality characterized. Conventional oil refining is achieved through the following steps: degumming, neutralization, bleaching and deodorization. We discovered that chitosan (functional ingredient derived from crawfish shell waste) was an effective adsorbent for removing free fatty acids (causing offensive odor) from crude catfish oil. The use of chitosan may eliminate the neutralization step. Further research on proper process design and process optimization for a larger scale production of catfish oil is essential. A market feasibility study is also needed.

## Economic Impact

The outlook for more innovative and effective processing technology for byproduct recovery is promising. With enforcement of pollution laws to protect the environment, catfish and crawfish processors have shown an increasing interest in using byproducts and processing wastes. This would minimize pollution problems and offset costs involved in disposal of processing byproducts and wastes and at the same time maximize the processors' profits. In the long run, the use of byproducts and wastes from catfish and crawfish processing plants will not only enhance the competitiveness of the Louisiana catfish and crawfish industries, but also enhance the state's economic development. ■

# Mayhaw Fruit Juice

**Alfred Trappey II, Witoon Prinyawiwatkul, Paul Wilson and Charles E. Johnson**

A freshly prepared mayhaw fruit juice should correspond to the composition of the fruit selection from which it has been prepared. If the juice extraction method has been effective, there should not be significant differences between the fresh juice and the original fruit. However, the processing of mayhaw fruit can change its juice composition, especially when heat-treated. Additionally, the mayhaw fruit selection used for juice production, stage of fruit maturity at the time of harvest as well as cultural variables can all produce variations and inconsistencies in the initial composition of the expressed mayhaw fruit juice. Here are results of a study of juice preparation using only one variety of mayhaw, the "Texas Star."

Six extraction methods were evaluated: steam extraction using whole fruits, steam extraction using whole fruits with added pulp juice, cold-press extraction using whole fruit, cold-press extraction using finely ground fruit pulp, hot press extraction using finely ground fruit pulp and hot press extraction using finely ground fruit pulp incorporating a commercial pectolytic enzyme as a pretreatment aid before pressing. Quantitative results on mayhaw fruit juice composition after the initial expression when using either fresh or frozen fruit were significantly different among each extraction method used.

Some aspects of mayhaw fruit juice, such as color, are entirely a consequence of processing methodology. Study results show that comminution or milling, fruit pulp holding temperature, type of extraction method and condition of fruit (fresh or frozen) singularly and collectively had a significant influence in determining the final composition and color of fresh mayhaw juice. Pectolytic enzymes, when used properly, will significantly increase juice extraction yields of both fresh and frozen mayhaw fruit.

For this study, mayhaw fruit juice was extracted with the use of a rack and

Photo by Mark Claesgens

*The mayhaw, the fruit of the thorny, hawthorne tree, is about a 1/2 to 3/4 of an inch in diameter and resembles a crabapple. Mayhaws are grown in about 20 Louisiana parishes, with most grown in Grant Parish.*

***Alfred Trappey II, Assistant Professor, and Witoon Prinyawiwatkul, Associate Professor, Department of Food Science; Paul Wilson and Charles E. Johnson, Professors, Department of Horticulture, LSU AgCenter, Baton Rouge, La.***

frame hydraulic press, which works well with small quantities of fruit. However, a disadvantage of this system is the inability to mix the fruit (whole or ground) during cold-press extraction of either fresh or frozen fruit. Study findings showed significant inconsistency in juice efficacy. This is primarily due to pockets of unpressed fruit that became trapped and unavailable for juice expression in the rack and frame hydraulic press system.

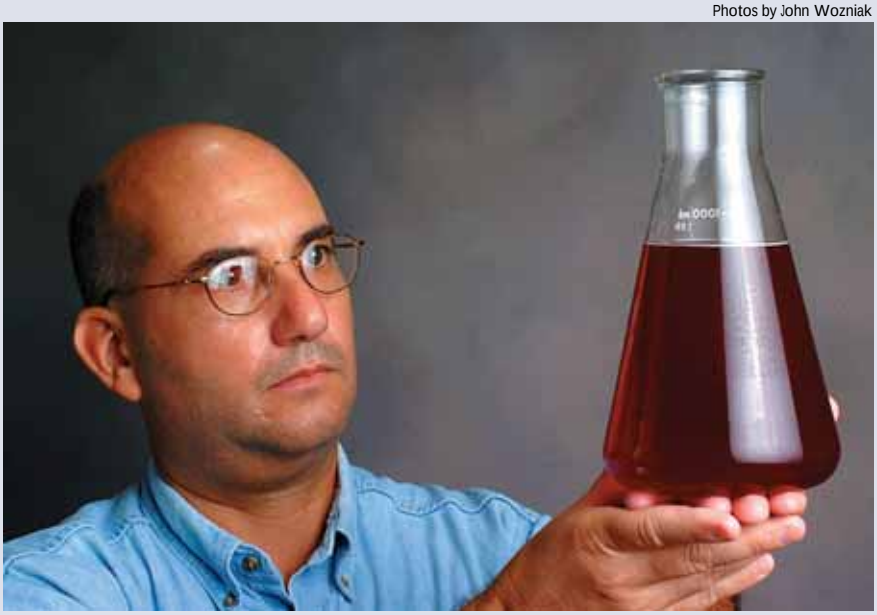
To optimize mayhaw juice processing, specific variables must interact effectively. For each of the six extraction methods, these variables were: mayhaw fruit quality, fruit pretreatment (freezing as a press aid), type of fruit preparation (whole or ground), the quality and type of juice desired (sugar to acid ratio), condition of mayhaw fruit at the time of comminution (texture), enzyme usage and temperature of the fruit pulp at the time of expression.

Handpicked mayhaw fruit is generally of good quality, but natural variations in the composition of mayhaw fruit, such as stage of maturity and cultural practices, will all produce significant variations or inconsistencies in the composition of expressed juice.

With the growth of mechanical harvesting of mayhaw fruit, quality standards must be developed to limit the introduction of the following: contamination by debris (leaves, insects, dirt and twigs), damage of fruit, and inconsistencies in fruit maturity, all of which have to be sorted and removed before processing. From a producer's perspective, minimum quality standards or grading guidelines must be established for large-scale mayhaw fruit purchase. On the processing end, impurities need to be identified and removed before milling and pressing, particularly sun-scaled mayhaw fruit, rotten fruit and insect-damaged fruit. The quality of the fruit determines the problems that may occur during juice processing.

Research indicates that frozen storage of mayhaw fruit can be used effectively without lowering juice yield or quality. Processing of fresh mayhaw fruit in the future with the advent of mechanical harvesting may present scheduling problems because most mayhaw selections tend not to mature at the same time. Frozen storage would allow for an accumulation of inventory, thereby creating a consistent supply of fruit, since crop yields may vary considerably from year to year because of extremes in weather conditions. ■

Photos by John Wozniak



*Alfred Trappey with a sample of the mayhaw-muscadine fruit juice drink.*

# Mayhaw-Muscadine Fruit Juice Drink:

## *A Competitor for Cranberry?*

The cranberry was once an obscure, regional fruit that through research and marketing has been propelled to a commodity with international demand. LSU AgCenter researchers hope that the mayhaw may also achieve such prominence, and research projects are under way. The following study involves mayhaw-muscadine juice blends.

Preliminary consumer preference testing determined that, after an adjustment to the sugar acid ratio, certain combination proportions of mayhaw-muscadine fruit juices were considered by consumers to be similar in flavor to commercially available cranberry/apple/grape juice drink. Before preference testing, mayhaw-muscadine juice blends were adjusted to about the same percent total soluble solids (17) as found in the Ocean Spray cranberry apple juice drink. Juice blends formulated from different combinations of mayhaw-muscadine differed significantly in color, flavor, taste and overall acceptance. Most important, fruit juice drinks produced from either 60/40, 30/70 or 40/60 mayhaw-muscadine blends were considered best in flavor and overall acceptability. Taste had the strongest effect on overall acceptability of finished juice formulated when varying the level of mayhaw juice used in combination with muscadine grape juice. Taste scores correlated significantly with acceptance for both 60/40 and 40/60 mayhaw-muscadine juice blends. ■

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# Value-added Forest Products: *Opportunities for Growth*

**Niels DeHoop, Michael Dunn, Todd Shupe, Ramsay Smith, Richard Vlosky and Qinglin Wu**

Solid wood forest products as opposed to pulp and paper products can be characterized broadly as primary or secondary. This classification is not always clear, but most industry observers agree that primary products are those produced directly from raw timber input. Examples include chips, lumber, veneer, plywood and their byproducts. Secondary products use primary products as input for remanufacturing. Examples include various types of panels or engineered composites. Secondary products also can include final consumer products such as cabinets and furniture.

Value-added wood products are most commonly thought of as being only those products with the highest value such as furniture, flooring or specialized paneling. Value, however, can be added to wood and wood products at various levels of processing. For example, value can be added to a log by properly cutting to the correct length so more product can be produced from straighter, less tapered material. Value can be added to lumber by processing more efficiently or manufacturing for special niche markets. In panel production, value can be added by enhancing certain properties such as dimensional stability or resistance to termites and decay. Value is greatly added when producing engineered wood products, such as building joists, beams and framing made from wood fibers or strands held together with a binder such as glue or resin.

The LSU AgCenter's Louisiana Forest Products Laboratory works to help Louisiana's forest products industries add value to their products through a number of activities. These include enhancing production efficiency in the primary and secondary processing industries, developing more durable wood-based products, developing methods and products for recycling wood-based products and enhancing economic development by encouraging better business practices.

The potential of the value-added forest products industry has been increasing as a means of facilitating economic development. Most industry development efforts focus on value-added secondary processing (furniture, flooring) instead of primary production (lumber, plywood) to retain and expand jobs in rural areas. Value-added secondary wood processing offers opportunities for increased profitability through higher margins and greater profits. Making secondary wood products often offers opportunities that primary processing does not normally offer. For example, secondary manufacturers can generally increase prices to make up for lost profits when raw material costs rise. Secondary products also earn higher profits by adding value and meeting specific customer needs.

## Louisiana's Forest Products Industry

The harvest of timber, Louisiana's No. 1 agricultural crop both in gross income and value-added processing, supports a solid wood forest products industry that includes about 200 primary and 750 secondary manufacturing establishments. In contrast to primary companies, secondary wood products manufacturers tend to be small; nearly two-thirds have fewer than 10 employees. More than half have annual sales of less than $250,000 with just over 5 percent having sales of $5 million or more. Average annual sales are an estimated $1.2 million.

Louisiana produces only 97 cents of value-added product for every $1 of lumber created by the sawmills operating in the state. This compares to the southern average of $2.13 of value-added for $1 of sawmill product produced. Improvement of industry competitiveness can increase potential for jobs creation and resource use in the rural-based forest products industry. However, to attain this potential, a wide variety of issues must be addressed. For example existing consumer market trends, location decision criteria, raw materials availability and applicability, labor force skills and training requirements, target market identification, recruitment and retention strategies, comparative advantages and effects on community stability should all be considered as part of an economic development initiative.

LSU AgCenter research has shown that if Louisiana could reach the Southern average of wood value-added production, about 5,500 jobs would be created. Recent research has indicated that the main barrier to secondary wood products expansion in Louisiana is the lack of an adequately trained work force. To help the industry attain its full potential, a wide variety of wood science and business issues are being addressed.

## Educational Activities

The first step in adding value to wood is to identify the species of wood correctly. Drying schedules and end-use options of wood are largely governed by the species. The LSU AgCenter's Louisiana Forest Products Laboratory conducts wood identification workshops. Fundamental in adding value to wood is kiln drying. Accordingly, lumber drying workshops are conducted in cooperation with LSU School of Renewable Natural Resources, Louisiana Tech University, Louisiana Forestry Association and dry kiln manufacturers. In addition, newsletters and publications include information on wood-moisture relationships such as lumber drying and wood decay. The Forest Products Lab also educates wood business owners on sound business practices such as record keeping and marketing. Evaluations

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indicate that more than half of the participants plan business expansions by adding employees and equipment and expanding facilities.

In addition, workshops are conducted to educate individuals working in the Louisiana secondary wood industry as well as those considering entering this industry sector. The wood science issues that have been targeted include wood-moisture relationships, wood identification, lumber drying and storage and wood preservation. Business issues are critical to the success of a secondary wood business, and workshops have targeted sound business practices, marketing, regulatory compliance, workers' compensatory insurance, business plans, obtaining a loan and Internet resources. Workshop evaluations indicate that participants have earned or saved their businesses about $1,000. Moreover, more than half of the participants say they plan to add at least one employee.

## Termite-resistant Products

One opportunity for value-added growth in Louisiana's forest products industry is the development of more durable termite- and decay-resistant engineered wood products. The damage to homes and forests caused by Formosan subterranean termites and resulting treatments and repairs is estimated at $2 billion a year nationwide, with $350 million or more of that in New Orleans. Moisture and decay cause additional losses. A major issue is the availability of treated engineered wood products for use in adverse environments. Various treatments are becoming available, but there is a need to develop stronger, more stable, more resistant, but environmentally safe wood-based treated products. Once proven, these products will have great demand in the residential and commercial construction markets.

The Louisiana Forest Products Laboratory is working with a number of companies to help develop durable wood-based materials. A Formosan subterranean termite lab has tested more than 70 treatments. In addition, products are being developed and tested for better moisture resistance, dimensional stability, strength and product performance. Specifically, research is being conducted on structural composite panels such as oriented strandboard (OSB), which cannot be pressure-treated once it is made into panel form. OSB is made of wood flakes glued with a thermal-setting resin. It is widely used as sheathing, flooring and I-joist materials in construction, replacing more traditional plywood. Thus, alternative techniques for protecting OSB against termites are being developed.

As durable wood-based materials are developed, homeowners and homebuilders who incorporate them into new homes and repairs of older homes can have more confidence that their investments will last. Through these efforts, significant new value-added markets can be developed that will enhance the industry supplying these markets and provide Louisiana homeowners reduced maintenance costs and a significant reduction in termite damage.

## Agriculture-fiber Composites

Sugarcane is an important agricultural crop in the southern United States. The cane stalk consists of an inner pith that contains most of the sucrose and an outer rind with lignocellulosic fibers. Cane processing crushes the entire stalk to extract the sucrose, from which refined sugar is produced. Large quantities of the bagasse, containing both crushed rind and pith fibers, remain after sugar extraction. Disposal of this byproduct from the sugar industry is so far still inefficient. For instance, about 85 percent of the bagasse produced in Louisiana is used as fuel in mill processes and for other low-value applications such as mulch and inexpensive ceiling tiles. The remaining 15 percent is waste that is allowed to decay or is put in landfills. Therefore, finding better ways to use bagasse is an important research interest with practical significance. Transforming bagasse into high quality industrial panel products provides a prospective solution. Research has been conducted to develop bagasse-based core material for laminate floors. Hammer-milled bagasse fibers were successfully combined with polymeric diphenylmethane di-isocyanate resin to form panels at various densities. Performance characteristics of the products were assessed and compared with respective properties specified in the industrial standard for commercial wood-based particleboard. The results of this study demonstrated that a consistent, high performance agrifiber composite panel with desirable environmental attributes could be developed successfully.

## Making Sawdust into Firelogs

A perpetual problem for the wood products industry has been the disposal of wood residues. Common methods of disposal include sending to a landfill or burning for energy. The sawmills and plywood mills in Louisiana use sawdust and wood pieces for particleboard and energy. The smaller secondary industries such as cabinet and furniture manufacturers cannot efficiently do this.

LSU AgCenter researchers have developed a way to create firelogs from sawdust and planer shavings. This turns a waste material into a profitable resource for homeowners without the mess and work of firewood. Conventional firelogs are made from sawdust and petroleum-based paraffin wax. The firelogs created in the Louisiana Forest Products Lab consist of sawdust and a wax made from soybeans. Dubbed an environmentally friendly firelog, it not only smells better as it burns, but is less polluting. Tests indicate that the firelogs produced less carbon monoxide and total hydrocarbons than either oak firewood or conventional firelogs. Researchers are now looking for ways to resolve economic issues to help bring the product to market.

## Markets and Business Development

In addition to developing value-added products, it is important to identify where the markets are for the products. More than 20 studies have been conducted by the Louisiana Forest Products Laboratory that offer information for Louisiana wood product manufacturers on baseline market structures, product opportunities and the competitive environment.

Although Louisiana ranks low in adding value to its wood product resources and in other productivity indicators when compared to neighboring states with similar resources and industry structures, the value-added wood products industry in the state has significant potential for expansion and development. ■

# Bioconversion of Processing Byproducts and Wastes

**Terry H. Walker, Caye M. Drapcho and Donal F. Day**

The usable carbon and nutrients contained in rice hulls and bran, sugarcane bagasse and sweet potato skins, which are Louisiana agricultural byproducts, may be converted by microorganisms to high-value products. LSU AgCenter researchers are developing bioconversion processes that can be used to produce specialty or nutraceutical compounds from these byproducts. The value of these beneficial compounds may exceed $50 per pound as compared to a value of less than 50 cents per pound for white rice, sugar and sweet potatoes.

In 2000, the Biomass Research and Development Board co-chaired by the U.S. Department of Agriculture and Department of Energy established the goal of tripling use of biobased products and bioenergy by 2010. To achieve this, a number of bioconversion and process technologies are needed to increase production while maintaining profitability. One concept that integrates most approaches is the development of a "biorefinery." This is a process that first extracts valuable components from a feedstock with the goal of complete use at optimum profitability and minimum waste generation.

A "biorefinery" is a concept in which high-value products are created from low-value byproducts.

LSU AgCenter researchers are coordinating efforts with other states to develop a biorefinery. The goal is bioconversion in three categories of biobased products: specialty chemicals such as pharmaceuticals, bulk chemicals such as ethanol and biomaterials. This collaborative effort will result in faster development of processes that will benefit Louisiana agriculture.

***Terry H. Walker, Assistant Professor, and Caye M. Drapcho, Associate Professor, Department of Biological and Agricultural Engineering; and Donal F. Day, Professor, Audubon Sugar Institute, LSU AgCenter, Baton Rouge, La.***

*The flow of material in a biorefinery starts with raw materials that are turned into products of lower value (bulk chemicals) and then into higher value (specialty biochemicals). The three E's address environmental, educational and economic considerations to sustain a successful biorefinery.*

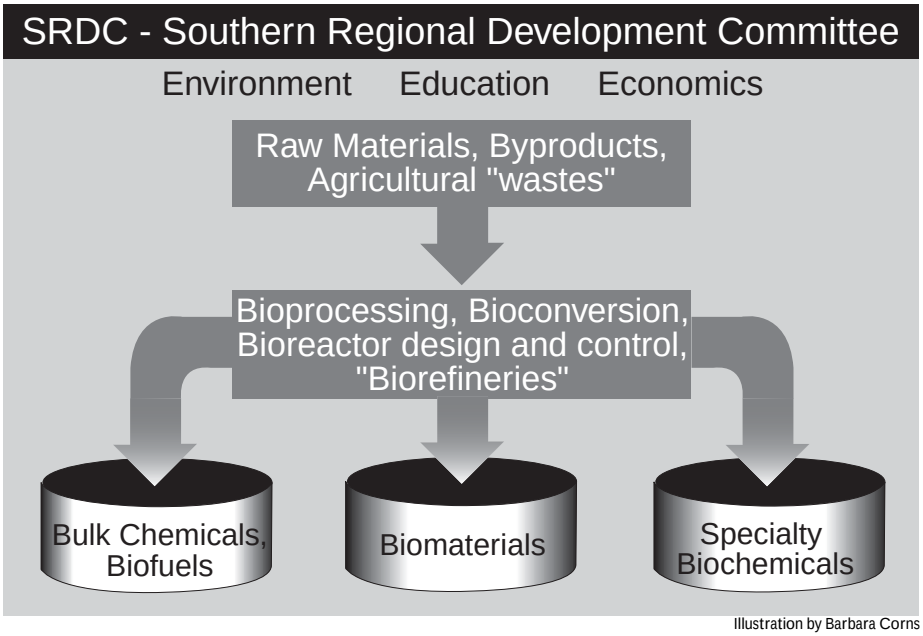



Illustration by Barbara Corns

## Fatty Acid Bioconversion

Beneficial health effects from consumption of certain fish oils have been attributed to essential polyunsaturated fatty acids. These fatty acids have been linked to a reduced risk for coronary heart disease, arthritis, inflammation, hypertension, psoriasis, other autoimmune disorders and cancer. Essential fatty acids are marketed as dietary supplements for adults and children at health food stores in the form of concentrated fish oils and as prescribed medications for humans and pets. The U.S. market is estimated to be at least $100 million per year with a value of about $50 per pound.

Declining marine resources and an increasing demand have prompted the search for alternative sources of polyunsaturated fatty acids. These sources include certain types of algae and filamentous fungi. LSU AgCenter researchers are examining a bioconversion process using the fungi *Pythium irregulare*. This fungi is effective at converting the carbohydrate in rice bran and rice husks into stored oils that contain high levels of the omega-3 fatty acids, such as eicosapentanoic and arachodonic acids.

This research has shown that 0.31 grams of oil per gram of fungal biomass can be obtained when rice bran and husks are used as the growth medium and that enhanced growth rates are achieved at a temperature of 25 degrees C. Adding enzymes did not enhance oil production, which is an important cost consideration.

This research used rice byproducts obtained from the Sataki pilot-scale rice mill in the Department of Biological and Agricultural Engineering, thus integrating the bioconversion process to traditional grain processing, which exemplifies the biorefinery concept. The oils are extracted by supercritical fluid

Photo by John Wozniak

*Zhu Hui, a graduate student in the Department of Biological and Agricultural Engineering, works with the pilot-scale bioreactor to produce specialty biochemicals. He does the fungal fatty acid production. In the background Erika Reeves, also a graduate student, is working with bioethanol production.*

extraction using carbon dioxide rather than toxic, flammable organic solvents. Supercritical carbon dioxide has advantages over conventional solvents in that high extraction rates are achieved at lower temperatures, which preserves many of the nutrients extracted.

## Production of Bioethanol and Xylitol

Research conducted in the Department of Biological and Agricultural Engineering has led to the investigation of a novel bioreactor system to maximize product formation rates for anaerobic or low-oxygen fermentation products. This system is being investigated for both ethanol production from sweet potato wastes and xylitol production from sugarcane bagasse.

**Bioethanol Production**. Ethanol is used as a precursor to other organic chemical production and as an additive to fuels to significantly reduce noxious emissions from fuel combustion. MTBE, the current fuel additive, is being phased out because of environmental concerns. LSU AgCenter researchers are focusing on the use of *Kluyveromyces marxianus*, a heat-tolerant yeast, to convert agricultural waste from the processing of sweet potatoes, rice, corn and sugarcane to ethanol. These byproducts contain large amounts of starch, cellulose and hemicellulose that must be broken down to sugars at high temperatures by enzymes in a process called saccharification so that the sugars can be used by the yeast for growth. Use of the high temperature-tolerant yeast allows for the saccharification step and the yeast growth to occur in the same reactor, which results in faster hydrolysis and growth rates, and therefore will lower operating and capital costs. AgCenter research has shown that *K. marxianus* grows well in hydrolyzed sweet potato wastes and that effective conversion of the organic compounds in the sweet potato waste to yeast biomass and ethanol was achieved.

**Xylitol Production**. Xylitol is an important sugar alcohol that has found wide application in foods. Xylitol is converted to glucose by human metabolism, but at relatively slower rates that do not significantly increase human insulin production. Food-grade xylitol has an economic value of about $12 per pound. AgCenter researchers are conducting studies into the production of xylitol by the yeast *Candida tropicalis* using sugarcane bagasse and leaf trash. This process involves the hydrolysis of the celluloses and hemicelluloses to the sugars glucose and xylose, followed by the bioconversion of the sugars to yeast biomass and xylitol. Conversion rates of 0.5 – 0.8 grams xylitol per gram of xylose have been found by other researchers. The goal of the research into the two-stage continuous reactor process is to increase production rates while minimizing costs compared to traditional batch fermentation systems. ■

Photo by John Wozniak

# Biorefinery and Sugarcane

**The large-scale and economic diversification of sucrose in other than food products has not been realized. The biorefinery concept can solve this problem.**

**Willem H. Kampen**

The cane sugar industry is under pressure because of global competition to diversify into value-added products. The sucrose molecule derived from sugarcane has properties that can lead to further development. The large-scale and economic diversification of sucrose in other than food products has not been realized. The biorefinery concept can solve this problem.

Analogous to an oil refinery, a biorefinery can produce many value-added products from sugarcane, such as glycerol, bioethanol, inositol, carbon dioxide, succinic acid, aconitic acid and an animal feed ingredient. The bagasse will be the fuel to cogenerate steam and electricity, so a biorefinery would be nearly self-sufficient in energy.

A biorefinery cuts down on loss occurring in raw sugar factories (Table 1). We have demonstrated in our research that a foliar application of betaine on sugarcane increases the sugar yield. This means more sugar is available for fermentation and raw material costs are reduced.

We have also demonstrated that Louisiana blackstrap molasses can yield 42 percent glycerol and 20 percent bioethanol on fermentable sugars in a special fermentation process. Yeast cells are forced to function under extreme fermentation parameters of high osmotic pressure, pH, temperature and cell concentration. The biorefinery has considerable swing capacity in terms of glycerol versus bioethanol production. Figure 1 shows the basic process and the yields obtainable. Glycerol has numerous applications,

**Table 1. Available sugars in the raw sugar factory and the biorefinery.**

| (Basis: 1 ton of cane) | Factory | Biorefinery |
|---|---|---|
| Sucrose in cane treated with betaine, lbs | 280 | 280 |
| Loss on the wash table, lbs | 11 | 0 |
| Loss in bagasse, lbs | 20 | 10 |
| Loss in filter mud, lbs | 5 | 0 |
| Loss in molasses, sucrose equivalent, lbs | 33 | 0 |
| Available sugars as sucrose, lbs | 211 | 270 |

*Willem H. Kampen, Associate Professor, Audubon Sugar Institute, LSU AgCenter, Baton Rouge, La.*

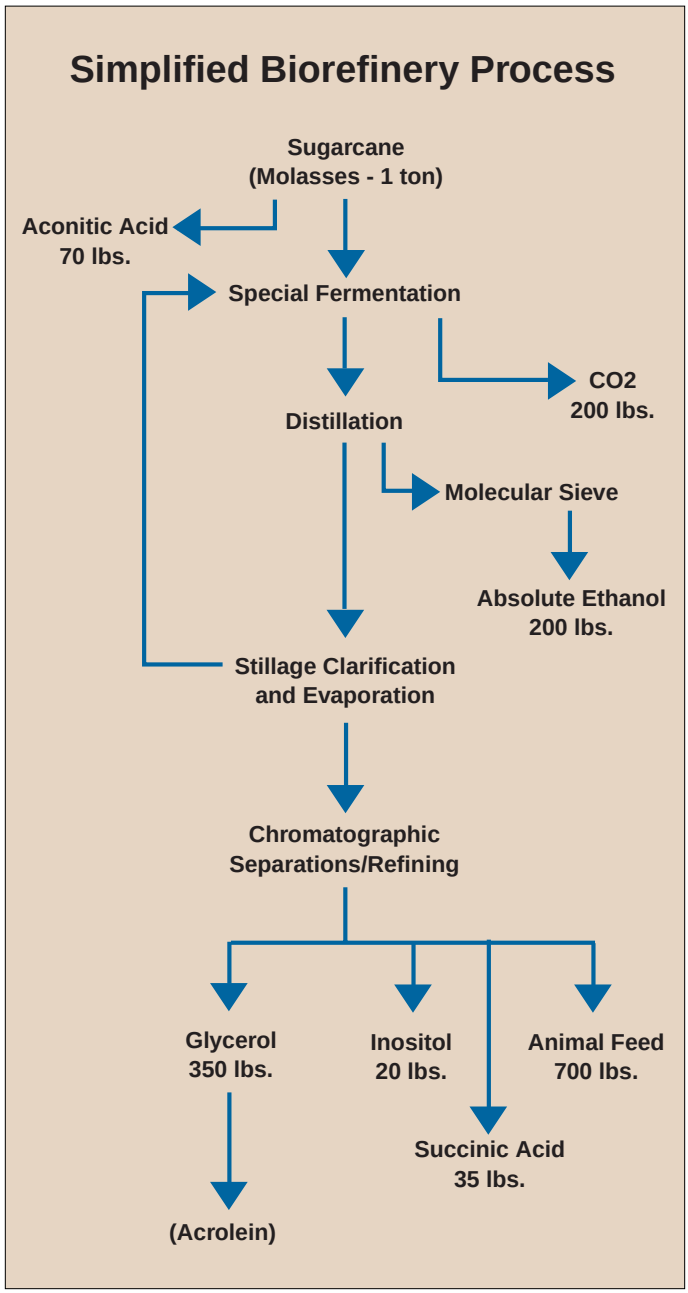
such as toothpastes, shampoos, skin care products, polyurethane, cellophane and pharmaceuticals. Inositol is used in baby formula and specialty animal feeds for salmon and shrimp. It is a high value-added product at $5 per pound. Succinic acid is used in photographic and pharmaceutical applications. Aconitic acid is used in rubber and paints.

The demand for bioethanol should triple by the year 2010. It is a renewable oxygenate in gasoline, which can be produced economically from molasses without the need for subsidies, if incorporated into the biorefinery process.

The remaining molasses solids are concentrated and blended with agricultural waste for animal feed, the demand for which should continue to increase.

Even though the total capital requirements are high, the return on investment would be about 20 percent, which is considered good. The process can be scaled up or down, and waste treatment requirements have been minimized. ■

**Figure 1. Simplified Biorefinery Process**




# Sugarcane History

New Guinea is the home of a cultivated form of sugarcane. In ancient times, people migrating from the Indochina area to New Guinea encountered different types of wild sugarcane. High-fiber forms were used for construction; softer and juicier forms were propagated in gardens for chewing. From about 8000 B.C. on, people migrated from New Guinea to several Pacific Islands, taking a cultivated form of sugarcane with them. It later reached Indonesia, the Philippines and Northern India. By 400 B.C., crude sugar was developed.

Cane culture spread slowly, reaching Persia by 500 A.D. Because of the Islamic Holy War, the Arabs brought sugarcane to Egypt, which they had conquered. They built plantations and stone mills. Around 710 A.D., the Egyptians developed clarification, crystallization and refining. Sugarcane spread westward across northern Africa and into southern Spain and Sicily. The first large shipment of sugar reached England in 1319. Sugarcane reached the Canary Islands in 1420, from whence Columbus introduced it to the New World in 1493.

From Santo Domingo cane culture spread across the New World. It reached Louisiana in the late 1700s. Until some 450 years ago, fruits and honey were the most important sweet foods in the world. Then cane sugar became the sweetener of choice until the 19th century.

Sugar beets have been grown for food and fodder in Europe for centuries. The German chemist Marggraff demonstrated in 1747 that pure beet and pure cane sugar were essentially identical. In 1802, the first beet sugar factory was started up in Cunern, Silesia, Germany. The French began construction of a beet sugar factory that same year. In 1806, England imposed a continental blockade against Napoleon. Imported sugar was unavailable, and consequently the beet sugar industry began to flourish in Germany and France. Napoleon, in 1811, ordered rapid development of the industry and its technology.

In the 1980s the corn wet milling industry diversified by marketing high fructose corn syrups (HFCS) and glucose syrups. Artificial sweeteners also entered the market. Now the natural sweetener market is made up of about 55 percent HFCS, 25 percent cane sugar (of which one-fourth is imported as raw sugar under the World Trade Organization quota system) and 20 percent beet sugar. ■

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***Willem H. Kampen, Associate Professor, Audubon Sugar Institute, LSU AgCenter, Baton Rouge, La.***

# Producing Nonwoven Materials from Sugarcane

**Yan Chen and Ioan Negulescu**

Louisiana is the second largest U.S. sugarcane producer, with sugarcane production accounting for 41.5 percent of the nation's total (Table 1).

**Table I U.S. Sugarcane Production* and Value****

| State | For Sugar | For Seed | Value |
|---|---|---|---|
| FL | 15,620 | 718 | 487.4 |
| HI | 1,878 | 54 | 64.0 |
| LA | 13,340 | 1,015 | 337.1 |
| TX | 1,937 | 25 | 53.3 |
| US Total | 32,775 | 1,812 | 941.8 |

* Updated in 2001, $10^3$ tons.
** Updated in 2000 for sugar and seed, million dollars.

Sugarcane refining generates a large volume of residue called bagasse. Disposal of bagasse is critical for both agricultural profitability and environmental protection.

*Yan Chen, Associate Professor, and Ioan Negulescu, Professor, School of Human Ecology, LSU AgCenter, Baton Rouge, La.*

The LSU AgCenter is conducting research on converting bagasse into value-added nonwoven materials. This research involves procedures for bagasse fiber extraction, bagasse fiber processing and bagasse fiber formation into nonwoven materials. It also involves methods of evaluating nonwoven bagasse products, including fiber bonding structure, mechanical and physical properties, and biodegradability. Potential applications of bagasse fiber nonwoven materials include horticultural products, animal bedding and aquaculture products.

## Sugarcane Production

The sugarcane stalk consists of two parts: an inner pith containing most of the sucrose and an outer rind with lignocellulosic fibers. During refining, the sugarcane stalk is crushed to extract the sucrose. This procedure produces a large volume of residue, bagasse, containing both crushed rind and pith fibers. U.S. sugar mills produced about 13 million tons of dry bagasse in 2001. In Louisiana, approximately 85 percent of waste bagasse is used as in-house fuel for power generation or as raw material for producing low-value products such as mulch and ceiling tiles. The remaining 15 percent is waste that goes to a landfill or is allowed to decay.

Previous research on bagasse has suggested many approaches to converting bagasse into value-added industrial products, such as liquid fuels, feedstocks, enzymes and activated carbon. Use of bagasse fiber for manufacturing material products is another prospective solution. Compared to pure synthetic materials, bagasse fiber-based materials have two advantageous features, light weight and renewability. The LSU Human Ecology Textile Processing Laboratory has developed a method to produce bagasse fiber nonwovens and composites. These biobased industrial materials have potential for diverse end-uses from automobile interior trim and housing to agricultural and other industrial sectors.

*Yan Chen holds the fiber web that has been needle-punched for further compaction.*

Photos by John Wozniak

*After being cleaned, the bagasse is blended with bonding fibers for forming a fiber web.*

## Bagasse Fiber Process

The process for producing bagasse fiber nonwovens and composites includes bagasse fiber extraction, bagasse fiber cleaning, opening and mixing, carding and needle-punching. Waste bagasse is manually sifted and put into an alkaline solution for boiling to remove lignin. After the treatment, bagasse fiber is rinsed with water and dried in an electric oven. The extracted bagasse fiber is cleaned using a cotton cleaning machine. The clean fiber is then blended with carrier fibers or bonding fibers in desired ratios and fed into a universal laboratory carding machine to form a fiber web. During the carding, the fiber blend is further opened and individual fibers are combed to be relatively parallel.

Needle-punching is a mechanical action to entangle fibers in the direction

perpendicular to the web surface. After needle-punching, the fiber web is significantly compacted and stronger.

## Property Evaluation

End-use quality and performance of the bagasse fiber nonwovens are critical for both the producer and consumer. The bagasse fiber nonwovens are tested for tensile strength, flexibility, compressibility, water absorption and biodegradability. Bonding properties between the cellulose fiber and polymer fiber are also characterized using various instruments.

## Agricultural End-uses

Enduses of the bagasse fiber nonwovens in agriculture include:

***Horticulture***. Bagasse fiber nonwovens can be used to make flowerpots. This type of flowerpot has excellent biodegradability and can be buried in a flowerbed or larger plastic or clay pots. A recent study indicates that the bagasse nonwoven pot buried in a flowerbed is dissolved within only 23 days. When the nonwoven pot is put in a larger plastic pot, it is biodegraded within 50 days. The study also shows that the bagasse nonwoven pot is capable of sustaining weather and watering during seedling and retailing.

***Animal Bedding***. The bagasse fiber nonwovens can be used as bedding material for poultry farms. Because the nonwoven is easy to lay out and pack, the used nonwoven bedding material (after collecting enough poultry wastes) can be packed and sold as garden mulch directly. This approach not only promotes production of biodegradable and nutritional garden mulches, but also helps ease animal waste management. LSU AgCenter researchers are working on the development and testing of this product.

***Aquaculture***. Like other geotextiles, the bagasse fiber nonwovens can be applied in aquaculture, such as bank weed control, filtration and pile wraps. Artificial habitats used in fish cultivation can benefit the aquaculture system by providing shelter and separation, additional nutrition and water quality improvement. Thus, availability of inexpensive artificial habitat materials can help fish farmers with profits. ■

*Yan Chen feeds bagasse, a waste product from sugarcane, along with bonding fibers into a universal carding machine at the LSU AgCenter's Textile Processing Laboratory.*

# News Briefs

## LSU AgCenter Targets Ukrainian Farmers

The LSU AgCenter is operating a program in Ukraine that is a model for how to run a successful educational effort in a country that was formerly part of the Soviet bloc. The program, "Improving Income of Private Ukrainian Agricultural Producers," targets farmers with less than 250 hectares and household plot owners (HPOs). Much of the food consumed within the country is produced by this latter group, who use their yards and land near their homes for orchards, gardens and a few dairy cows.

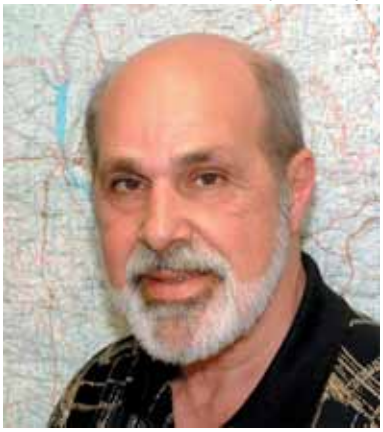
The goals of the AgCenter project include helping the farmers and HPOs become more efficient, learn the latest technology and develop marketing skills.

Initial interest in Ukraine came about in the 1980s through the efforts of the AgCenter's former chancellor, H. Rouse Caffey. This current project is directed by Lakshman Velupillai, director of International Programs. The heart of the program, though, is with Larry Brock, former county agent in St. Mary Parish, who is teaching the Ukrainians how an agricultural extension program can work.

Brock lived in Ukraine, which is slightly larger than the state of Texas, for two and a half years, giving the project his full attention. With the renewal of the second phase of the current project on March 1, 2002, he spends from six weeks to eight weeks every quarter in the country. The U.S. Agency for International Development, which funds the project, is so pleased with the results so far that it has renewed this three-year phase for a record $3.2 million.

The LSU AgCenter's project is headquartered in Vinnytsia, which is in the Vinnytsia oblast (province), but has expanded to two nearby oblasts.

Photo by Mark Claesgens



*Larry Brock, former county agent in St. Mary Parish, is teaching the Ukrainians how an agricultural extension program can work.*

Although Ukraine is a beautiful country with rolling hills and a picturesque landscape, the agricultural problems are immense. Conversion from state-run collective farms to privately run farms has been extremely difficult. Among the obstacles are:

- Farmers cannot get loans.
- Equipment is expensive and hard to come by.
- Farmers cannot buy and sell land given to them as part of the breakup of the collective farms. ■ **Linda Foster Benedict**

# USAID Awards AgCenter $3.2 million for Ukraine Project

Photos by Linda Foster Benedict

*Much of the food consumed in Ukraine is grown in individual gardens that are fenced and gated.*

*Bright colors are common in Ukrainian cities and towns, such as this university building in Kiev.*

*A corn variety trial at Vinnytsia State Agrarian University, one the LSU AgCenter's partners.*

*Illya Krotyuk, left, is a Ukrainian raion specialist (county agent) who works as part of the LSU AgCenter project. He is visiting with a farmer in Tyvriv Raion.*

*Most households in Ukraine have gardens and orchards instead of lawns. They grow vegetables, fruits and flowers. This is a scene in Komainetz-Podilsky.*

***Inside:***




LOUISIANA AGRICULTURE

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