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Utilizing and developing our resources to enhance quality of life

Farm & Home RESEARCH

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COMPETITIVE AGRICULTURE

BALES OF OPPORTUNITY

115TH ANNUAL REPORT

CONTENTS

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Director's comments

BY KEVIN KEPHART
Director, South Dakota Agricultural Experiment Station

Kevin Kephart

The five-point blueprint
for the here and now and the future

Here at the South Dakota Agricultural Experiment Station, we keep five goals in the back of our minds as we go about our work. Those goals are an agricultural system that is highly competitive in the global economy; a safe and secure food and fiber system; a healthy, well-nourished population; greater harmony between agriculture and the environment; and enhanced quality of life for Americans.

Those are the five national goals as determined by our partner in Washington, D.C., the USDA's Cooperative State Research, Education and Extension Service.

Someone didn't just pull those goals out of thin air. There was a nationwide effort many years ago to boil down and synthesize the areas of relevance for land-grant institutions through the Cooperative Extension Service and the Agricultural Experiment Stations. Many of the stations, including ours, use the goals as a means of organizing and categorizing our activities. They provide focus to what we do.

In this issue of *Farm & Home Research*, we'll look at a few recent projects here at SDSU that help us address those goals. This is only a tiny snapshot of what SDSU scientists are doing, but it offers a glimpse of why this set of goals is important.

Certainly the land-grant institutions around the country, because of the needs of their states, prioritize some goals over others. Obviously, being the most agricultural state in the country, South Dakota's system emphasizes Goal No. 1, an agricultural system that is highly competitive in a global economy. But we have activities in the Experiment Station and Extension dealing with all five national goals.

I don't want to diminish the importance of any of the five goals or the activities of any of the people working on projects that fit those goals. Certainly a safe and secure food system is important. Certainly a healthy and well-nourished nation is important. So is greater harmony between agriculture and the environment.

We also know that from year to year and decade to decade one or another of the goals can become more important if local needs demand it.

We can see one of those shifts taking place right now in South Dakota. Recognizing that South Dakota is an agricultural state, state leaders have shown significant interest in ag-based economic engines to help drive economic development. Clearly agricultural production in a competitive manner is going to continue to be important, but Goal No. 5, enhancing economic opportunity and quality of life for Americans—at least as dictated by the state and state stakeholders—will be gaining prominence as an area of emphasis here at SDSU.

The goals are all interconnected and a shift in one can very easily bring about a positive shift in another one.

Let me give an example: Certainly corn production research has been a priority here at SDSU. We don't develop hybrids but we do a lot of the agronomic work for corn production. During the 1990s we began seeing this dramatic increase in the state in ethanol production. Our involvement in that is certainly Goal No. 1, agricultural production, but it's also related to Goal No. 5, enhanced economic opportunity and quality of life for Americans. But as we forecast what the limitations might be when processing corn to make ethanol and its co-product, dried distillers grains, we recognize there's an environmental component. Dried distillers grain has a higher concentration of phosphorus, which can represent a limitation to our ability to exploit DDGs as a feed source. That leads to Goal No. 4, which is greater harmony between agriculture and the environment.

That's an example of how the flow and evolution of research in the subject matters or issues at hand can impact more than one goal.

The beauty of our five-point blueprint is that it works in the here and now, but also in the future. Some of the South Dakota Agricultural Experiment Station's work can roll right out of the labs and into farmers' fields. But really, most of our work is trying to use a crystal ball to envision the problems down the road and to have answers ready when they come up. Or, more optimistically, to foresee new opportunities and help South Dakotans be prepared to take advantage of them.◆

COMPETITIVE AGRICULTURE

Competitiveness in the global economy:

a question-and-answer interview with Kevin Kephart, director of the South Dakota Agricultural Experiment Station.

Q: Dr. Kephart, one emphasis of research at South Dakota State University is making sure that American agriculture stays highly competitive in the global economy. How important is that to agricultural scientists as they go about their jobs?

A: It's not the only focus of research by any means, but it's very important. South Dakota State University researchers also are at work on projects to make sure our food and fiber system is safe and secure, that our population is healthy and well-nourished, that there is harmony between agriculture and the environment, and that there is enhanced economic opportunity and quality of life for Americans. But competitiveness is vital because it often deals with the bottom line—and that's what producers and the commodity and livestock groups who represent them are concerned about.

Q: What do you see on the horizon to make South Dakota producers more competitive?

A: There are a number of positive developments that all could fall under the heading "value-added agriculture." For starters, I'll list three: continued development of the renewable energy industry in South Dakota, the recognized need for more dairy development, and the vast potential for biotechnology to reshape the way we farm and even the products we produce on the land.

Q: Could you summarize some of the issues you see under each of those categories?

A: In terms of renewable energy, there's a lot of interest in this part of the country in developing biodiesel from our oilseeds crops such as soybean and sunflower. Meanwhile, the growth in the ethanol industry is obvious. According to the South Dakota Corn Growers Association, more than 8,000 South Dakota farm families have invested in ethanol plants. Right now there are seven ethanol plants operating in South Dakota, while three more are under construction and others are in various stages of development. In 2003, South Dakota will produce more than 340 million gallons of ethanol.

But there are a couple of bottlenecks that pose challenges for the ethanol industry in South Dakota.

One is what to do with all the distillers grain, the co-product produced in the process of making ethanol. For every gallon of ethanol produced, there are 6 pounds of distillers grains produced. In either wet or dry forms,

Kevin Kephart, director, South Dakota Agricultural Experiment Station

distillers grains are a very good feed source, and a great deal of research is going on at SDSU about how to use them in diets of dairy cattle, beef cattle, and swine.

But we frankly don't have enough animals in South Dakota to feed all the distillers grains the state will be producing. It can be shipped out of state, and some of our South Dakota-produced distillers grains already goes to feed animals in states such as California. But it's not the most economical product to ship. In addition, our neighboring states have significant amounts of distillers grains to use or export as well.

A logical solution would be to grow the livestock industry here in South Dakota, and commodity and livestock groups are enthusiastic about doing that very thing.

But that's where a second bottleneck occurs: Distillers grains are rich in phosphorus. Federal Environmental Protection Agency regulations handed down in December 2002 say large livestock facilities, called "concentrated animal feeding operations," soon will have to take phosphorus as well as nitrogen into consideration when applying manure to soil.

We've known this change in regulations was coming. That's why SDSU soil scientists, with support of livestock and commodity groups, already have been looking at such questions as how much phosphorus different soil types can contain before phosphorus begins to be a problem for lakes and streams. Though not harmful to humans, phosphorus in lakes can cause algae blooms that in turn can lead to oxygen depletion and fishkill in some cases.

So it's apparent that the growth of the ethanol industry brings new challenges along with the benefits. It offers clear advantages for the environment in offering motorists a cleaner-burning fuel. But it also calls for wise use of the co-product, distillers grains, in growing the state's livestock industries; and it requires careful management of the manure from livestock operations. Those are all issues our scientists will be involved in.

Q: What about dairy development?

A: The first thing to note is that overall milk production has held steady for the past several decades in South Dakota. We produced 1.53 billion pounds of milk in 1970 and 1.58 billion pounds in 2001.

That's only possible because our production per animal has more than doubled. The data tell us that South Dakota had 183,000 dairy cows in 1970. In 2001 the state had 99,000 head.

And while those cows would have been scattered about the state a few decades ago, when it wasn't uncommon for a farmer to milk 20 cows as part of a diverse operation, those cows are on fewer, larger farms today, with an average herd size of 120 cows.

South Dakota's actually doing better than other Plains states, which have lost production over the decades. And we see potential to grow the dairy industry for a number of reasons: land is relatively inexpensive here compared to many other places, we're frequently second only to California in alfalfa production, we're among the leaders in production of corn silage. And we're also producing an increasing share of distillers grains, another excellent feed source.

On the eastern fringe of South Dakota, we also have the I-29 corridor, which runs north and south to connect with main east-west running routes. That's essential because getting our product to market will be an issue.

That brings up another point: Most of the milk produced in South Dakota, probably more than 80%, is processed into cheese. That's because it's cheaper and easier

Competitiveness "deals with the bottom line," says Kevin Kephart. It means changes "in the way we farm and even the products we produce on the land." From the ethanol industry comes the co-product distillers grain, which SDSU scientists formulate into nutritious livestock diets. SDSU dairy scientists add value to milk by developing new cheeses, and SDSU plant breeders develop transgenic crops that will benefit both producers and consumers.

to transport cheese to distant markets than to transport the milk and process it elsewhere. So it's a natural that SDSU dairy research will have a lot to do with cheese. Recently the Dairy Science Department launched a new premium smoked cheddar cheese spread, for example. Our SDSU students can expect to be involved in more projects of that kind as teachers and researchers explore new products that fit in with the direction the state's dairy industry is heading.

Q: You also mentioned biotechnology. SDSU and the South Dakota Agricultural Experiment Station are already quite deeply involved in new uses for biotechnology, aren't they?

A: Yes, and we see that increasing. Already South Dakota farmers are growing a transgenic soybean developed under an agreement between SDSU and Monsanto, the first of its kind anywhere, that uses Monsanto's patented Roundup Ready® trait in soybeans developed by SDSU plant breeders specifically for South Dakota producers. Those soybeans are called "transgenic" because they have genetic material from another source added in the early stages of development to give them a special trait—in this case, the trait is tolerance to glyphosate herbicide, which gives farmers one more tool to control weeds.

Next on the horizon may be a spring wheat developed for South Dakota that uses Roundup Ready® technology. But that will depend on several factors: whether the transgenic wheat gets regulatory approval in the U.S. and other countries, whether trade agreements are in place so that American farmers can be confident they can export it, whether grain-handling procedures are developed to keep transgenic wheat separate from conventional wheat, whether best management practices for farmers are in place.

Looking beyond products which offer clear benefits to the producer, we can see a new generation of transgenic crops that pack definite benefits to the consumer or the ag processor. However, adding traits that are supposed to bring benefits to consumers is going to be a huge, huge challenge. If the trait significantly changes the composition of the grain, the grain is no longer the "substantial equivalent" and will face hurdles in getting approval from regulatory agencies.

Biotechnology also will have animal applications. Even here in South Dakota, private firms are already talking about growing components for the pharmaceutical industry in the milk and blood of cows, for example. Obviously there will be more such applications in the future, and our scientists will have a role in charting that new frontier.

Q: You've mentioned ethanol plants, the dairy industry, biotechnology as important factors in keeping South Dakota farmers competitive in the global economy. Are there other projects of this nature under study at SDSU?

A: In the longer term we could speak of the research going on at SDSU and other places to learn how native grasses such as switchgrass, Indiangrass, and big bluestem can be grown as biomass crops. The thought is that they may be grown as feedstocks for production of transportation fuels, electricity, bio-oil, and intermediates for industrial applications.

Commercial growing of switchgrass or other native grasses for such uses is still years down the road, not even on the skyline yet. But that's our job as scientists—to try to reach beyond that horizon to see if there are new commercial applications from what we grow here in South Dakota that turn to the advantage of South Dakotans.◆

Safe Food

In home kitchens, fast-food and local restaurants, hospitals, school lunch lines, wherever food is served, the first concern is that it is safe food.

Scientists and professional food managers admit there is no sure-fire method that assures absolute food safety without impairing the food's taste, texture, and nutritional qualities.

South Dakota State University scientists have tested different ways to minimize the dangers from harmful bacteria in meats; their methods are irradiation, ozonation, and treatment with bacteriocins made from fermented lactic acid bacteria. The scientists have tested the effectiveness of each method separately, as well as the synergistic effects of bacteriocins combined with either irradiation or ozonation. Synergism happens when the total effect of two agents working together is greater than if the separate effects

Joan Hegerfeld, left, is skilled in using a dial thermometer to check internal temperature in a hamburger (160 degrees F in a patty interior to assure safe food) but suggests home cooks would be more comfortable with a digital thermometer. Jim Julson, above, holds a Kramer shear cell that reveals any changes in meat texture after exposure to different levels of ozone or irradiation.

were added up—the whole is greater than the sum of its parts.

THE SCIENTISTS ALSO GAUGED consumer attitudes to these preservation techniques in focus groups held in Sioux Falls in 2000 and 2002.

"The focus group participants had heard about irradiation in the media, and they were fairly accepting of it," says Joan Hegerfeld, Extension food safety specialist.

"They were willing to purchase irradiated meat, as long as price and taste weren't affected."

The consumers did not associate ozone with food preservation, and they had never heard of bacteriocins, a term that conjured up negative images of adding bacteria to the food.

When asked about the use of a combination of several food preservation techniques, the Sioux Falls area consumers expressed skepticism, Hegerfeld says.

"Irradiation, ozonation, bacteriocins—that's too many big terms on the label. If one method isn't good enough, why use two? Is the food that unsafe to begin with? Those were the reactions shared by several of the participants."

However, the rationale for combining techniques is the so-called hurdle concept, says Jim Julson, associate professor of agricultural and biosystems engineering. The idea is to find the lowest level of treatment that is still effective.

By combining treatments, thus creating hurdles, the probability of a safe food product is greatly enhanced, he adds.

"We wanted to see if we could irradiate at lower levels and still get good microbial control by combining with bacteriocins," Julson says. He adds that a high level of irradiation is known to be very effective in obtaining microbial kill, but it affects the color and taste of the food.

AN ELECTRON ACCELERATOR is the instrument most often used in irradiating food, says Julson.

"The food is placed on a conveyor belt and passes underneath the electronic beam that bombards it with high speed electrons. The electrons ionize and kill or damage the harmful microorganisms in the food."

Irradiation does not make the meat radioactive, nor does it produce any substances that are harmful to humans, Julson says. The effects of irradiation on food and on the people who consume it have been studied extensively since the 1940s and its safety has been demonstrated. Irradiation has been used for decades by the U.S. Army to sanitize food for the troops, and it is used for astronauts in space.

Irradiation is effective against most common pathogens in food, such as *Escherichia coli* 0157:H7 and *Listeria monocytogenes*, says Julson. It is approved by the FDA for use with a variety of foods, including spices, fruit, vegetables, meat, and poultry. Irradiated foods are commercially available in stores and fast food restaurants.

The South Dakota State University scientists used the Linear Acceleration Facility at Iowa State University for their irradiation research. They inoculated fresh ground beef with high levels of *E. coli* 0157:H7 and irradiated the meat at 0.25, 0.5, 1.0, and 1.5 kiloGray (a measure of irradiation intensity). The FDA has approved up to 4 1/2 kGy for irradiation of meat.

Half of the meat samples also were treated with 1% Microgard® 300, a brand name for the type of bacteriocin effective with ground beef in other studies.

"We found that the effect of irradiation was so overwhelming compared to the bacteriocins that there wasn't really any synergistic effect at all," Julson says.

An irradiation level of 1.5 kiloGray practically eliminated all harmful bacteria in the meat when irradiation was combined with Microgard® 300. There was no synergism, and hence irradiation alone could be effective in controlling such pathogens.

OZONE HAS BEEN a water sanitation technique for years. It is approved by the FDA for use with food, says K. Muthukumarappan (Muthu), associate professor of agricultural and biosystems engineering.

"Some companies are using ozone to treat water used to wash fruits and vegetables. And some meat processors have started using ozone-treated water to clean carcasses. This will reduce surface bacteria and may prevent further contamination," Muthu says.

For the South Dakota State University research, ozone in a gaseous form was pumped over the meat in an airtight chamber. Ozone vaporizes quickly and leaves no harmful residues in the food. It only treats the surface and does not penetrate the meat, so it is better suited for chunks of meat or lunchmeat than for ground beef.

For this project, cured ham was inoculated with *L. monocytogenes*. Ozone was applied at 0.2, 0.5, and 1 ppm (parts per million), and samples were either treated with ozone alone or with ozone and 1% Microgard® 300.

The results indicated that ozone applied at 1 ppm was effective in killing more than 98% of the microorganisms. No synergistic effect with bacteriocins was detected.

When the meat was stored for up to 10 days, the effect on microbial kill increased. But it never reached the desired level of 99.9999%, which would be required to safeguard the food from harmful bacteria, says Muthu.

Rajiv Dave, left, dairy scientist, and "Muthu," foods scientist, used ozone treatments and bacteriocins on food samples inoculated with microorganisms. No treatment attained a 99.9999% kill.

BACTERIOCINS ARE MADE from fermented milk or dextrose based media. They are completely natural and safe substances, commonly used as preservatives in cottage cheese, says Rajiv Dave, associate professor of dairy science.

But the idea of using these bacteriocins for meat preservation is new. Two types of bacteriocins were tested for effectiveness against common food pathogens.

The scientists inoculated samples of ground beef with either *E. coli* 0157:H7 or *L. monocytogenes*, treated them with different levels of Microgard® 200 or Microgard® 300, two different types of bacteriocins, and then refrigerated the meats.

Both Microgards are powders and easy to mix with ground beef, says Dave.

Although Microgard® 300 turned out to be relatively more effective than Microgard® 200, both products were more effective against *Listeria* than against *E. coli*. While *E. coli* counts went down over time after treatment with bacteriocins, more than 60% of the bacteria were still intact after 5 days in storage.

"These bacteriocins are not capable of making our meat completely safe when used without other food preservation systems," Dave says.

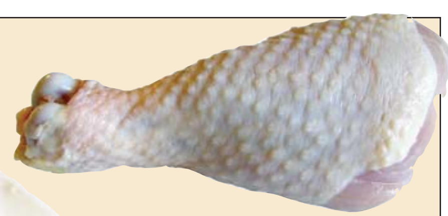
He adds that the samples in the experiment were inoculated with very high levels of microbes. "Under normal circumstances in the meat industry, the meat wouldn't be infected with millions of cells. If you consider the reduction we obtained against an actual level of infection, this may be an effective method.

"We have done another study that showed that bacteriocins preserve the color and increase the shelf life of meat by 1.5 days. When we are developing these techniques, we don't just want to get only the right amount of microbial kill. Taste, color, and texture of the meat are also important for consumers," Dave says.

Funding for the research was provided by the South Dakota Agricultural Experiment Station.◆

Food Safety Facts

Foodborne illnesses affect an estimated 76 million people and cause more than 5,000 deaths in the U.S. every year, according to the Centers for Disease Control and Prevention. Some of the most common disease causing pathogens are *Escherichia coli* 0157:H7, found in raw meat; *Listeria monocytogenes*, found in raw meat, unpasteurized milk, soft cheeses, and cold cuts; *Campylobacter*, found in raw poultry; and *Salmonella*, found in raw poultry and eggs.






David Francis and Diane Baker

E. coli O157:H7 bacteria

E. coli **O157:H7 bacteria** sometimes cause serious sickness or death in humans but at other times apparently go unnoticed by humans who ingest the bacteria.

Now, a new study at South Dakota State University may explain why some *E. coli* O157:H7 strains are more virulent than others.

The U.S. Centers for Disease Control and Prevention estimate that 73,000 cases of infection and 61 deaths occur in the U.S. each year from *E. coli* O157:H7, one of several hundred strains of *Escherichia coli*.

Infection often causes severe bloody diarrhea and abdominal cramps. In about 2 to 7% of cases, the infection can cause a complication called hemolytic uremic syndrome, in which red blood cells are destroyed and the kidneys fail.

"We knew from what other investigators were finding that there were more sources of potential contamination out there than would be accounted for by the number of cases of human disease that have occurred. There is probably a lot of subclinical or overlooked infection in people."

—David Francis,
SDSU veterinary science professor

***E. COLI* O157:H7** differs from more benign *E. coli* strains in that it produces a toxin, called "Shiga-like" by scientists. This toxin is a protein that causes severe damage to the cells that line the intestine. The complication is that there are more than just one toxin.

Diane Baker's master's degree thesis in microbiology found that only one of two toxins produced by the *E. coli* O157:H7 bacteria in her study correlated directly to human health. Baker, who is now manager of South Dakota State University's Animal Resource Wing, completed her study in 2002, working with David Francis, professor of veterinary science.

Baker had the Centers for Disease Control and Prevention in Atlanta select at random 10 strains of *E. coli* O157:H7 bacteria that had been implicated in outbreaks of food-borne illness in humans. At the s ame time, the National Animal Disease Center in Ames, Iowa, chose at random 10 bovine strains of *E. coli* O157:H7. Those were strains of the bacteria that had been found in bovine feces rather than in human outbreaks.

E. coli contamination can come from many food sources. Baker confined her study to bovine strains, however, because most human outbreaks trace back to consumption of beef products.

She stipulated that the bacterial strains selected produce both of the two toxins she was looking at in the study—Shiga toxin type 1 and Shiga toxin type 2—as well as a protein she was evaluating as a factor in virulence.

Pigs are the only known animals that respond to *E. coli* O157:H7 much like humans do. Working with the pigs in a germ-free environment that eliminated any outside contamination, Baker and Francis found that, although some human and bovine *E. coli* strains were highly virulent, one of the human-origin strains did not cause serious illness or death in the animals. Five of the bovine-origin strains caused no serious effects.

There is a distinct difference in the illness caused by virulent and avirulent strains, Baker summarizes. "The strains we already knew that caused illness in humans were more virulent in the animals."

Francis says the finding falls into line with genetic marker studies of *E. coli* O157:H7 by Andrew Benson, University of Nebraska scientist. Benson has noted that *E. coli* strains separate into two "clades" or groups within the same species. Bacteria strains from human disease almost invariably separate out into one of these two clades, and the majority of bovine strains fall into the other.

"The upshot of all this is that probably the strains that cause disease in people have been selected from the more virulent strains that are moving through the cattle population," Francis says.

"We knew from what other investigators were finding that there were more sources of potential contamination out there than would be accounted for by the number of cases of human disease. There is probably a lot of subclinical or overlooked infection in people."

SO WHY DON'T ALL STRAINS of *E. coli* O157:H7 pack the same punch in making people ill?

"If not all *E. coli* O157:H7 strains are created equal, it would be nice to know which ones are going to cause a lot of havoc," Francis says.

The scientists looked at three different possibilities. One was called "adherence." A protein called intimin is associated with the ability of the *E. coli* O157:H7 bacteria to adhere to cells. They drew a blank, finding no correlation between how well bacteria adhere to cells and how virulent a strain is.

Next they examined two toxins produced by the *E. coli* strains included in the research.

This hit pay dirt.

The amount of Shiga toxin type 1 not significant in determining if a strain was virulent or not.

"However, with Shiga toxin type 2, there was a strong correlation between amount of toxin produced and how virulent the strains were," Francis says. "This needs to be confirmed, but it would suggest the amount of Shiga toxin type 2 is important in assessing the virulence of these strains."

This wasn't a major surprise to Francis. A South Dakota State University study some years ago looked at *E. coli* O157:H7 strains that either had the capacity to produce Shiga toxin type 1, Shiga toxin type 2, or both. The experiment found that strains of the bacterium had to produce Shiga toxin 2 to be highly virulent to pigs in the experiment. Scientists elsewhere have since corroborated those findings.

"There have been some other studies in this area but they don't differentiate between Shiga toxin 1 and Shiga toxin 2," Francis says. "When you lump the two together, you're not going to get a lot of data, because Shiga toxin 1 will dilute the more virulent Shiga toxin 2."

Another student scientist will likely repeat a part of Baker's study to verify the findings, Francis says. In the long run, he adds, the new knowledge could help health professionals to know early in an *E. coli* O157:H7 outbreak how virulent the strain is.

Baker adds that the study could be one stepping stone in learning how to deal with the toxins produced by *E. coli* O157:H7 bacteria.

And it may help food safety inspectors go after the real villain in *E. coli* O157:H7 outbreaks. "Our research is pointing to the Shiga toxin type 2 being the significant factor," Baker says.

"It could be the piece that will lock the whole puzzle together."◆

E. coli primer

- There are hundreds of strains of *E coli*; most are harmless or actually beneficial to humans. In return for our giving them homes in our guts, they provide us with vitamins, especially vitamin K and the B-complex vitamins. *E coli* O157:H7 is one of the virulent strains.

- Five billion bacteria of various kinds, including the *E coli* group, may be living in your intestines; to put that in perspective, there were 6.2 billion people alive on earth in 2000.

- *E coli* O157:H7 is responsible for three types of infections in humans: urinary tract infections, neonatal meningitis, and intestinal diseases (gastroenteritis). Symptoms depend on state of health, natural resistance, and the number of organisms ingested.

- Contaminated hamburger which has been incompletely cooked can carry *E coli* O157:H7. Cook ground beef patties to 160 degrees F. Use a meat thermometer to determine if meat has been cooked to a safe level; there are dial and digital types. Digital thermometers are handier for meat patties. Color of meat or juice is not an indicator of cooking to a safe level. If browning ground beef for a meat dish, add about a cup of water for each pound of meat. This makes it easier to break up the meat and evens out the heating. Let the water boil away and then continue browning.

- *E coli* O157:H7 survives in the refrigerator and freezer. It can only be killed by cooking to 160 degrees F.

- *E coli* is everywhere in the environment, so wash your hands, wash your countertops, wash your fruits, wash your vegetables!

- It only takes 10 or so *E coli* O157:H7 bacteria to infect a human, says the U.S. Food and Drug Administration.

- The *E coli* genome has been mapped. Scientists speculate that some time in the past, an *E coli* was attacked by a virus (phage) that inserted its own DNA into the *E coli* chromosome; every time the bacterium multiplied, the virus DNA went along for the ride, and this strain became *E coli* O157:H7. The virus genes contribute information for the production of the toxin that causes the damage to human intestinal cells.

- *E coli* has been called the "lab rat of the scientific world" because it is convenient to work with and it can double its numbers in only 20 minutes.

- It is also the "canary of the environmental world." Since it is a regular inhabitant of human intestines and feces, it has become an indicator of pollution and water contamination.

- The combinations of letters and numbers, as in *E coli* O157:H7, refer to the specific markers found on the surface of the bacterial cell.

- For more information on safe food preparation, contact your local Extension office, see www.foodsafety.gov or e-mail hegerfeld.joan@ces.sdstate.edu

Odor control

Proposals to build hog-confinement operations

can prompt concerns from local citizens about odor, even in rural counties in South Dakota. South Dakota State University scientists and engineers are using science to help address the odor problem so that public and agriculture can live in harmony.

At least three projects are under way: an outdoor biofilter that takes odor and waste nutrients out of the air as it is being pumped out of the building, an indoor biofilter that can trap dust and odor in barns, and a photobioreactor that uses algae to reduce odors from livestock facilities. Still on the drawing boards is another project that will use soybean oil or sunflower oil to remove dust and ammonia from air.

AN OUTDOOR BIOFILTER is cheap and easy to build, says Extension Swine Specialist Bob Thaler.

"This is not rocket science. It's compost and woodchips, pallets, and mesh," Thaler says.

Thaler and Stephen Pohl, agricultural and biosystems assistant professor, have installed a biofilter outside a hog barn at the Agricultural Experiment Station's Southeast Research Farm near Beresford. Nick Michael, sophomore ag and biosystems major from Yankton, helped fine-tune and build the filter, which was funded initially in part by the South Dakota Pork Producers Council.

Thaler explains that the filter only works on mechanically ventilated hog barns. Fans also must be powerful enough to force air through the biofilter.

At the grow-finish barn, Thaler, Pohl, and Michael built plywood ductwork to direct air under a group of wood pallets. They spread a mesh netting on top of the pallets to keep material from falling into the area beneath, and finally they spread about 14 inches of compost mixed with woodchips on top of the mesh-covered pallets. They keep the biofilter moist so that the microbes in the compost/woodchip mixture stay alive.

The reduction in odor concentrations so far has been 90 to 95%, Pohl says.

Samples of air entering and leaving the filter were collected in Kevlar bags. The samples were sent to the University of Minnesota where a trained panel of humans evaluated them—still the only way to evaluate odor.

"There's no such thing as an electronic nose," Thaler says.

More than 200 gases that make up hog odor, he explains. That means that while individual components such as hydrogen sulfide or ammonia can be measured in air samples, the human nose is still the best way to evaluate whether the odor level is high in a sample.

Biofilters already have been used elsewhere with good success. University of Minnesota studies show biofilters reduced emissions from nursery and gestation barns by 90 to 95%. Some hog producers already are using such filters on their farms.

TRICKLING FLOW FILTERS at water treatment plants are in the background of a biofilter prototype designed by Mylo Hellickson, professor of agriculture and biosystems engineering. In treatment plants, water trickles over rocks that provide a place for bacteria to grow. The bacteria feed on nutrients in the wastewater.

Similarly, Hellickson's prototype will pass air over multiple layers of plastic mesh while a low-pressure sprinkler system similar to the ones that keep vegetables moist in grocery stores will keep the mesh wet.

Hellickson says the sprinkling system alone will take some dust out of the air. In addition, the wet mesh will provide an ideal environment for bacteria. They will feed on waste nutrients in the air trapped as the air passes over the layers of mesh.

Eventually a layer of slime—made up of the type of things found in the air of a hog barn, including dust, dandruff, molds, yeasts, feed particles—will build up on the mesh and then be washed off by the water. Installed in a hog barn, the filter would be placed where debris would fall into the waste pit below the barn.

Hellickson can evaluate how well the filter removes ammonia, dust and hydrogen sulfide when he changes variables such as air flow, the misting rate, and the number of layers of mesh.

A grant from the National Pork Producers Council partially funds the project.

Scientists at Ataturk University in Erzurum, Turkey, a sister university to South Dakota State University, are working on the same concept for use in poultry facilities.

Algae thrive on waste nutrients in farm ponds and basins, even to the point of forming a green scum in the summertime. Gary Anderson has scooped up some of these little green cells and deposited them in a photobioreactor in his lab. The instrument has 21 separate chambers that can evaluate factors such as different lighting and air flow rates that can affect the appetite of algae for nutrients in the water and air of a hog barn. Perhaps, he says, the algal biomass when harvested will have additional uses.

ALGAE CLEAN UP the air and water in Gary Anderson's photobioreactor. Anderson is a professor in the Agricultural and Biosystems Engineering Department.

Most biofilters work on the same general principle, Anderson says, running waste nutrients past living organisms so that the organisms can use the nutrients—such as nitrogen, phosphorus, carbon, and sulfur—to make cell biomass.

Anderson's project, however, has a twist: Light is a necessary ingredient to help algae thrive as they process waste nutrients. He has tested a table-top model and now is building a much larger one that will feature 21 separate chambers. That will give him 21 different sets of data to evaluate which variables—different placement of lighting, for example—are most successful in getting algae to use nutrients.

It should be possible to at least partially clean the air from hog barns by bubbling it through an algae solution, Anderson says. Similarly, liquid waste can be strained to separate solids, then added as a liquid fraction to an algae solution to provide the nutrients the algae need.

Anderson said the algae would be harvested regularly. He adds that in the long term, the algae grown in the photobioreactor could become even more important than the environmental benefit they provide. There are more than 30,000 types of algae, he says, and some species in cold climates produce valuable omega 3 fatty acids. That raises the possibility that such algae could be raised and sold as a livestock feed ingredient to add omega 3 fatty acids to meats.

It's also possible to make algae produce hydrogen, which is being talked about as the fuel of the future.

Anderson is just beginning another AES funded project that would use soybean or sunflower oil to remove ammonia and dust from air. About 60 to 70% of hog odor may be associated with dust, he says.◆

Bales of opportunity

Ethanol plant operators want a steady stream of grain trucks rolling onto their scales. Will these same operators someday be off-loading bales of grass? Or will Small Town, S.D., be burning biomass for electricity?

It's not out of the question, say scientists across the region.

South Dakota State University is one of the northern plains land-grant schools exploring this possibility. Its partner in the research is the Great Plains Institute for Sustainable Development (GPISD) out of Minneapolis, which is coordinating a $1 million project awarded by the U.S. Department of Energy.

"Agriculture has always produced food," says Fred Cholick, dean of the College of Agriculture and Biological Sciences. "It is still first and foremost the prime mission of South Dakota producers, and it is first and foremost our mission to support that production. The list of projects in the research portfolio included in this magazine shows our commitment to this goal.

"However, it is also our mission, as it is for every land-grant institution in the U.S., to enhance economic opportunity and quality of life. Exploring biomass production is an opportunity that could lead to additional energy for our citizens, enhanced rural incomes, and stabilized small towns in South Dakota.

"Growing biomass for ethanol does not mean replacing our most productive commodity crops with grass. There's plenty of marginal land to go around, these acres can't return much of a profit if intensively farmed.

"Turning marginal land into grass that can be used to make ethanol or electricity also improves our quality of life and sustains us all. Grass adds, or returns, diversity to the rural landscape. Grass holds the soil, sequesters carbon, helps clean up runoff, provides habitat for wildlife," Cholick adds.

"The point that should be emphasized is 'diversity.' Growing both energy and food crops could diversify a producer's on-farm management options and could also provide access to new markets, thus providing economic diversity as well. This opportunity for diversity moves

Arvid Boe, SDSU forage breeder

right into the town, in the development of jobs and allied industries, for example.

"Remember, not so many years ago you couldn't find a soybean field anywhere in the state except the southeast corner. And before that, hybrid corn was a novelty. Who knows, switchgrass may be our next money crop."

THERE ARE HURDLES to jump before that becomes reality.

The U.S. Department of Energy (DOE) has designated switchgrass, a warm-season tall-grass prairie native, as a potential biomass energy crop, chosen because it produces more biomass than most other native grasses. Hybrid poplar and willow were DOE's plants of choice in other parts of the country.

The DOE forecasts that eastern South Dakota and surrounding states would be well placed to cash in on switchgrass as an energy crop.

Harvested and baled with conventional farm equipment and delivered to an energy conversion plant, a ton of switchgrass can produce approximately 80 gallons of ethanol, according to North Dakota scientists working on the economics of production.

If that doesn't seem like a good-enough return, consider the cost of producing those 80 gallons.

Ethanol from switchgrass can produce about five times more energy than it takes to grow, harvest, and deliver it, according to studies by Oak Ridge National Laboratory (ORNL) scientists.

But patience is required. Plenty of it.

The first year is the toughest for the producer. First-year costs per acre in a Nebraska study that included four cooperating farmers in South Dakota and others from Nebraska and North Dakota, averaged $75, and some farmers didn't bother to harvest. The project is 3 years old.

Growing a perennial crop means "you're in it for the long haul," says Arvid Boe, forage breeder at South Dakota State University.

"You may have large establishment costs, but yields will rise and you've probably got at least 10 years of harvests ahead of you. You might spread a little nitrogen fertilizer once or twice. Otherwise, you leave the grass alone to do its thing.

"The people conducting this three-state research expect long-run total production costs of $30 a ton. And about $10 per ton to get the bales to the nearest plant."

And that's another hitch.

A power or ethanol facility isn't likely to modify its operations unless its managers can be assured of significant and steady inputs of biomass crops. Growers aren't likely to plant biomass fields unless they have a market.

A unique venture in southern Iowa is meeting that challenge head-on, says Boe.

The Chariton Valley Resource Conservation and Development nonprofit is affiliated with USDA and linked up with Alliant Power, a major Iowa energy company. USDA gave the farmers authorization to use existing CRP land for a 4,000-acre biomass demonstration area, giving the producers an income while waiting for the switchgrass to establish and the market to develop. Knowing the biomass crop would be coming gave Alliant the impetus to go ahead with plant modifications, which to this point have all been made with conventional technology. The first co-firing tests burned 1,269 tons of switchgrass and provided about 3% of the heat input to the power plant. No environmental incidents and no drop in electricity output occurred. Studies on possible corrosion and fouling effects are next.

The Chariton producers hope to scale up to 50,000 acres of switchgrass producing 200,000 tons of biomass per year to supply 5% of the power plant's fuel. Put another way, that would mean delivery to the boiler during full-load operation of 50 1,000-pound bales per hour.

> **"One way or another, this work here and across the Northern Great Plains is going to enhance economic opportunity and improve the quality of life for all who live here. I can already say that with certainty."**
>
> —Arvid Boe, SDSU plant science professor

That's one use of switchgrass, says Boe. "Switchgrass for ethanol production is another. The economics on this one are still out. The DOE projects, however, that the cost of producing ethanol could be reduced by as much as 60 cents per gallon by year 2015 with some new cellulose conversion technology.

"TO SOME OF US, growing switchgrass for itself is enough. If it's grown for biomass, it's cut once a year, in the fall after frost, leaving about a 6-inch stubble. In the meantime, it's home for pheasants, grouse, and grassland birds.

"Ornithologists say grassland birds are declining faster than any other group of birds in North America, faster than forest dwellers, faster than waterfowl. They say it's due to loss of habitat. It'd be nice to give birds back a place to live," Boe says.

Switchgrass grown on marginal lands would stabilize the soil, reduce soil erosion and siltation, and reduce nutrient runoff. There's very little soil compaction and soil disruption from machinery, Boe adds.

"THE GPISD GRANT takes us back to basics," says Boe of the grant awarded in fall of 2002. "We'll leave the economics and forecasting and power plant conversions to others."

The grant evolved from a previous cooperative project with USDA-ARS, he adds. "We worked on growing native grasses for biomass production before and we will keep on after this grant runs out. We anticipate funding from sources such as the Sun Grant Initiative."

It is a four part integrated program:

- Boe's in charge of genetics. He is evaluating existing switchgrass cultivars and developing new cultivars specifically for biomass production in South Dakota and neighboring states. For example, the 19-acre switchgrass biomass production field on the Central Grassland Research Station in North Dakota was seeded to 'Sunburst,' a South Dakota AES cultivar.
- Vance Owens, forage researcher, is point man for the GPISD project. He is comparing production and energy conversion potential of pure and mixed stands of switchgrass, Indiangrass, and big bluestem. These are the three dominants of the tallgrass prairie once found along the eastern edge of South Dakota. He has cooperating farmers in South Dakota, Minnesota, and North Dakota.
- Jim Doolittle and colleagues in plant science are focusing on the ability of native grasses to tie up carbon in the soil.

  All plants remove carbon dioxide from the atmosphere and incorporate it into plant tissues. Switchgrass just does a better job of this than many other plants. At harvest and burning, carbon dioxide is again released into the atmosphere. Left behind, however, is at least half the biomass underground where the carbon is also sequestered. Switchgrass roots can penetrate the soil to 10 feet, and their underground mass may equal a year's worth of above-ground growth.
- Ken Higgins from the Wildlife and Fisheries Sciences Department will set his graduate students to determining bird species richness and their habitats on biomass-producing grasslands. The students will be working in South and North Dakota, Minnesota, and Nebraska.

Switchgrass, a tall-prairie native, has been chosen by the U.S. Department of Energy as a potential biomass energy crop that could provide enhanced economic opportunity on farms and in communities in eastern South Dakota. Meantime, it has value, says Arvid Boe, simply by its presence in the landscape.

HOW FAR WEST INTO SOUTH DAKOTA could switchgrass biomass production extend?

"It depends on the soils and particularly on drought cycles," Boe says. "Much farther west than Pierre, we couldn't rely on sustained profitable production.

"But we're having pretty good luck at Pierre. Of course, last year was so dry we went from 5 tons per acre of switchgrass production in 2001 to a little over a half ton in 2002."

It's not just east-west. The north-south gradient also determines switchgrass success.

"Native grasses have a relatively narrow adapation range latitudinally. If you move an individual plant up here from Nebraska, it could be very lush and high-yielding but mature late and never get around to producing seed," Boe explains.

"That wouldn't be a problem if biomass production were your goal, but not producing seed and not surviving winter seem to go hand in hand. And since we're developing cultivars for biomass production, we need seed."

WILL SOMEDAY the wagons and flatbeds be lining up at South Dakota ethanol and power plants? That's beyond the ability of any person to predict. But, Boe says, "We're going to get some excellent grass cultivars and a whole lot more knowledge of how the prairie functions out of this research.

"One way or another, this work here and across the Northern Great Plains is going to enhance economic opportunity and improve the quality of life for all who live here. I can already say that with certainty."◆

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AES RESEARCH PROJECT PORTFOLIO

Administration

G-012	Planning the Sun Grant Initiative; Kephart, Tidemann, Cassel, Tschetter
G-022	Four-state ruminant consortium; Kephart, Boggs
G-042	Consortium for alternative crops; Tidemann

Agricultural & Biosystems Engineering

H-023	Assessing potential transport of antibacterial chemicals in the landscape; Trooien, S. Clay, Thaler, Werner
G-041	Effect of calcium on functional and structural properties of mozzarella cheese; Muthukumarappan
H-062	Effect of cheese calcium and phosphate on functionality and structural characteristics of process cheese; Muthukumarappan, Julson, Metzger
H-072	Management of water and biological effluent for crop production in South Dakota; Trooien
H-091	Enhancing the value of South Dakota agriculturally based materials; Julson, Muthukumarappan, Henning, West
H-102	Swine facility design for odor reduction; Hellickson, Pohl, Thaler
G-122	Acquisition of a rheometer for research and teaching; Muthukumarappan, Mahappattra, Julson (equipment grant)
R-130	Improvement of thermal and alternative processes for foods; Muthukumarappan, Julson, Krishnan, Wang
H-141	Enhancing post-frame building design for reduced environmental impact, increased structural integrity, and energy efficiency; Anderson, Schippull
H-229	Impact of climate and soils on crop selection and management; Bender
H-262	Engineering technology applied to quality and production issues in Northern Plains agriculture; Humburg, Long, Robert, Kvien, Clay, Carlson, O'Neill, T. Schumacher, L. Schumacher.

Animal & Range Sciences

H-012 Marbling and fresh meat quality; Maddock
H-033 Effects of water quality on cow/calf production; Johnson, Patterson, Gates, Walker, Beutler, Epperson
H-043 Adding value to South Dakota and Great Plains lambs by evaluating and reducing the incidence of lung lesions; Daniel, Burns, Held, Epperson, Holler
H-087 Production systems to reduce cost of production and improve reproductive performance of beef cows; Pruitt
H-131 Factors affecting nutrient utilization and excretion by growing swine; Stein
H-132 Minimizing neonatal lamb losses; Daniel, Held, Epperson
H-149 Genetic and environmental factors affecting meat quality; Wulf
R-170 Molecular mechanisms regulating skeletal muscle growth and differentiation; McFarland
H-172 Hormonal control of growth and reproduction in swine; Clapper
H-192 Production systems to reduce the cost of production and improve reproductive performance of beef cows; Pruitt, Clapper, Epperson, Owens, Patterson, Young
H-281 Nutritional management of health and growth in beef cattle backgrounding programs; Pritchard
H-292 Improving economic and environmental sustainability of South Dakota pastures through multiple-season use and correct stocking rate; Smart
H-312 Alternative feeds as energy and protein sources in beef cattle production systems; Tjardes
H-351 Grazing patterns and plant responses to grazing on mixed-grass prairie vegetation; P. Johnson, Patterson, Xu, Walker

Biology/Microbiology

H-059 Genes important in livestock health; Westby
H-088 Mechanisms of viral persistence and pathogenesis; Wang
H-089 Use of native plants and a permacultural approach for development of niche markets crops for the Northern Great Plains; Reese
H-110 Genetic modification to enhance crop quality and insect resistance; Cheesbrough
H-151 Production of organic chemicals from biomass; Gibbons, West, Julson
H-152 Biotechniques to enhance wheat germ plasms; Yen
H-168 Ecological analysis of land-water interactions in prairie environments; Troelstrup
H-191 Analyses of mammalian genes (agouti, mahogany, POMC) that regulate pigmentation, obesity, fertility, and systemic physiology; Granholm, Westby, Marshall, Campbell, Diggins
R-392 Science and engineering for a biobased industry and economy; Gibbons, Julson

Chemistry/Biochemistry

G-032 Acquisition of a 10MM broadband NMR probe; Rice (equipment grant)
H-049 Analysis of pesticides and related substances; Matthees
G-051 Calcium signaling during embryonic development in cattle; Sergeev
H-090 Characterization of livestock sperm that demonstrate susceptibility to DNA denaturation in situ; Evenson
G-129 Corn-based production of commercially available gellan gum; West
G-142 Characterization and plasticization of rigid sorption domains in soil organic matter; Schindler
H-179 Calcium and vitamin D regulation of cellular processes in domestic livestock and poultry species; Sergeev
H-182 Microbial biomass conversion into specialty chemicals; West
G-210 Molecular probes of bull sperm nuclei producing abnormal embryos; Evenson
S-996 Analytical services; Thiex

Dairy Science

H-031 Improving the quality and consumer acceptance of milk and dairy products; Baer
H-100 Expanding use of whey in food products; Dave
H-101 Improvement of the nutritional value of process cheese and methods of management and utilization of dairy byproducts; Mistry, Specker, Vukovich
H-121 Strategies for improved health and productivity of early lactation dairy cows; Hippen, Schingoethe, Kalscheur
R-209 Modifying milk fat composition for enhanced manufacturing qualities and consumer acceptability; Schingoethe, Baer, Hippen
H-272 Strategies to increase the utilization of co-product and traditional feeds for lactating cows; Schingoethe, Hippen, Kalscheur, Garcia
H-302 Strategies to reduce nutrient losses to the environment from dairy cattle; Kalscheur, Hippen, Schingoethe
R-342 Metabolic relationships in supply of nutrients for lactating cows; Hippen, Schingoethe, Kalscheur
R-352 Management systems to improve the economic and environmental sustainability of dairy enterprises; Kalscheur, Hippen

Economics

H-021 Case profile of profitability determinants in the South Dakota beef cow-calf enterprise; Cumber, Dunn, Hamilton
H-069 Changes in global patterns of food products trade: implication for the U.S. and South Dakota; Qasmi
H-081 Agri-environmental policy options and implementation based on multifunctionality; Dobbs
H-148 Rural labor markets and factors influencing rural/urban and metro/nonmetro migration; Adamson
H-160 Value added agriculture in South Dakota: its impact on structure, efficiency, prices, and agricultural policy; Taylor, Klein
H-200 Perception of biotechnology, biotech produced agricultural products and implications for risk management; Franklin
H-222 Value-added agriculture activities in a changing food and fiber system; Van der Sluis
H-252 Representative farm and agricultural land market analysis for South Dakota; Janssen
R-382 Enhancing the competitiveness of U.S. meats; Fausti

Family & Consumer Sciences

SD0001 Liquid chromatograph mass spectroscopic measurement of folic acid and natural folates in food; Krishnan
H-098 Promoting healthy families and communities through high school relationship education; Gardner
H-202 Soy phytochemicals: chemistry, analysis, processing, and health impacts; Wang, Krishnan, Matthees, Scott, Woodard, Julson
H-211 Value addition of cereal, grains and oilseeds: investigation of bioactive compounds of economic, health, and food value; Krishnan, Wang, Scott, Grady, Muthukumarappan, Doehlert
R-238 Impact of technology on rural consumer access to food and fiber products; Lyons
R-311 Using stage based interventions to increase fruit and vegetable intake in young adults; Kattelmann

Horticulture, Forestry, Landscape & Parks

MS-028 Trends impacting forest production and forest recreation: 2010; Stubbles
MS-048 Restoring riparian woodland in agroecosystems of the Northern Great Plains; Johnson
H-112 Dormancy and early acclimation responses of woody plants; Fennell
H-198 Evaluation, selection, and management of turfgrass species/cultivars by geographical region in South Dakota; Schleicher
MS-239 Evaluation of native and introduced trees and shrubs for South Dakota in relation to their growth on varied soils in urban landscapes; Evers
R-258 Freeze damage and protection of horticultural species; Fennell
H-261 Cultural practices optimizing growth of herbaceous horticultural plants in the Northern Great Plains; Burrows, Fennell, Schleicher, Reese
R-270 Integrating biophysical functions of riparian systems with management practices and policies; Schaefer, Johnson, Boettcher

Plant Science

H-011 Winter wheat breeding and genetics; Ibrahim, Jin, Langham
H-013 Estimating phosphorus release from South Dakota soils; Gelderman, German, Schindler
H-038 Nutrient recycling in crop rotations; Woodard
H-058 Ecological and alternative management considerations for corn rootworms in the Northern Great Plains; Fuller, McManus
H-068 Spring wheat breeding and genetics; Rudd, Jin
H-077 Development and utilization of oats and rye adapted in South Dakota; Reeves
H-078 Genetics of fungal pathogens of row crops; Chase
H-079 Sunflower breeding and testing of alternative oilseed crops; Grady
H-092 Biological control of Fusarium head blight and other wheat diseases; Bleakley
H-099 Soybean breeding, genetics, and production; Scott
H-108 Breeding perennial grasses and legumes for forage, wildlife habitat, and tolerance to stresses; Boe
H-111 Pedology information transfer for South Dakota; Malo, Doolittle, Schumacher, D. Clay, S. Clay, Carlson, Gelderman, Ellsbury, Lee, Lindstrom
H-117 Forage production, quality, and persistence; Owens
H-118 Weed management in conventional and alternative cropping systems; S. Clay
R-128 Supplemental information support for pesticide use in minor crops; S. Clay
H-138 Wireworms of the Northern Great Plains; Johnson
H-150 Influence of potassium (K) rate, placement, in-season treatment, hybrid, and tillage on K deficiency in corn; Gelderman
H-159 Soil management for improved soil quality and reduced biostress; T. Schumacher
H-161 Studies of host-parasite interactions between small grains and their fungal pathogens; Jin
H-169 Etiology and epidemiology of plant viruses in South Dakota; Langham
H-178 Corn genetics, physiology, and breeding; Wicks
H-180 Plant biotechnology methods and applications in agriculture; Carter
H-181 Water and soil management for maximizing returns to agriculture; Kohl, Jin, Bleakley, Johnson, Schumacher, Carlson
H-188 Fate and transport of waste components when land-treated; Doolittle
R-199 Persistence of Heterodera glycines and other regional important nematodes; Smolik

R-218 Management of eroded soils for enhancement of productivity and environmental quality; T. Schumacher, Lindstrom
H-220 Tillage and crop rotations for eastern South Dakota; Berg
H-221 Linking soil characteristics, remote sensing, simulation models, and enterprise analysis through GIS to improve site specific management; D. Clay
R-230 Characterizing weed population variability for improved weed management decision support systems to reduce herbicide use; S. Clay
R-231 Assessing nitrogen mineralization and other diagnostic criteria to refine nitrogen rates for crops and minimize losses; D. Clay
H-248 Diversifying crop rotations; Beck
R-260 Reducing the potential for environmental contamination by pesticides and other organic chemicals; S. Clay
H-282 Drought and freeze survival of winter wheat: a genomics approach; Sutton
H-291 Using emerging technology to increase agronomic productivity and producer profitability; Carlson
G-301 Linking ecological and soil property information to improve site specific management; D. Clay, S. Clay, Batchelor, Ellsbury, Carlson, Dierson, Malo, Dalsted
H-322 Bison culture; Rickerl
R-332 Breeding and genetics of forage crops to improve productivity, quality, and industrial uses; Boe
R-372 Conservation, management, enhancement, and utilization of plant genetic resources; Boe
S-957 Plant Science farm; Kohl
S-958 Plant Science greenhouse and seedhouse maintenance; Gallenberg
S-991 Seed certification; Pollmann
S-992 Seed testing; Turnipseed
S-993 Variety testing; Hall
S-994 Survey entomologist; Fuller
S-995 Foundation Seed Stock; Ingemansen

Rural Sociology

H-162 Rural Life Census Data Center; Hess
G-190 Consortium to address social, economic, and ethical aspects of biotechnology; Hess

Veterinary Science

SD-9902298 Receptor binding specificity of the K88 fimbriae of E. coli; Francis
G-052 Acquisition of a becton-dickinson facscalibur flow cytometer; Young, Francis, Chase, Erickson (equipment grant)
G-070 Biochemical basis for genetic resistance to K88 Escherichia coli; Erickson
G-120 Genomic quasispecies associated with the persistence and pathogenesis or porcine reproductive and respiratory syndrome virus (PRRSV); Benfield
R-171 Evolving pathogens, targeted sequences, and strategies for control of bovine respiratory disease; Chase, Epperson
H-208 Understanding the role of transferred maternal immunity in the development of the neonatal immune system; Young
R-219 Porcine reproductive and respiratory syndrome: mechanisms of disease and methods for the detection, protection, and elimination of the PRRS virus; Benfield, Christopher-Hennings
H-228 Control of cattle parasites in South Dakota: profitability assessment; Hildreth, Epperson
AH-241 Antimicrobial sensitivity and characterization of Campylobacter spp isolates from ovine abortions and comparison to other Campylobacter; Epperson, Holler
H-251 Description, impact, and risk factors associated with lung lesions in lambs; Epperson, Holler, Held
AH-271 Evaluation of anti-diarrhea substances in pigs; Francis
G-321 Genetic analysis of PRRSV attenuation; Ropp
AH-341 Controlling bovine viral diarrhea virus: improving methods for diagnosis and understanding mechanisms of pathogenesis; Chase, Lemire
R-362 Enteric diseases of swine and cattle: prevention, control, and food safety; Francis, Nelson, Young

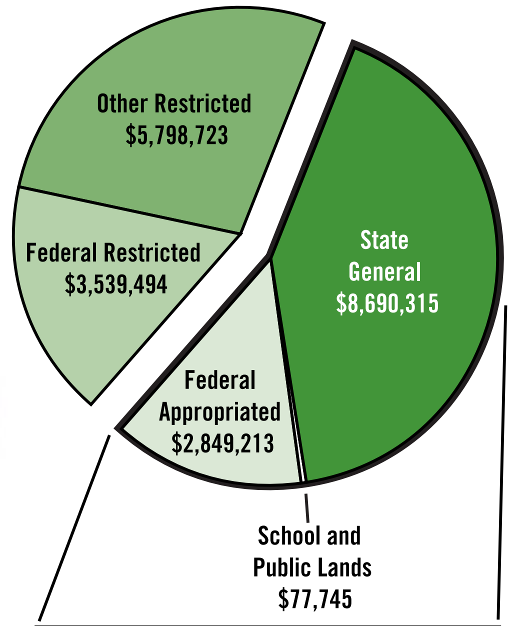
Wildlife & Fisheries Sciences

H-061 Yellow perch fingerling production and harvest methods for ponds and small glacial lakes in eastern South Dakota; Brown, Scalet
MS-071 Merriam's wild turkey in the southern Black Hills of South Dakota, survival, recruitment, movements, habitat use, and farmstead dependence; Flake
H-158 Human, habitat, and biotic influences on panfish populations; Willis
H-212 Intrasexual variation in digestive efficiency of white-tailed deer, Jenks
S-963 South Dakota Cooperative Fish and Wildlife Research Unit; Berry, Higgins

Operating Budget

South Dakota Agricultural Experiment Station

Fiscal Year 2003



Salary & benefits	$10,351,163	88.51%
Operating	$1,343,855	11.49%
Total	**$11,695,018**	

SOUTH DAKOTA STATE UNIVERSITY
College of Agriculture and Biological Sciences
Agricultural Experiment Station
Brookings, SD 57007
Kevin Kephart, Director

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