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The
Brookings
Register

Better bread: SDSU researchers improve staple

BROOKINGS — To the human eye, starch — a complex carbohydrate that is one of the greatest sources of energy for humans — appears to be a very fine, white powder. But underneath a microscope, starch granules emerge as seemingly imperfect tennis balls. Some are oval, some are round, and some are in-between — but all have that same general “round-ish” shape.

This gave South Dakota State University associate professor Srinivas Janaswamy an interesting idea. Over the past few years, Janaswamy had noticed a growing demand for “functional foods” — food that has health benefits beyond basic nutritional value — and wanted to develop his own novel functional food.

With a background in food science, Janaswamy had ideas of what types of functional foods could be developed but ran into various problems along the way. What he really needed was a carrier system that, for example, could provide the body with healthy compounds needed to fight diseases.

Starch granules, Janaswamy hypothe-



sized, could be the perfect carrier for his novel idea.

Healthy compounds

Fruits and vegetables are considered healthy foods because of the compounds found in them. Polyphenols, with their

antioxidant and anti-inflammatory properties, are particularly notable due to their potential in disease prevention. These compounds are found abundantly in almost all fruits and vegetables.

But the challenge with polyphenols is their bioavailability in the body. Polyphenols have low bioavailability for a variety of reasons, some of which are related to digestion. A good example of this is curcumin, a compound found in the roots of the ginger plant that has proven beneficial to diabetes complications. But for curcumin to provide these benefits to the body, it needs to make it to the gut — which it rarely does.

In the field of food science, researchers have been using a process called “encapsulation” to control the stability and release of polyphenols during the digestive process. Janaswamy had also previously utilized this process in his work. In the early stages of his research, he found that oriented polysaccharide fibers could be used to encapsulate different polyphenols.

See **BREAD**, page 10

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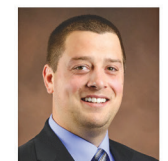
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New farming tech on display at CES 2025

LAS VEGAS (AP) — When Russell Maichel started growing almonds, walnuts and pistachios in the 1980s, he didn't own a cellphone. Now, a fully autonomous tractor drives through his expansive orchard, spraying pesticides and fertilizer to protect the trees that have for decades filled him with an immense sense of pride.

"The sustainability of doing things perfectly the first time makes a lot of sense," the first-generation farmer told The Associated Press at CES 2025, where John Deere unveiled a fleet of fully autonomous heavy equipment, including the tractor Maichel has been testing on his northern California farm.

Sustainability is a key theme this year at the annual tech trade show in Las Vegas. From Volvo CEO Martin Lundstedt announcing their commitment to net-zero emissions by 2040 to Wisconsin-based OshKosh Corporation showing off its electric fire engines and garbage trucks, companies big and small are showcasing their green innovations and initiatives.

"We absolutely need more climate-smart technologies," said Jacqueline Heard, CEO and co-founder of Enko Chem, which researches climate tech solutions in agriculture — an industry Heard says is "under a lot of pressure right now."

That much is clear on the CES show floor, where farming is on full display and company leaders are highlighting the impacts of climate change and labor shortages on farmers.

Not far from John Deere's booth where autonomous tractors and dump trucks are towering over conference attendees, Kubota, another equipment



AP photo

The KATR robot with Smart Plant Imager designed to work in agriculture and construction is on display at the Kubota booth during the CES tech show on Jan. 7 in Las Vegas.

manufacturing company, is showcasing its AI technology that detects diseases in crops and sprays where pests have been identified.

Todd Stucke, president of Kubota

Tractor Corporation, said AI is the future of farming, especially with "summers getting longer and storms getting stronger."

Stucke himself grew up on a potato

farm in Ohio. Each night after dinner, his father would scour the field for bugs and then send Stucke out to spray the crops with insecticides.

See **TECH**, page 10



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USDA-SDSU project aims to help bison ranchers

BROOKINGS — Jeff Martin has been around bison nearly his entire life. He grew up on a bison ranch in Wisconsin, worked for a large bison ranch in western South Dakota, and studied dozens of bison herds across North America. Over the last few decades, Martin has acquired a nearly unmatched level of experience working with the United States' national mammal.

Now Martin, assistant professor of bison biology and management in South Dakota State University's Department of Natural Resource Management, is considered the nation's leading Extension bison specialist, and the U.S. Department of Agriculture has awarded him a \$1.997 million research project that will support bison producers in South Dakota, Nebraska, North Dakota, Montana, Minnesota, Wisconsin and Texas.

"I'm excited to lead this team to advance knowledge about bison and their grazing ecology. We will coordinate with bison producers to implement actionable management practices that contribute to enhanced sustainability," Martin said. "Dr. Leffler and Dr. Perkins will lead efforts to understand how the soil and plants change with bison grazing while Dr. Short will generate educational resources to address bison producer needs."

The project will work to implement innovative conservation practices into ranching operations that may help improve grassland productivity. Over a three-year period, the research team will conduct an experiment on winter bale grazing systems for bison. These systems have been successfully used by cattle ranchers, and the researchers, led by Martin, have collected enough preliminary data to begin to show the systems can also benefit bison producers in the Great Plains.

"Anecdotally, some bison managers have been using bale grazing for many years without measuring the positive and negative outcomes," Martin said. "Our team is well positioned to do just that. Our goal is to improve soil microbial health, soil organic matter, dung beetle habitat, and body condition of bison over winter."

For cattle ranchers, winter bale grazing has proven to save time and money while also providing considerable benefits to their rangeland. The system is implemented prior to the first snowfall



Courtesy photo

In a new study, South Dakota State University researchers explored what strategies are being deployed by farmers in South Dakota, Minnesota, Nebraska and North Dakota to combat fertilizer costs.

as bales are arranged in a grid pattern on the rangeland. With cattle, electric cross-fencing is used to progressively move the herd around the grid throughout the winter – however, this approach seldom works with bison as they want to both play with the unrolled bales and may break through electric fences to access the next bales. As the bison move to eat, their urine and manure enrich the soil and feed microbes, which slowly release nutrients back into the field, stimulating plant growth.

In a 2023 USDA-produced newsletter, a South Dakota rancher said he saw nearly one-third higher hay production after using a winter bale grazing system.

Other South Dakota ranchers mentioned the fuel savings and time benefits that come with winter bale grazing.

During the experiment, Martin and his team will assess the environmental impact of bale grazing on the soil and wildlife habitat while monitoring bison health. The results of this work will help promote sustainable bison ranching practices in the region.

"We will also implement several workshop training modules for producers and various nationwide train-the-trainer workshops for USDA's Natural Resources Conservation Service and land-grant university Extension agents to become better acquainted with bison

biology and ecology as well as bison management practices such as winter bale grazing," Martin added.

SDSU has partnered with the National Bison Association, Tanka Fund and a private producer on this project, funded under the Conservation Innovation Grants from USDA's Natural Resources Conservation Service.

The project is part of a larger, \$90 million investment from the federal government to develop new tools, approaches, practices and technologies to further natural resource conservation on private lands.

— SDSU Marketing & Communications

SDSU releases new wheat, oat cultivars

BROOKINGS — The South Dakota State University Agricultural Experiment Station and the South Dakota State Foundation Seed Stock Division is releasing a new hulled oat cultivar and a hard spring red wheat cultivar to certified seed growers.

“South Dakota State University understands that the development of new wheat and oat varieties is vital to ensuring the economic sustainability of farmers in South Dakota and the Upper Midwest,” said John Blanton, associate dean for research for the College of Agriculture, Food and Environmental Sciences and the director of the South Dakota Agricultural Experiment Station. “We are proud to release two new varieties that embody our commitment to agricultural innovation. These varieties represent years of dedicated research collaboration, and we hope they contribute to improved productivity, resilience, and profitability for our customers and stakeholders.”

SDSU’s plant breeding programs
See **CULTIVARS**, page 9



Courtesy photo

South Dakota State University Professor Karl Glover, pictured at left examining a wheat field, leads SDSU’s hard red spring wheat breeding program and is a member of SDSU’s Variety Release Committee. SDSU is releasing new wheat and oat cultivars to certified seed growers.



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SDSU researchers battle against turkey virus

BROOKINGS — Researchers in South Dakota State University's Animal Disease Research and Diagnostic Laboratory are racing to develop a vaccine for a new strain of a highly contagious disease that is currently wreaking havoc on the U.S. poultry industry.

Avian metapneumovirus, or aMPV, is an upper respiratory tract viral infection that affects all types of poultry but is most harmful to turkeys. The virus is divided into four different subgroups: A, B, C or D. While each subgroup can be found in different parts of the world, the U.S. has previously only experienced outbreaks of subgroup C.

That was until last January.

SDSU assistant professor Sunil Mor and his research team identified the U.S.'s first known instance of aMPV subgroup B after testing a sample from an outbreak in a North Carolina turkey flock. The news of subgroup B's arrival was surprising to virologists and veterinarians around the U.S. and sent shockwaves through the U.S.'s \$67 billion poultry industry. Four months after Mor identified the virus, it had spread to all the major poultry-producing regions in the U.S.

Minnesota is the country's largest producer of turkeys, and reports from the state's independent producers during a recent aMPV working group session paint a grim picture. Egg shortages. Thousands of dead birds. Entire operations on the brink of bankruptcy.

The virus is challenging in that it "moves silently," according to Mor. Once a producer notices symptoms, like a cough, nasal discharge or swelling, the entire flock is already most likely infected. The aMPV virus doesn't usually outright kill the birds, Mor said. But it weakens their immune system so much that a secondary infection, like *E. coli*, will. With limited antibiotics available for treatment, the challenges turkey producers face are being compounded.

"Producers are facing the issue from different sides," Mor said. "This is why the virus is so threatening. The economic impact is huge."

This all comes at a time when the turkey industry is still reeling from the highly pathogenic avian influenza (HPAI) and other ongoing diseases.

Official numbers of aMPV cases are difficult to count because the U.S. Department of Agriculture does not offi-



Courtesy photo

Researchers at SDSU identified a highly contagious disease that is currently causing significant problems for the U.S. poultry industry — and are now working toward developing a safe and effective vaccine.

cially track aMPV infections. However, the National Turkey Federation estimated in September that the virus is present in 60%-80% of U.S. flocks.

It's not just turkeys being affected; chickens are dying, albeit at a lower rate. Turkey breeders are also seeing significant reductions in eggs being produced, which is leading to a national shortage of poult.

The SDSU team, headed by Mor and Tamer Sharafeldin, an SDSU assistant professor and veterinary pathologist, is leading a nationwide effort to develop safe and effective vaccines for aMPV subgroup B. Vaccine development began immediately after subgroup B was first identified back in January. The team successfully isolated the virus in just four weeks and since been able to "weaken" it — a key part of vaccine development. Now, the researchers are in the process of developing the baseline criteria for testing the vaccine's efficacy.

"Our main concern right now is developing the vaccine," Sharafeldin

said. "It's our top priority."

But the vaccine is only part of the solution. The SDSU team is also working to develop very specific diagnostic testing that will help producers identify the virus quicker.

"There's a very small window to detect the virus," Mor said. "This testing is more specific to subgroup A and subgroup B."

Improved testing will help producers manage this multifaceted challenge better while the vaccine is in development, which in these instances, takes around two to three years to get on the market. However, the circumstances may allow for the vaccine to be expedited, and Mor is hopeful the development timeline can be shortened.

"We are working hard to provide the vaccines to producers," Mor said. "Our target is next year, hopefully in the fall, to complete all vaccine trials."

The SDSU team is working to not only develop a safe and effective vaccine, but also to improve testing. This will help

poultry producers minimize losses while the vaccine is in development.

aMPV poses little to no risk to humans. While other metapneumoviruses may affect humans, aMPV does not. Turkeys that have been infected with aMPV and pass USDA inspection at slaughter are also safe to eat.

The SDSU team members, the first to discover aMPV subgroup B in the U.S. and the first to isolate the virus, have cemented themselves as nationally recognized leaders in aMPV research and are continuing to work closely with poultry producers and industry stakeholders to solve this complex challenge.

"I am impressed with Dr. Mor's close connections to poultry production stakeholders and his responsiveness to help improve the health of their flocks," said Angela Pillatzki, director of Animal Disease Research and Diagnostic Laboratory. "His research contributions will positively impact poultry production for years to come."

— SDSU Marketing & Communications

Solar farms putting hungry sheep to work

BUCKHOLTS, Texas (AP) — On rural Texas farmland, beneath hundreds of rows of solar panels, a troop of stocky sheep rummage through pasture, casually bumping into one another as they remain committed to a single task: chewing grass.

The booming solar industry has found an unlikely mascot in sheep as large-scale solar farms crop up across the U.S. and in the plain fields of Texas. In Milam County, outside Austin, SB Energy operates the fifth-largest solar project in the country, capable of generating 900 megawatts of power across 4,000 acres (1,618 hectares).

How do they manage all that grass? With the help of about 3,000 sheep, which are better suited than lawnmowers to fit between small crevices and chew away rain or shine.

The proliferation of sheep on solar farms is part of a broader trend — solar grazing — that has exploded alongside the solar industry.

Agrivoltaics, a method using land for both solar energy production and agriculture, is on the rise with more than 60

solar grazing projects in the U.S., according to the National Renewable Energy Laboratory. The American Solar Grazing Association says 27 states engage in the practice.

“The industry tends to rely on gas-powered mowers, which kind of contradicts the purpose of renewables,” SB Energy asset manager James Hawkins said.

A sunny opportunity

Putting the animals to work on solar fields also provides some help to the sheep and wool market, which has struggled in recent years. The inventory of sheep and lamb in Texas fell to 655,000 in January 2024, a 4% drop from the previous year, according to the most recent figures from the U.S. Department of Agriculture.

Because solar fields use sunny, flat land that is often ideal for livestock grazing, the power plants have been used in coordination with farmers rather than against them.

Shepherd JR Howard accidentally found himself in the middle of Texas’ burgeoning clean energy transition. In 2021, he and his family began contracting with solar farms — sites with hundreds of

thousands of solar modules — to use his sheep to eat the grass.

What was once a small business has turned into a full-scale operation with more than 8,000 sheep and 26 employees.

“Just the growth has been kind of crazy for us,” said Howard, who named his company Texas Solar Sheep. “It’s been great for me and my family.”

Following the herd

Some agriculture experts say Howard’s success reflects how solar farms have become a boon for some ranchers.

Reid Redden, a sheep farmer and solar vegetation manager in San Angelo, Texas, said a successful sheep business requires agricultural land that has become increasingly scarce.

“Solar grazing is probably the biggest opportunity that the sheep industry had in the United States in several generations,” Redden said.

The response to solar grazing has been overwhelmingly positive in rural communities near South Texas solar farms where Redden raises sheep for sites to use, he said.

“I think it softens the blow of the big

shock and awe of a big solar farm coming in,” Redden said.

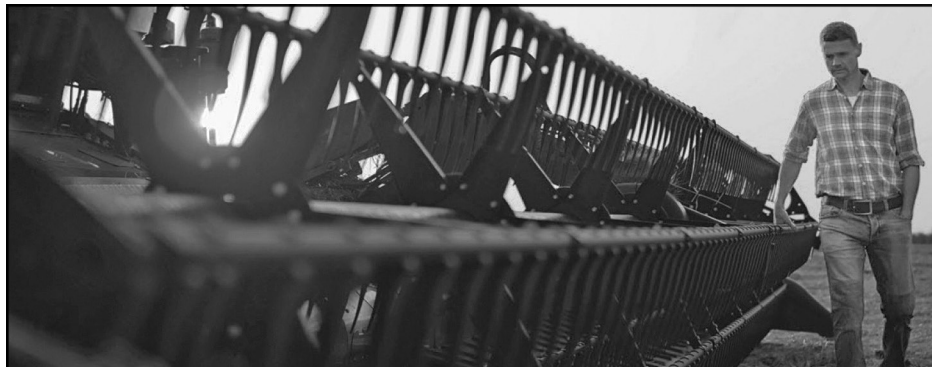
Fielding more research

Agrivoltaics itself isn’t new. Solar farms are land-intensive and require a lot of space that could be used for food production. Agrivoltaics compensates by allowing the two to coexist, whether growing food or caring for livestock.

There is a lot still unknown about the full effects of solar grazing, said Nuria Gomez-Casanovas, an assistant professor in regenerative system ecology at Texas A&M University.

Not enough studies have been done to know the long-term environmental impacts, such as how viable the soil will be for future agriculture, although Gomez-Casanovas suspects solar grazing may improve sheep productivity because the panels provide shade and can be more cost-efficient than mowing.

“We really have more questions than answers,” Gomez-Casanovas said. “There are studies that show that the land productivity is not higher versus solar alone or agriculture alone, so it’s context-dependent.”



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Feds sue John Deere over 'right to repair'

SPRINGFIELD, Ill. (AP) — Deere & Co. unfairly forces farmers to visit authorized dealers to repair their equipment, resulting in higher prices than if they could fix it themselves or get help from independent shops, the Federal Trade Commission claims in a federal lawsuit filed Wednesday with the attorneys general of Illinois and Minnesota.

The Moline, Illinois-based manufacturer produces repair software that is available only to its dealers, making it impossible for owners to seek less-costly remedies, according to the lawsuit filed in U.S. District Court in Rockford, Illinois.

The action comes as the FTC stepped up enforcement actions in the final days of President Joe Biden's administration. Deere & Co. said in a statement that the lawsuit was based on a "flagrant misrepresentation of the facts and fatally flawed legal theories."

The complaint claims that the "unfair steering practice" has boosted Deere's multibillion-dollar profits on agricultural equipment and parts while burdening practitioners "who rely on affordable and timely repairs," FTC Chairperson Lina M. Khan said in a prepared statement.

Khan said farmers should be "free to repair their own equipment or use repair shops of their choice — lowering costs, preventing ruinous delays, and promoting fair competition."

Farmers for decades were able to fix their tractors and combines themselves or take them to nearby repair shops. With increased computerization in the past few decades, Deere, the dominant industry player, made its high-tech repair tool available only to authorized dealers, who invariably eschew generic parts for higher-priced Deere parts, according to the FTC.

The company refuses to share information with independent software developers that's necessary to build their own tools, a common practice in the automotive and trucking industries, the FTC said.

Attorneys General Kwame Raoul of Illinois and Keith Ellison of Minnesota, both Democrats, joined in the lawsuit.

"Deere has made it virtually impossible for farmers themselves or independent repair shops to fully repair Deere equipment, which forces farmers to rely on authorized Deere dealers, which can



Associated Press photo

John Deere equipment is on display at the Farm Progress Show in Decatur, Ill., in 2015.

be more expensive, slower, and for some a long distance away from farms," Ellison said in a statement.

Deere & Co. asserted the FTC ignored the company's "long-standing commitment to customer self-repair" and announced an addition this week to its "suite of digital solutions" available for customers to do their own repairs.

Deere Vice President Denver Caldwell said in a statement that the company was actively involved in settlement negotiations with the FTC and said it was still answering commission questions when the lawsuit hit.

Those discussions "revealed that the agency still lacked basic information

about the industry and John Deere's business practices and confirmed that the agency was instead relying on inaccurate information and assumptions," Caldwell said.

Public pressure for self-repair has grown. A 2023 "right to repair" law in Colorado forces manufacturers to provide manuals, software, tools and parts to farmers who want to get their tractors running again themselves.

A similar law that year in Minnesota exempts farm equipment.

The Minnesota Farmers Union has been pressing lawmakers to remove that exception, union president Gary Wertish said.

The lawsuit, which the FTC approved on a 3-2 vote, fits a flurry of activity — issuing consumer refunds, taking enforcement actions against companies the agency accuses of deceptive practices and finalizing rules it deems necessary to make the marketplace fairer — leading up to the inauguration of President Donald Trump.

Trump has named Andrew Ferguson, one of the FTC's five commissioners, to be the next chairperson. Ferguson joined Commissioner Melissa Holyoak in voting against the Deere lawsuit, saying it carries "the stench of partisan motivation" and was "taken in haste to beat President Trump into office."

CULTIVARS: SD Ranger is the new oat cultivar available

Continued from page 1

— including oats, winter and spring wheats — are designed to increase the profitability of farmers in South Dakota and surrounding states by developing and releasing new cultivars. SDSU's cultivars are widely used by farmers in South Dakota. For example, around 75% of hard red spring wheat acres in South Dakota are sown to cultivars developed by SDSU's hard red spring wheat breeding program.

The cultivars are developed over a number of years at different sites, including SDSU's experiment station farms and rented land. They are tested in crop performance testing trials in different soils and moisture conditions. The SDSU Variety Release Committee, composed of producers, researchers and administrators, reviews data from the trials and decides whether to increase the number of seeds with the intent on releasing the cultivar for future sale or discontinuing it.

Oat cultivar

"SD Ranger" is a white hulled oat cultivar derived from a spring 2017 greenhouse cross of SD150160/SD150081. It was released due to its gain yield and excellent test weight. SD Ranger is resistant to smut, moderately resistant to moderately susceptible to crown rust, and moderately tolerant to barely yellow dwarf virus.

Melanie Caffe, associate professor in the Department of Agronomy, Horticulture and Plant Science, leads SDSU's oat breeding program and carries out various

research projects related to oat improvement.

"SD Ranger is a good replacement for Rushmore with similar test weight and plump seed but with higher grain yield potential," Caffe said. "SD Ranger is among the varieties approved by the milling industry."

Over the course of a three-year evaluation, SD Ranger finished second for grain yield (behind CDC Endure) and third for test weight. It exhibited an average thousand kernel weight of 35.8 g.

Seed increase and purification of SD Ranger was initiated in 2021.

An application will be submitted for a U.S. Plant Variety Protection.

Wheat cultivar

"Enhance-SD" is a hard red spring wheat cultivar from a fall 2014 hybridization of SDS4576 and Prevail in the SDSU spring wheat breeding program. Important points associated with Enhance-SD include: high yield potential, above average test weight, above average grain protein concentration, moderate resistance to Fusarium head blight and Bacterial leaf streak, and average to above average end-use quality performance.

Karl Glover, professor in the Department of Agronomy, Horticulture and Plant Science, leads SDSU's hard red spring wheat breeding program and is a member of SDSU's Variety Release Committee.

"Over the past five years of its development, we've noted that Enhance-SD seems best suited to the northern areas of spring wheat production in South Dakota,"

Glover said. "I am always happy to release a new variety, and I believe growers situated north of Highway 14 will find Enhance-SD to be very competitive in terms of grain yield production, protein content, and disease resistance."

End-use quality tests carried out at the USDA Hard Red Spring Wheat Quality Laboratory and Northern Crops Institute in Fargo, North Dakota, demonstrated that most milling and baking quality parameters associated with Enhance-SD were generally similar to or better than those of several contemporary commercial-available cultivars.

An application will be submitted for a U.S. Plant Variety Protection.

South Dakota State Foundation Seed Stock

Organized in 1944 and incorporated in 1945, the South Dakota State Foundation Seed Stock Division is a nonprofit corporation made to increase and distribute agronomically superior varieties of seed and propagating materials from the South Dakota Agricultural Experiment Station, the U.S. Department of Agriculture's Agricultural Research Service and other agriculture experiment stations for the benefit of South Dakota agriculture and the citizens of this state. In addition, the division provides storage for reserve of pure seed stock materials.

The operation is financed through the sale of seed and helps fund the continued development of new cultivars.

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TECH: Hopes high that AI can smooth unpredictability

Continued from page 3

"We sprayed the whole field, but we might've only needed to spray a part of the field or a plant," he said. "Take that analogy into vineyards, orchards and so forth, you don't have to spray everything."

This is known as "precision agriculture," Heard said. "It allows farmers to really optimize their land."

The idea, Heard said, is that farmers can expand the lifespan and improve the quality of their crops while using fewer chemicals, like pesticides and fertilizer.

"It's good for the environment. It's good for farmers," she said.

Heard said she wouldn't be surprised if AI can one day help farmers map out their land, showing them the different soil types and what kinds of crops would grow best there.

"It could be that with climate change, they should move to a crop that's much more adapted to this new world," she said.

Back at the John Deere booth, Maichel, a tree nut farmer, said he's hopeful that advancements in AI will help him better manage the unpredictability of farming. Each year on his orchard is different from the last.

"There's no sliding scale, per se, that we have to deal with as far as climate change goes," he said. "We really bend to the climate that we're dealt with. It's not something I can predict. It's really something we have to adapt to every growing season."

If someone had told him just 10 years ago that a



AP photo

The Articulated Dump Truck is on display at the John Deere booth during the CES tech show.

tractor would one day be driving itself through his orchard, he said he wouldn't have believed it. But now, he says, he sees how this evolving technology can help him adapt to the changing industry and

climate.

"We all need to eat, right?" Maichel said. "A farmer's job is one that we all need."

BREAD: Research stores antioxidants in starch pockets of bread

Continued from page 2

"The combination of both the functional ingredient and the carrier system is highly important to creating a functional food," Janaswamy said.

The roundish shape of starch granules, Janaswamy thought, would make for the perfect carrier system to encapsulate, or "pocket," compounds in by creating pores on them.

A novel functional food

After researching many different food and compound combinations, Janaswamy and Maryam Wahab, a doctoral candidate at SDSU, decided to develop a wheat bread made with porous starch loaded with curcumin or resveratrol — an antioxidant polyphenol found in red grapes.

"Porous starch has demonstrated significant potential due to its capacity to safeguard encapsulated polyphenols, which enables a gradual release during the digestive process," Janaswamy explained. "The holes and concavities increase the absorption rate of polyphenols into the starch granules."

In the experimental phase of the research, Janaswamy and Wahab prepared seven different types of breads: a white bread without any added compounds and six other breads with varying levels of curcumin or resveratrol. Previous research has shown that adding certain polyphenols to white bread can cause bitterness and "off flavors." However, encapsulating them in

porous starch granules can alleviate these concerns, Janaswamy says.

"The incorporation of curcumin and resveratrol impacted the physical characteristics of bread," Janaswamy said. "These findings further highlight the significance of carefully determining the concentration of bioactive compounds in food formulations to achieve optimal nutritional and physical properties."

One of the key findings during the experimentation phase was the antioxidant activity of the breads. The curcumin and resveratrol variations showed much higher antioxidant activity than white bread.

Antioxidants have proven to help reduce risk of disease, including heart disease and certain cancers.

The higher concentrations of polyphenol-loaded starch granules were also found to reduce the rate of starch hydrolysis of breads. Starch hydrolysis is the process of breaking down starch into smaller sugars, like glucose. Slowing down starch hydrolysis implies a slower starch digestion process, which will aid in lowering the glycemic response when consuming polyphenol-enriched breads. This could lead to a more gradual release of glucose and could potentially alleviate diabetes complications. Janaswamy notes that further research must be conducted to verify these concepts, however.

But the encapsulation of polyphenols is the key to the development of the team's novel functional bread,

Janaswamy said. The starch granules act as a physical barrier, which allows the compounds to have greater bioavailability over a longer period of time in the body.

"The results of this research suggest that our approach has the potential to enhance the nutritional value and functional properties of bread products," Janaswamy said. "They also provide the scientific fundamentals necessary for creating more nutritious bread options for consumers."

The research team's bread improves antioxidant retention and better controls starch digestion, both of which will help blood sugar management and prevent chronic diseases. While more research needs to be completed before this novel functional food reaches the shelves of local grocery stores, this study, published in the academic journal *Food Hydrocolloids* is a significant step toward increasing the healthy properties of bread through the addition of fruit- and vegetable-derived compounds.

In the future, this novel functional food could contribute to the global functional food market, which is projected to reach \$237.8 billion by 2033.

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