



Will Consumers Embrace Science-Based and Information Technologies for Food and Agriculture Products?

Consumer purchasing behavior and food choices are complex processes influenced by many social, economic and personal factors. As consumer incomes and purchasing power increases, they diversify their diets and purchase more nutrient-dense foods, including dairy, fruit, vegetables and meat. They also vary their diets with processed and prepared foods and are increasingly interested in the composition and origin of their food.



Yet nearly 500 million consumers are also smallholder farmers or rural laborers, producing basic staple crops which they rely on for most of their energy and nutrition. They face challenges such as drought, flooding, pests, stagnating wages and political instability.



Programs that provide social protection, investments, training and access to improved technology will help them grow better products and businesses and move out of poverty.

(Growing Cassava in Vietnam. Photo credit: Georgina Smith / CIAT)

But most consumers no longer produce their own food and are unfamiliar with the agricultural practices and innovations that producers rely on to keep food affordable, safe and nutritious.

In a world of “high-tech” agriculture, the distance between the consumer’s plate and the farmer’s field can lead to misunderstanding and distrust.

For producers to meet the demands of seven billion consumers today and nearly 10 billion consumers in 2050 within a changing climate, they increasingly rely on the development, customization and dissemination of science-based and information technologies and innovative production practices. Creating a dialogue and building trust between consumers, producers and policymakers is urgently needed to ensure that the world will have a sufficient supply of affordable, safe and nutritious food.

Growing Consumer Trust

How can people learn more about modern innovations, practices and technologies that enhance sustainable food systems? And how can they feel confident that they are consuming safe, nutritious products?

Farmers, agribusinesses, retailers and others in the agri-food system are directly engaging with consumers about the innovations and practices they use to produce food.



Farmers Share Their Stories

Farmers have a powerful story to share with consumers about life on their farms and how innovation adoption and modern production methods bring lower-cost food to market while conserving soil, water and biodiversity, and reducing the climate impact of agriculture.

Farmers can grow consumer trust by directly marketing their food products in farmers markets, restaurants and other public venues, and by engaging consumers in social media conversations about their practices, production methods and the challenges and successes of farming. Telling their personal stories [through videos](#) and [blogs](#) provides a direct connection between consumers and farmers as well.



In 2015 more than 167,000 U.S. farmers produced and sold food locally through intermediaries, such as local retailers, or directly to consumers. These sales generated \$8.7 billion in revenue for producers. The local and regional food sector is expected to reach \$20 billion by 2019¹.

Knowing Who to Trust

When surveyed, consumers identify university scientists and government agencies as their most trusted sources of information on agricultural production practices and dietary guidelines.

University scientists produce rigorous, science-based research about food quality, safety and crop and livestock production innovations. To increase consumer awareness of their research, university researchers collaborate with government scientists, the food and agriculture industries and consumer organizations to publish reports and educational materials about food production and nutrition. In the United States, organizations such as the **Council for Agricultural Science and Technology (CAST)** [make reports available](#) for the public covering technologies for productive, safe, sustainable agriculture.

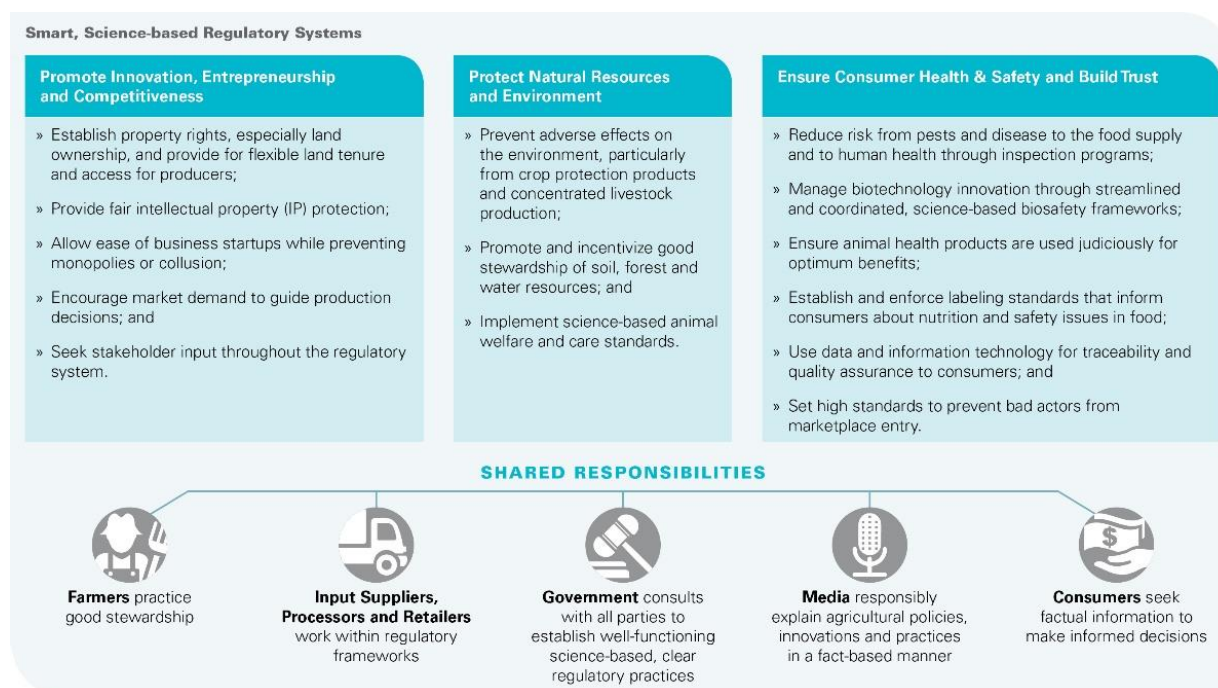
To be transparent with consumers and the general public, **private-sector agribusiness** can also share safety-related data and research results [on open platforms](#).

Governments also play a critical role by ensuring that consumers have access to science-based information to help them make choices about food and agriculture products and food safety. Examples include the consumer information sections of the [Food and Drug Administration \(FDA\) website](#) and [U.S. Department of Agriculture](#) that provide up-to-date consumer information. The [EU Commission website](#) shares food safety and agriculture technology information for consumers living in the European Union.

While public and private agricultural research and development investments spark innovations in food and agriculture systems, governments must create smart regulatory systems that build consumer acceptance and trust of those innovations.

Smart Science-Based Regulatory Systems

Governments establish agricultural policies and regulations to ensure human health and safety, protect the environment and animal welfare, and foster economic growth while meeting consumer needs for food, fiber, fuel and other agriculture products.



Regulatory systems should have a sound legal and empirical basis, minimize costs for producers and consumers and promote innovation through intellectual property protection and market incentives. They must be clear and consistent and compatible with domestic and international trade laws.

Today regulatory systems are being called upon to do even more, as consumers seek information about production methods, nutritional content, labor practices and sustainability of local, national and international food and agriculture systems.

Smart regulatory systems must keep pace with rapidly changing innovations in science and technology to help consumers gain access to safe, high quality products at lower prices. New advancements in biotechnology and bio-innovation, genetic research and plant and animal breeding will [require capacity-strengthening and innovation](#) in the existing regulatory system as well as increased investments in regulatory science and linkage with public education activities.

Smart regulatory systems rely on a shared commitment between all participants in the food system to provide science-based information so consumers understand the nutritional and environmental benefits and trade-offs of their food choices.

Consumers Take the Lead

Consumers prefer transparency and freedom of choice in the marketplace. [Research shows](#) that consumers express a desire for clear information about food and a chance to engage with food brands.

With the advent of information technologies and data on mobile phones, consumers have at their fingertips many tools to learn more about the price, origin and production methods of the food they eat. Smart labels, QR codes, apps and websites from trusted government agencies, farmers, food companies and food retailers can help them access information and make decisions about food purchases.

In the U.S., the [SmartLabel® App](#) is one example of how retailers and food manufacturers are responding to consumer demand for information about nutrition, allergens, ingredients, social-compliance programs and safe-handling instructions.

(SmartLabel® App courtesy of the Food Marketing Institute and Grocery Manufacturers Association)

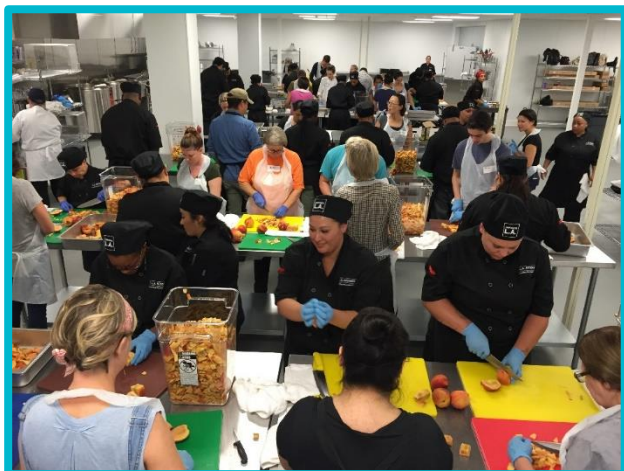


Consumers Tackle Food Waste

New initiatives have been developed in response to increasing consumer demand for fresh and safe foods, while also reducing food waste. The **U.S. Department of Agriculture** is raising awareness and suggesting practical steps consumers can take in tools such as The [FoodKeeper](#) mobile phone app, developed by USDA, the **Food Marketing Institute** and **Cornell University**. The app helps consumers decipher “best by date” labels with access to clear, scientific information on food storage, proper storage temperatures, food product dates and expiration dates.

College students are taking the lead to reduce food waste by developing [campus initiatives](#) to raise awareness and cut food waste while reusing and composting unused food.

Innovative non-profit organizations such as [DC Central Kitchen](#) and [LA Kitchen](#) are successful models for reducing hunger, improving job skills and avoiding food waste by recycling unused fresh and prepared foods.



(Volunteers and LA Kitchen trainees work side by side to prepare 3,500 fruit parfaits for the Special Olympics. LA Kitchen has a multipronged mission to reduce food waste and unemployment while combating hunger. Photo credit: Robert Egger, LA Kitchen.)

In Denmark, a [consumer-led campaign](#) to cut food waste has become a national movement serving as a paradigm for how countries can raise awareness, dramatically reduce waste and improve sustainability.

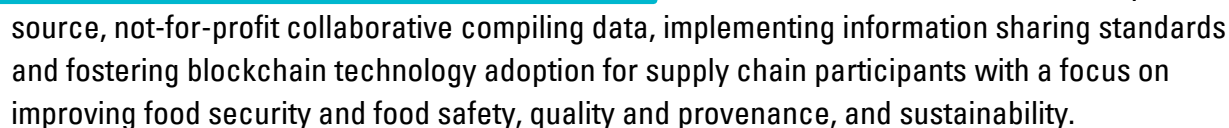
Initiatives to quantify, measure and monitor food loss and waste are foundational to define the scale of the problem. One such initiative is the [Food Loss & Waste Protocol](#), a multi-stakeholder partnership that has developed the global Food Loss and Waste Accounting and Reporting Standard, enabling the consistent quantification of baselines and tracking of progress towards the [Sustainable Development Goal 12 \(SDG 12\)](#) of halving food loss and waste.

Testing Technology for Traceability

Nearly [one in ten people around the world become ill from foodborne diseases](#) and food recalls often come late or may result in unnecessary food waste. By improving food traceability, retailers, restaurants and the food processing industry can more quickly locate and manage the source of the problem, help protect health of consumers and build trust in the food system.

Participants in the food system are beginning to explore and use a new data and information management technology, [blockchain](#), that functions as a distributed ledger for sharing secure online data in business and trading transactions.

Blockchain technology is in the early stages of development but is advancing at a fast pace. Academic researchers, food retailers and the food industry are [now exploring how to apply blockchain technology to trace and manage agriculture and food products](#) from the farm and through the processing, distribution and retail levels.



The [Global Food BlockChain](#) is an open

source, not-for-profit collaborative compiling data, implementing information sharing standards and fostering blockchain technology adoption for supply chain participants with a focus on improving food security and food safety, quality and provenance, and sustainability.

Private-sector collaborations such as the [Food Trust blockchain system](#) are testing how to apply blockchain for various global food and agriculture supply chains from farm to retail level. All of these examples are first steps in the effort to build a more traceable, safe food system.

In developed countries consumers have benefitted from productivity and innovation in agriculture, resulting in affordable food prices and sufficient supplies. But consumers are increasingly interested in the nutritional quality of food, food safety and the impact of food production on the natural resource base.

A recent [large-scale review](#) of the adoption of Bt corn (corn that is genetically modified to be resistant to the corn borer pest) by farmers in North America demonstrates how this innovation is an important part of [integrated pest management](#) that also brings benefits to consumers and the environment.

Using Bt corn has enabled farmers to gain control of the corn borer population that feeds on corn as well as other crops in nearby fields, protecting the health of the local agricultural ecosystem. Over time, fewer pesticide applications for corn and vegetable crops have been required, resulting in lower environmental impact, lower costs and more safe, nutritious vegetables reaching consumers at affordable prices.

Scientists are also developing genetically modified [potatoes that are resistant to potato blight](#) (a mold that rapidly destroys potato crops) thereby enabling reductions in fungicide applications of between 80 and 90 percent.²

Seed breeding innovation has improved the quality, yield and hardiness of vegetables. Today, scientists are using a range of traditional and advanced breeding techniques to improve the nutrition of vegetables and other crops. The recent breeding and commercialization of [broccoli with high levels of phytonutrients](#) that help reduce the risk of heart disease is an example of innovation that brings direct health and nutrition benefits to consumers.

In developing countries, private-sector vegetable breeding has provided excellent options for farmers wishing to produce more nutritious, hardy products for the growing consumer market.



Photo credit: Agribusiness Systems International (ASI), an affiliate of ACDI/VOCA



When surveyed, strong majorities of U.S. consumers say they are willing to pay more for foods without pesticide residues, despite the fact of the 99.5 percent of the 10,000 fruit and vegetables tested by USDA had pesticide residue levels far below EPA standards. (USDA Ag Marketing Service, February 2018.)

Between 2001-2002 and 2016-2017, vegetable production in India doubled, with significant credit due to private vegetable seed companies that invested in research to produce higher yield, pest-resistant products benefiting farmers, while also breeding quality traits such as taste, shelf-life and color for consumer markets.³ Indian vegetable farmers are now earning more and providing consumers with more nutritious food.

Winning the Race Against Time: Getting Nutritious Tomatoes from Farm to Plate

Case Study: Monsanto Company (Bayer AG)

The tomato is one of the most important vegetables in the world. It contains essential vitamins and minerals and is also a key source of lycopene, which has anti-oxidant properties and can help protect against heart disease and cancer. Yet in many developing countries, getting fresh healthy produce such as the tomato from the field to consumer markets is a challenging race against time.

India is one of the top three tomato-producing countries, with nearly 184 million tons of the global amount of 223 million tons produced in 2016.⁴ Despite a high volume of production, nearly 40 percent of all tomatoes grown in India are lost on the farm and along the supply chain to the market, due to pests, the lack of cold storage and inadequate road systems.⁵ These losses mean a loss of potential income for farmers and tomato transporters, lost nutritional value for consumers, along with higher prices and wasted water, soil and crop nutrients.



Plant breeders are now using conventional breeding techniques along with [advanced phenotyping breeding technologies](#) to improve the tomato plant for producers, consumers and the entire agricultural value chain. Phenotyping involves assessing the physical characteristics of an organism resulting from genetics, environment and crop management; new precision phenotyping technologies can rapidly assess thousands of breeding lines over time to help breeders select plants that can adapt to different challenges.

To improve tomato shelf-life and the firmness required to make the journey to market in developing countries like India, tomato breeders from **The Monsanto Company** (acquired by **Bayer AG** in June 2018) evaluated more than 500 tomato cultivars for transportability and shelf-life. Over the two-year research period, breeders developed tomato hybrids that featured a 12 to 14-day shelf-life, (an improvement over the five to seven-day period within which tomatoes typically spoil). These hybrids also yield 20 percent more fruit, have greater adaptability to heat stress, and appeal to consumers with an attractive red color. Additional tomato traits are in the research pipeline, to address consumer demand for flavor, nutrition and culinary appeal.

While the government of India has begun to incentivize investments in cold storage, investments that will address the large needs and wide array of agriculture products across India will require several years. In the short term, genetic improvements in tomato shelf-life will complement improvements in cold storage and will prevent food loss while providing more consumers with healthy affordable food.

Ending Malnutrition and Hidden Hunger Through Innovation

Nearly one-third of the global population, based primarily in developing countries, depends predominantly on a single staple crop for survival. Global emissions of greenhouse gas are at record highs and are expected to continue to rise through at least 2100. Carbon dioxide emissions (CO₂) threaten human nutrition by reducing crop yields and by altering the nutrient profile of many of these staple food crops.⁶



Across Africa and India, 90 million very poor people depend on various types of millet for daily food and income. Photo credit: ICRISAT

Some of these staple crops, including millets and quinoa, are hardy and nutritious, but suffer from a lack of productivity and require additional research and investment. Other staple crops such as rice, sorghum, cassava and maize, provide energy, but less of the vital nutrients such as vitamin A, iron and zinc required for growth and health. Research and innovation are needed to enhance the nutrition of crops that millions of people consume daily.

Making the Crops that Feed Millions More Nutritious and Productive

Across the drylands of India and Africa farmers and consumers grow and eat sorghum and millets, annual grasses that produce small seeded grains. These cereals are exceptionally resilient in dry conditions, require short growing seasons (three to four months from planting to harvest), are suited to low-input smallholder farming systems and are culturally accepted staple foods for about one billion people.⁷

With additional partnerships and investments, sorghum and millets can be enhanced to bring even greater benefits to consumers, farmers and to the planet.



In Africa, sorghum is a basic staple food for 300 million people in rural communities, especially in drought-prone areas.

Photo credit: Kitavi Mutua

Millets are an important source of micronutrients for nursing mothers and weaning children, as they are high in calcium, iron, folic acid, and zinc. Sorghum and millets are also low in gluten and are good sources of fiber. Consuming them helps keep blood sugar levels stable and manage weight and diabetes.

Campaigns to educate consumers and create new market demand for sorghum and millet products help develop the food value chain for these crops.

The government of India is partnering with food companies to develop new products and launching a [Smart Food](#) initiative to popularize millets and sorghum and has declared 2018 the

“National Year of Millets.” Influencers such as food writers, chefs, doctors and the media are helping inform Indian consumers about the health and sustainability benefits of millets. School feeding programs and cookbooks are featuring millets in meals and in recipes.



Millet Icon for India's National Year of Millets Campaign

In Kenya, an effort to [raise awareness about sorghum](#) as a drought-resilient crop is promoted by the **United Nations International Fund for Agricultural Development (IFAD)** and includes [“Recipes for Change”](#) with chef and farmer participation.

Biofortification for More Crops and More Consumers

Micronutrient malnutrition is a key challenge facing nearly two billion people around the world. Insufficient amounts of vitamin A, zinc and iron results in low disease resistance, stunted growth in children, and a reduction in both cognitive development and economic growth. The problem is especially severe in much of Sub-Saharan Africa and in South Asia, where up to 80 percent of the population in some countries are affected by the lack of these nutrients.

Solutions include improving dietary diversity, fortifying staple foods with added nutrients and with increasing the density of vitamins and minerals in a crop through both conventional and biotechnology breeding methods.



Children in Mozambique enjoy HarvestPlus nutritious biofortified vitamin A sweet potatoes.

Photo credit: HarvestPlus

Through collaborative research partnerships, [HarvestPlus](#) (part of the [Consultative Group for International Agricultural Research](#), CGIAR) has developed biofortified products such as iron-rich beans, millets and wheat, vitamin A maize, sweet potatoes and cassava, iron-rich wheat and zinc rice.

Sorghum is resilient and grows well in challenging soils and climates and is widely eaten by smallholder farmers across Africa and South Asia. A multi-stakeholder partnership has formed to improve the levels and availability of vitamin A, zinc and iron in the crop. **The Africa Biofortified Sorghum (ABS) project** includes Africa Harvest, Corteva Agriscience™ and other partners and funders including the Bill and Melinda Gates Foundation and the Howard G. Buffett Foundation.

Partnerships to Boost Crop Quality and Productivity

Case Study: Corteva Agriscience™

While sorghum and millets have great potential to transform the health, nutrition and livelihoods of farmers and consumers, barriers exist to their greater use as high-value food products in the food system. Millets, and especially sorghum, can have levels of an anti-nutrient called phytate that inhibits the uptake of iron and zinc. Low levels of pro-vitamin A also can be problematic.



Ms. Velma Okaron, Research Assistant, Biotechnology Lab ICRISAT Kenya, conducts research on sorghum, millet and groundnuts for nutrition and income security.

Photo credit: ©ICRISAT

2018 Global Agricultural Productivity Report® (GAP Report®)
Will Consumers Embrace Science Based and Information Technologies?

There is a need for greater investment and partnerships to bring more productivity and nutritional quality to these important crops, as yields are low compared with wheat, maize and rice. In April of 2018, a multi-year partnership was established between the **International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)** and **Corteva Agriscience™**, the Agriculture Division of DowDuPont. The partnership will strengthen food security by boosting the productivity of sorghum and millet varieties through sharing modern breeding technologies.



The ICRISAT and Corteva Agriscience™ partnership brings together expertise in state-of-the-art transformational breeding techniques and plant biochemical pathways with a global network of research institutions.

Corteva Agriscience™ will provide access to advanced plant breeding tools like [CRISPR-Cas](#)⁸ and guiding principles for gene-editing, as well as its intellectual property, technology capabilities, infrastructure and scientific expertise. ICRISAT has research capabilities and relationships with national agricultural research institutions across Africa and India, where sorghum and millet germplasms can be customized into seed varieties for local smallholder farmers.

A Need for Seed—And Seed Systems

Developing improved affordable seeds and getting them into the hands of smallholder farmers in a timely way is a complex and challenging process. Continued investment and capacity building of seed systems in countries across Sub-Saharan Africa and South Asia will be critical in the delivery of improved sorghum and millets to farmers.⁹

To enable widespread adoption of these new varieties, farmer organizations and cooperatives can help their members purchase improved seeds and gain growing skills. Cooperatives can also

develop seed production ventures. Agricultural retailers can provide certified seeds, fertilizers and crop protection products and agronomic advice to accompany improved seed. Using small-size seed packets enables farmers to experiment with new varieties at a lower price with less risk.

Government regulatory agencies can streamline and harmonize national and regional seed standards so that farmers can gain access to quality, improved seeds and improve the nutritional quality of these staple crops.

Embracing Animal Welfare Strengthens Productive Sustainable Food Systems

Consumers are increasingly interested and concerned about the welfare and well-being of livestock and animals in the food and agriculture system. The animal agriculture community, made up of farmers and ranchers, veterinarians, nutritionists, meat processing companies and retailers, recognizes these concerns and is creating a more innovative and transparent food system. Enacting good animal welfare systems is a “triple win” and is good for livestock, producers and consumers.



The [World Organization for Animal Health \(OIE\)](#) is an international intergovernmental organization that sets global standards for animal welfare. Standards are science-based and adopted by member country delegates annually.¹⁰ In the United States and the European Union, livestock industries have developed science-based programs that are increasingly adopted by more of the agriculture community to ensure high standards of animal health and welfare throughout an animal’s life.

Industry commitments to animal welfare are tied to specific animal care program guidelines. Guided by scientists, veterinarians and animal welfare experts, these programs help farmers, ranchers and processors improve stewardship of livestock, ensuring that animals are raised in conditions that provide regular access to fresh water and food, proper handling, health care, and

good animal husbandry. Industry guidelines refine these concepts by how they apply to specific animals, as well as creating measurable standards.

One example of such industry guidelines for pork production in the United States is through the [Pork Quality Assurance Plus™](#) (PQA Plus™) program, which provides detailed practices for proper care to ensure that pigs are healthy and safe. The program addresses caretaker training, space allocation and animal handling, among other topics. Additional commitments by the pork industry include the [We Care](#) initiative which [promotes responsible pork farming practices](#) and helps consumers connect with pork farmers to learn more about production practices. Similar programs are in place for dairy, beef, chicken, turkey, veal and sheep.

In addition to the industry animal care guidelines, many farms participate in third-party animal welfare audits. The audits are performed to verify that farmers and ranchers are using best management practices to promote the health and well-being of the animals under their stewardship.

A Leader in Animal Care

Case Study: Smithfield Foods

Healthy animals raised with good animal welfare practices result in safe, wholesome, high quality meat, dairy and poultry products. A commitment to transparency and access to information about production practices can help bridge the “trust gap” between farmers, processors and consumers today.



For many years, the standard practice of pork producers has been to keep sows (female breeding pigs) in individual pens for much of their adult life to efficiently feed and care for the animals, protect piglets after birth and during nursing and ensure the safety of farm workers.

Smithfield Foods, a global food company that is also the world’s largest hog producer and pork processor, was the first in its industry to develop and implement a comprehensive, systematic animal welfare management system. Further underscoring their commitment to animal care, Smithfield was the first large-scale producer in the industry to convert to group housing. All pregnant sows on company-owned farms, including joint ventures in Mexico, are now in group housing systems. Smithfield leads the pork industry with improved animal welfare practices, while continuing to balance the need for safety of animals and workers.

Smithfield announced this commitment in 2007, investing more than \$360 million to complete the transition over 10 years. Sows are now housed in groups during pregnancy and are moved into individual stalls when they give birth and until the piglets are weaned.

Smithfield also released a [360 degree video](#) so consumers can “visit” a company-owned sow farm operation and learn more about these and many other innovative pork production practices. A [similar video](#) of a wean-to-finish farm is also available.



Graphic source: Smithfield Foods, Inc.

Smithfield recommends that all contract sow growers in the United States complete a transition to group housing by the end of 2022 and provides guidance and expertise when requested to help growers make the conversion.

Other [innovations in pig production](#) include systems that reduce the overall amount of feed needed to produce more meat per animal, thereby reducing other crop inputs such as fertilizer, irrigation, land and fuel.

Embracing and implementing high standards of animal welfare is an integral part of a responsible, sustainable food system, bringing benefits to farmers and their livestock, the environment and to consumers.

Endnotes

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⁵ Hegazy, Rashad, 2013. Post-harvest Situation and Losses in India. Accessed online at https://www.researchgate.net/publication/301770292_Post-harvest_Situation_and_Losses_in_India

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⁸ CRISPR-Cas (Clustered Regularly Interspersed Short Palindromic Repeats) are DNA sequences that protect organisms by identifying threats. These sequences can be used to instruct genes to perform beneficial functions and more precisely edit DNA, improving plants through editing within the gene sequence.

⁹ "Seed Systems: Models and Lessons Learned." ICRISAT, accessed online September 6, 2018 at <http://www.icrisat.org/wp-content/uploads/2017/10/ICRISAT-Seed-system-booklet.pdf>

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