Barriers to global implementation of current and development of new performance-enhancing technologies in meat production

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Implications

• Increased demand for meat in the coming years must be met with improved efficiencies in livestock systems to reduce the environmental impact of meat production. This will require the use of technologies in livestock systems.
• Barriers to the use of current technologies and development of new technologies exist but differ between developing and developed countries.
• In developing countries, lack of education and economic resources, infrastructure, and access to marketplaces are barriers to technology implementation.
• In developed countries, lack of consumer understanding of agriculture and the changing view of risk hampers the use of technologies in livestock production.

Key words: consumer education, global implementation, perceived risk, production enhancement technologies.

Introduction

In the next 40 yr, the world population is predicted to increase 40 to 50%, resulting in an increased demand for food, including meat. Additionally, as disposable incomes increase globally, protein from meat consumption is also increasing. Currently, livestock systems occupy approximately 30% of the earth’s ice-free land (Steinfeld et al., 2006). Given that land availability for agriculture will be in flux due to climate change and population growth (Zhang and Cai, 2011), increasing land devoted to crop production for livestock and to livestock themselves for grazing is unlikely, and available land may in fact decrease. This increased demand for protein from meat will need to be met by improved production efficiencies in livestock systems. Therefore, the need for technology to increase the efficiency of meat production from traditional livestock species and non-traditional animals used for meat production cannot be disputed. However, there are currently barriers that prevent the widespread global adoption of current, established, and safe technologies and slow the development of new technologies. To overcome those challenges and increase the efficiency of meat production overall, a thorough understanding of the complex issues surrounding those barriers is needed to foster global discussion, improve consumer education, and provide transparency of current and future production practices.

Barriers to Global Adoption of Current Performance-enhancing Technology

In terms of meat production and technology implementation, vast differences exist among countries of the world. Global differences in crop yields are large and directly related to economic development. Crop yields among the countries with the greatest amount of gross domestic product (GDP) are more than 300% greater than those with the least amount of GDP (Tilman et al., 2011). These differences also likely reflect differences in availability of critical inputs and natural resources such as consistent water, irrigation, and affordable “modern” seed and fertilizers. While these differences do not speak directly to meat protein production, it can be assumed that yield difference in meat from livestock follow the same trends. Increasing production among these poorer nations can be achieved by either expanding crop production to newly cleared and cultivated land (extensification) or through development and implementation of updated technology practices or tools to increase yields on current land (intensification). A recent analysis by Tilman and others (2011) suggests that global crop production can be expected to double by 2050 and that through intensification, this doubling can occur in such a way that reduces yield gaps, increases global food security, reduces greenhouse gas emissions, and minimizes or prevents species extinction that would result from land clearing. Through proper implementation of new or modern technology, the same can be said for meat production. Through more intensification, global demand for protein from meat, which is expected to continue to increase, can be met while limiting or reducing environmental impacts if technologies that improve the production efficiencies and performance of livestock species are developed and implemented on a wider global scale.

Increased consumption of meat, milk, and eggs among current “food insecure” populations can result in improved nutrition and health (Speedy, 2003), especially in children (Dror and Allen, 2011). In addition to im-
proving food security, increased livestock production efficiency and the resulting improved meat production yields have the potential to reduce poverty through improved livelihoods and increased incomes among farmers (Otte and Chilonda, 2002; Staal et al., 2009). Furthermore, given that sub-Saharan African countries and some countries in Asia are also among the most vulnerable to negative effects due to future population growth and the effects of global climate change (Godber and Wall, 2014), the need for technology to increase food production in these areas is paramount. Even so, in developing countries, there is a lack of availability, or economic resources, that allow the implementation of technologies that are established in developed countries.

In developed nations, performance-enhancing technologies for meat production are often synonymous with production- or growth-enhancing pharmaceuticals and feed additives. However, as other articles in this issue illustrate, dietary optimization, housing, genetics, enhanced selection criteria, reproductive technologies, semen sexing, animal health and husbandry improvements are all forms of performance-enhancing technologies. To improve yields and production efficiencies in developing nations, these established forms of technologies need to be refined to fit local livestock systems, overcome local fears or skepticism, and be implemented more uniformly. However, barriers to this implementation include the lack of education, economic resources, local infrastructure, informality of regional marketplaces, the lack of access to global marketplaces, and the prevalence of counterfeit animal pharmaceuticals.

Globally, the prevalence of counterfeit human and animal pharmaceuticals is staggering. These counterfeit drugs are cheap, low quality, and often ineffective. They are often also produced without adequate safety regulation, and therefore, can pose risks to animal and human health. The
overall market for counterfeit medications was estimated at 20 to 30% of the market in Latin America, sub-Saharan Africa, and India (IMPACT, 2006). Counterfeit animal health drugs that are ineffective undermine producer confidence in animal health technologies. The presence of counterfeit drugs in the marketplace also lessens the economic incentive for an ethical animal health company to market their product to an area.

In developing nations, large parts of the livestock and food transactions take place in informal marketplaces. This informality affects how food animals are produced, how disease and health are monitored, and how quickly changes can be made from a top-down regulatory agency sense. These informal markets often are a part of shadow, or unregulated, economies that exist to a greater extent in developing compared with developed countries. The size of shadow economies in developing countries ranges from 12 to 67% (Schneider et al., 2010). As transactions in the shadows are unregulated, it is not possible for government agencies responsible for oversight to enforce regulations. Simply adopting a technology as a matter of law or policy nationwide would be ineffective given the amount of livestock products that flow through unregulated means. Therefore, local education and enforcement are key to implementing policy changes and curtailing the use of counterfeit, ineffective technologies.

In addition to the transfer of individual technologies to developing nations, the transfer of knowledge to producers of livestock and meat is critically important. The agricultural research that generated new data that increased producers’ knowledge along with the revolutionary technologies that fueled the “Green Revolution” relied on technology transfer to producers through either public university systems or private company extension efforts. This is especially important in African nations that have seen stagnant or limited growth in agricultural productivity over the last several decades. While several African nations have excellent national agriculture research institutes, these are separate from the universities where students are trained (Juma, 2012). Therefore, African universities, for the most part, struggled to fully engage in the powerful land grant triad of research, teaching, and extension. National research institutes lack students and extension while universities lack innovative research.

Where agricultural production extension education does occur in Africa, it suffers from a substantial gender gap (Juma, 2011). Nearly 80% of African agricultural producers are female. However, while 97% of male producers receive visits from agricultural extension agents, only 69% of female producers are visited. One potential reason for this disparity is the local cultural barriers or male-dominated perceived threats of educating women that, in turn, hinders the education or opportunities of female extension agents (only 7% of agents are themselves female). Coupled with an overall education gap between men and women, it is no wonder that female agriculture producers in Africa lack knowledge of potential yield-enhancing technologies. Examples of effective extension efforts that involve female producers in African countries do exist and include the Uganda Rural Development and Training Program, which established the African Rural University for women in the Kabala district of Uganda (http://aru.ac.ug/). The goal of the African Rural University, an all-women university, is to educate women as agents of change for their communities using theoretical knowledge and field experience.

Barriers to the Development of New Performance-enhancing Technologies

Given the improved yield and efficiency advantages of meat production in developed over developing nations, it might be easy to assume that global efficiency issues could be solved simply by spreading current technologies to developing nations. However, meat production in developed nations can and should also be improved by utilizing performance-enhancing technologies that not only increase production efficiency and profitability of livestock operations, but that also improve animal health and well-being, enhance the quality and nutrition of meat products, and reduce the negative impacts of meat production on the environment and natural resources. Barriers to investments in development of such new technologies do exist in developed countries. Currently, these barriers even limit the use of established technologies in some markets around the world. Simply put, the most significant barrier to the development and implementation of performance-enhancing technologies in developed nations is a perceived lack of transparency, which has fostered the growth of skepticism and distrust between consumers of meat and other agricultural products and the commercial producers of food products.

There is no doubt that modern agriculture production does not resemble the farms of the 1900s to 1970s that are still so often depicted in storybooks. Instead, farms are specialized, especially those that raise
livestock intended for meat production. Recent advances (1980s to present) in understanding nutrition and affordable availability of critical vitamins, minerals, and amino acids in poultry and pork have resulted in the majority of those species being produced largely by vertically integrated companies. Beef production is more disconnected or segmented into production segments such as cow/calf, stockers/pasture, and feedlot, but the majority of beef producers do not also engage in the production of other livestock meat species.

Technology and science are employed in every step of meat animal production. The need to efficiently and economically produce large numbers of animals has led to improved selection and genetic technologies to more precisely mate sires and dams and maximize genetic gains from one generation to the next. Diets are specifically formulated for each stage of production and more precisely delivered than previously. Animal health is closely monitored, and sick animals are swiftly treated and returned to good health. The use of feed additives and animal health pharmaceuticals like β-adrenergic agonists, steroidal implants, and ionophores increase the conversion of feed to weight gain consisting largely of muscle that is converted to meat.

The implementation of technology in agriculture has resulted in vast improvements in agricultural yields in developed nations. According to USDA agricultural productivity estimates in 2011, total U.S. agricultural production was more than 2.5 times its 1948 level with inputs growing by a mere 4% between 1948 and 2011 (USDA Economic Research Service, 2013). Overall, the gains in livestock production in the US in the last 40 yr are staggering and were calculated in a recent review in Animal Frontiers (Lusk, 2013). The amount of pork produced per sow increased by 1,262 kg (240% increase) from 1970 to 2012. In that same time frame, the number of sows in the US declined per capita from 5.18 sows per person to 1.87 sows per person and fell by 4.7 million on an absolute basis (Lusk, 2013). Therefore, US pork producers are truly making more meat with fewer pigs. Beef production has also made positive gains though they are not as sizeable of those of pork production. Beef producers in the US produced 1.8 metric tons more beef in 2012 compared with 1970, despite having more than 39 million fewer cows. The amount of beef produced per cow has increased 98 kg (50% increase) from 1970 to 2012 (Lusk, 2013). While layers are also more productive today than in 1970, some of the gains in overall chicken production are the result of increased layer inventory. Per layer productivity increased by 193 kg (156% increase) from 1970 to 2012, but there are 17 layers per person in the US compared with just 13.5 layers per person in 1970. The increase in layer inventory likely resulted from the focused specialization or segmenting of the poultry industry into producers raising parent stock laying eggs intended to be incubated and hatched for broilers and a distinctly different egg layer segment producing eggs for human consumption.

However, gains in production and efficiency have largely gone unnoticed by the consuming public. Perhaps the only perceptible change in agriculture felt by consumers is the decline in disposable income spent on food in developed nations. For example, US consumers spent 17% of disposable income on food in 1960 and in 2014, they spent just 5.5% (USDA, 2016). While not as low as the US, disposable income spent on food in the European Union is much lower than that of Russia, China, India, and countries in Africa. The other shift in agriculture that may have been noticed by the public in developed nations is that fewer people are employed in agriculture food production. Today, much less than 2% of the US population is engaged in production agriculture, and on average, people are two to four generations removed from a family member who was engaged in farming and food production as a livelihood. These figures are similar in the United Kingdom and much of Europe, as well. This is in contrast to Russia, Ukraine, and Pakistan where 7, 15, and 44% of the population are farmers, respectively (The World Bank, 2014). Therefore, in developed nations, the typical
consumer has little direct exposure with modern agricultural production and may have negative misperceptions about food production, but at the same time, they enjoy relatively low food prices.

Given that today’s consumers have little experience with modern agriculture, it is not surprising that they question everything about food production, including the use of modern technology, and are vulnerable to social misinformation about technology. Consumers are skeptical about the benefits of modern food production and distrustful of its techniques. This skepticism and distrust is evident at any local US grocery store. Consumers are bombarded with labels proclaiming foods to be free from various technologies or ingredients while such foods do not differ in nutritional content or quality. Advertising the absence of something—be it hormones, antibiotics, or gluten—is compelling to food marketers seeking to differentiate their product in a crowded “food choice” environment that overwhelms and confuses the consumer with dozens, if not hundreds, of choices on how to spend their food dollars. It inherently implies that other products without such labels contain these “substances,” and that, in more sinister advertising, imposes doubts in the consumer’s mind that these substances are somehow harmful. The current labeling requirements that require asterisks or footnotes to such claims do little to change the perceptions of consumers that certain substances are undesirable or harmful.

Underlying the skepticism and distrust of the consuming public, however, is a shift in the perception and comfort of consumers regarding risk. In order for a current or new technology to be considered “safe,” it must present effectively no risk to consumers, animals, and the environment. This “zero tolerance” view of risk, where any risk no matter how small or remote is unacceptable, has altered the structure and process for the approval of new technologies by regulatory agencies. In some parts of the world, this “precautionary principle” has even been extended to insulate producers of livestock and other foods from competition as new or different technologies would pose a “perceived” risk to traditional livelihoods. An additional complication in this new and changing view of risk is that our analytical capability to detect the presence of compounds is currently outpacing our scientific ability to analyze what risk they pose. For example, while the presence of a growth-promoting compound in the livers or other organs of animals at parts per billion levels can be detected, the likelihood that those levels would result in any measurable physiological or pharmacological effect, adverse or otherwise, to people who consume those products is negligible (Lu et al., 2012; US Food and Drug Administration, 2015). However, the compound can be detected, and given the precautionary principle, consumers are led to believe a risk must exist.

The willingness of companies to invest in developing livestock performance-optimizing technologies that impact the high-value characteristics of growth rate measured by increased average daily gains, improved milk production, increased carcass leanness, higher egg production, increased offspring, and efficiency of feed utilization may be diminishing. Many countries are adding regulatory requirements that performance optimization is not sufficient and must be accompanied by a claim or indication for some benefit to the animal from the novel technology. Some countries have gone so far (largely due to political or trade barriers) to declare that they will not accept edible products from animals receiving certain types of performance-optimizing technologies. These countries’ decisions are not based on demonstrated safety, but as mentioned previously, on the precautionary principle, trade barriers, or global political maneuvering. There-
fore, there is an increasing danger for a diminished appetite by companies to research and invest in pure production optimization technologies, even though there is a great demand for affordable protein products globally.

This skepticism and distrust of technologies in food animal production poses a significant barrier to the development and implementation of new performance-enhancing technologies. Even today, previously accepted technologies are being phased out of production systems due to retailers reacting to consumer misperceptions, confusion, and unfounded social demands. Technologies that promote gain or efficiency in livestock are viewed as only benefiting the producer or manufacturer with no benefit to the consumer. Instead, consumers want food production systems that lessen environmental impact, promote social justice, and improve animal well-being. Therefore, development and implementation of new technologies to enhance animal performance must also address these consumer desires to lower barriers for the implementation of these technologies.

**Literature Cited**


W.M. “Mose” Moseley, Ph.D., earned his B.S. and M.S. degrees from Texas A&M University and his Ph.D. from the University of Wyoming. In 1980, he began his career with The Upjohn Company and continued with that company as it was bought by Pharmacia, Pfizer, and then became Zoetis Animal Health. Throughout his career, Dr. Moseley led teams developing products to enhance the health and performance of livestock species throughout the world. Most recently, he was the Director of Global Development and Operations. In June 2016, Moseley retired from Zoetis after more than 35 years in the industry. As an author or co-author of more than 150 technical reports and 60 journal articles, he is a recognized expert on performance-enhancing technologies in livestock and their development and implementation globally.

Anna Dilger, Ph.D., earned her B.S. and M.S. at Purdue University and her Ph.D. at the University of Illinois where she is currently an associate professor in the Department of Animal Sciences. The focus of her research is in muscle biology, especially the mechanisms regarding increased animal growth, efficiency, and their effects on meat quality. Her work relates the use of performance-enhancing technologies on growth performance of livestock to the quality and quantity of meat produced from those animals including the shelf-life and sensory quality of those products. Dr. Dilger has published more than 40 journal articles in the area of animal growth and meat science.

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Aubrey L. Schroeder, Ph.D., was raised on a general livestock and grain farm in southern Michigan. Dr. Schroeder received his B.A., M.S. and Ph.D. degrees from Michigan State University and has worked with the Animal Health Industry for more than 35 yr in various roles. He spent 21 yr at Elanco Animal Health and the last 6 yr at Pfizer Animal Health/Zoetis responsible for conducting clinical development programs, regulatory affairs interactions with FDA/CVM and USDA, technical support for a wide variety of animals health products and co-authoring numerous peer-reviewed journal articles for many of the animal production technologies currently in use today. His work has involved conducting extensive pre- and post-approval research evaluating the effects of new technologies on live animal performance, changes in carcass composition, and the ultimate impact on meat quality and sensory properties of meat and food products for the consumer.

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