Sustainability in the Food Industry

Sustainability is beginning to transform the food industry with environmental, economic, and social factors being considered, evaluated, and implemented throughout the supply chain like never before. Sustainability in the Food Industry defines sustainability with a comprehensive review of the industry's current approach to balancing environmental, economic, and social considerations throughout the supply chain. In addition, tools and information are provided to enhance future progress. To achieve this, the book combines technical research summaries, case studies, and marketing information. Coverage includes sustainability as it relates to: agricultural practices, food processing, distribution, waste management, packaging, life cycle analysis, food safety and health, environmental labeling, consumer insight and market demand, product development, practices in food manufacturing companies, food retailing, and food service. An international group of authors covers the information from a global perspective.

Sustainability in the Food Industry offers an overview of sustainable sources of impact and improvement, how they relate to the key sectors of the food industry, and how programs may be implemented for further improvement.

Special features include:

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• Evaluation of sustainability factors throughout the supply chain from seed to store
• Technical research summaries including life cycle assessments and case studies
• Marketing information and consumer insight on sustainability
• Strategic opportunities throughout the supply chain including principles for sustainable food products

Cheryl J. Baldwin, PhD, is Vice President of Science and Standards for Green Seal, a Washington D.C.-based non-profit organization dedicated to safeguarding the environment by transforming the marketplace by promoting the manufacture, purchase, and use of environmental standards and providing independent certification to those standards. Previously, Dr. Baldwin served as Program Leader and Senior Research Scientist at Kraft Foods, Glenview, IL.
Sustainability in the Food Industry
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INTRODUCTION

Cheryl Baldwin

The food supply chain affects every individual on the planet. As a result, sustainable development of the food supply chain is imperative. Sustainable development has been defined as meeting “the needs of the present without compromising the ability of future generations to meet their needs” (WBCSD, 2000). The food supply chain, also called the food industry or food system, includes aspects from production of the food, processing, distribution, consumer purchase, consumer use, and end of life. A sustainable food supply would then mean that food is produced and consumed in a way that supports the well-being of generations.

The current food supply has demonstrated impacts that make it unsustainable. Such impacts include overreliance on inputs for food production such as high-intensity animal production and production of produce out of season. For example, the supply chain contributes significantly to climate change, with agricultural production alone responsible for 17–32% of global greenhouse gas emissions (Bellarby et al., 2008). It has been estimated that the food system consumes close to 16% of the total energy use in the United States (Hendrickson, 1996). Food processing also constitutes 25% of all water consumption worldwide and 50–80% of all water used in industrial countries (Okos). Further, there remains widespread malnutrition, both under- and over-nutrition. As a result, the key sustainability considerations for the food supply include energy, waste, water, air, climate, biodiversity, food quality, food quantity, food price, food safety, employment, and employee welfare (Kramer and Meeusen, 2003). These issues, along with others, are discussed in detail in the chapters of this book.

The food industry has the capability to provide safe, nutritious, and flavorful foods to a range of consumers. Agricultural production can
provide a range of commodities for nourishment. The processing of commodities can provide a means to preserve foods for appropriate distribution and storage and also may reduce total waste by preparing commodities consumption. Distribution then can enable the food to reach those who need it.

The Strategy for Sustainable Farming and Food in the United Kingdom developed the following key principles for a sustainable food chain (DEFRA, 2006):

- Produce safe, healthy products in response to market demands, and ensure that all consumers have access to nutritious food and to accurate information about food products.
- Support the viability and diversity of rural and urban economies and communities.
- Enable viable livelihoods to be made from sustainable land management, both through the market and through the payments for public benefits.
- Respect and operate within the biological limits of natural resources (especially soil, water, and biodiversity).
- Achieve consistently high standards of environmental performance by reducing energy consumption, minimizing resource inputs, and using renewable energy wherever possible.
- Ensure a safe and hygienic working environment and high social welfare and training for all employees involved in the food chain.
- Achieve consistently high standards of animal health and welfare.
- Sustain the resource available for growing food and supplying other public benefits over time, except where alternative land uses are essential to meet other needs of society.

As a result, agricultural production should be focused on providing the most nutritionally dense options with the least intensity. Food processors and manufacturers need to include sustainable actions like waste reduction and recovery, composting, recycling, and processing with minimal water and energy use. Distribution should be as efficient as possible.

The benefits of sustainable practices are important for the global social and environmental benefits mentioned, but the World Business Council for Sustainable Development has also found that businesses that incorporate sustainable practices have had greater financial success
Introduction

(WBCSD, 2002). Benefits of sustainable practices include lower production costs, improved product function and quality, increased market share, improved environmental performance, improved relationships with stakeholders, and lower risks.

Consumer interest in sustainable food has grown. This interest has been attributed to the desire to improve one’s personal and family health and safety (Sloan, 2007). Environmental reasons have remained a secondary benefit, and in many ways unknown to consumers. For example, in a survey conducted by the Leopold Center for Sustainable Agriculture in 2007, 88% of respondents perceived local and regional food systems to be somewhat safe or very safe and had purchase preferences for such food, compared to only 12% perceiving global foods as safe (Pirog and Larson, 2007). The survey also showed that the respondents, however, did not know that airplane transport of food emitted more greenhouse gases than trucks (on a per pound basis of product transported) (Pirog and Larson, 2007).

The impacts of an unsustainable food supply on health and food safety are discussed in this book, and go well beyond the average consumers’ knowledge. This indicates that as consumers learn more, their interest in sustainable food will only increase. Further, it is already evident that environmental concerns are moving higher in priority to many consumers.

This book will evaluate the sustainability of each of the main supply chain components of the food industry. There will be emphasis on environmental considerations given its significance and need for progress. Finally, the last chapter (Chapter 11) will bring the discussion from all the chapters/supply chain components together to outline sustainability principles for food and beverage products, including strategies on how to develop/innovate more sustainable products.

References

Introduction


Sustainability in the Food Industry
Chapter 1

Agriculture

Charles Francis and Justin Van Wart

Introduction: Human Food Supply Is a Continuing Challenge

Development of a sustainable agriculture and food system must be an essential part of our long-term economic and environmental planning. Adequate food and a livable environment are both critical to the long-term survival of our species.

Research and development over the past century have provided an impressive and even unexpected surge in production of food across the prime agricultural regions, especially those with potential for irrigation. Adding to these gains have been the extraordinary contributions of plant breeding to high-input production systems and the corresponding advances in fertility and pest management. The fruits of the Green Revolution and the impacts of the International Agricultural Research Centers provide evidence of what a focused public domain program can achieve. At the same time, such an acceleration in food production has come at a price. As with any biological population, human numbers have increased in response to available food and other resources. Human population is likely to reach the current projection of 9.6 billion before it is predicted to level and drop (Brown, 2008). The increasing human population and demands for food, fuel, and other products that depend on nonrenewable natural resources have put an unprecedented pressure on the global life-support system (Tilman et al., 2002). Human activities currently exploit over 40% of total net primary productivity captured by photosynthesis, leaving just over half for the maintenance of all other species.
Perhaps the fragility of the global ecosystem is best illustrated by the current rate of extinction of plant and animal species. Economist and author, Lester Brown, states that we are presently in the midst of the sixth major extinction event in the earth’s history, the last of which occurred 65 million years ago, wiped out the dinosaurs, and was likely the result of an asteroid hitting the planet (Brown, 2008). Today’s problem is the first such event that is almost entirely a result of human activity and our destruction of habitat. One of the immediate economic and food system impacts is the disappearance of fish and collapse of the fishing industry, with 75% of commercial fish species being removed at unsustainable rates (FAO, 2007). More far-reaching consequences of these human activities include the losses of life-sustaining ecosystem-support services (Daily, 1996). We must acknowledge that our expansion in human population and increase in food production do come at a cost, often one that we are unable to calculate.

Thus, we appear to be reaching a tipping point in the balance between exploitation of natural resources and satisfaction of human wants and needs. Brown’s Plan B 3.0: Mobilizing to Save Civilization (Brown, 2008), provides an overview of current challenges as well as potential solutions at the global scale. Also, the recent book Developing and Extending Sustainable Agriculture: A New Social Contract (Francis et al., 2006) provides an up-to-date catalog of sustainable practices in agriculture, and serves as another prime resource for this chapter.

Technical Research in Agriculture

The agricultural advances during the past century were truly spectacular. While human population increased from 3 to 6 billion people between 1960 and 2000, food grain production increased by a factor of three, easily keeping up with population in aggregate and solving hunger problems in some areas (Kang and Priyadarshan, 2007). The advances in production contributed to nutrition and better health in many areas, yet persistent poverty, especially in sub-Saharan Africa, continues to prevent food from reaching many who most need this basic resource. The inequities in distribution of food appear to be growing today, along with a skewing of the economic situation between rich and poor, North and South, all in the face of food surplus in favored areas. The current move toward biofuels, especially ethanol from maize and
rapeseed in the North and from sugarcane and oil palm in the south, provides another challenge to food production and availability.

The increases in food production have been due in large part to expansion of irrigated farmlands and also to increased human productivity, based on mechanization that made the farming work load lighter. This process liberated labor to pursue other activities in the later part of the industrial revolution. Of special importance is the series of genetic advances in our major food crops that has sparked the Green Revolution, uniquely impacting rice and wheat production in Asia and Latin America and maize production in temperate regions. These advances have been coupled with large increases in chemical fertilizer application and use of chemical pesticides. The combination of these components in well-designed and efficient cropping systems has produced synergisms among the new technologies to increase food production.

Genetic improvement of crop varieties has been a continuous process since the first people settled in permanent communities and began to extract the most desirable plants from their nearby environment (Plucknett and Smith, 1986). They saved seed of cereals and pulses and propagated cuttings from trees and vines that proved most desirable for their home diets. Often they were plants with the largest edible seeds, those that held tightly in the head or ear or pod rather than shattering and dispersing, and those with the best cooking qualities. Most of the genetic progress in improving yields of crop plants was achieved by women who found these early selections, while men were off hunting, and we have continued to fine-tune their efforts over the past centuries. Rediscovery of Mendel’s principles of genetics was a key to understanding the mechanisms of crossing and development of hybrid maize. Genetic selection techniques for important self-pollinated cereals such as wheat and rice were equally successful. The contributions of the International Agricultural Research Centers and their partners in national programs were central to genetic progress in major crops during the last half of the twentieth century. Plants provide three-quarters of the calories and protein to fuel human diets, and it is valuable to explore the advances in the three major cereals, since together they contribute over half of all the energy in our food on a global basis.

**Advances in Wheat**

Wheat is one of our most important cereals for human consumption (see Figure 1.1, FAS, 2008), with global annual production of nearly
600 million tons (Singh and Trethowan, 2007). Half of the production is in developing countries, and much of the genetic progress can be attributed to improving adaptation to a range of water-limiting conditions through shuttle breeding carried out by the International Center for Improvement of Maize and Wheat in Mexico. Spring wheat can be grown from the equator to as far as 60° north and south latitudes and from sea level to over 3,000 m elevation. Winter wheat provides another type of adaptation to low winter temperatures and after passing through a vernalization phase can sprout early in spring and produce high yields by midsummer. Together, these wheat varieties are adapted to a wide range of ecoregions and have proved to be especially drought tolerant. Some of the highest yields have been achieved in Europe under favorable rainfall conditions, using high levels of fertilizer and growth regulators to prevent excessive vegetative growth and lodging or falling over before harvest. These systems appear to be sustainable, as long as the supply of fossil fuels, fertilizers, and chemicals needed to produce them are available. Finally, the sustainability will depend on environmental regulations and how well we are able to use these inputs without creating excessive nitrate or chemical residue loads on the environment that are detrimental to humans and other species.

Two of the irrigated areas where yields have increased in an impressive way are northwest Mexico where many of these new wheat varieties were developed, and in the Punjab of India and Pakistan where water has been available and double cropping with a summer cereal or pulse crop has been possible. Such systems are sustainable as long as soil
fertility can be maintained, subject to the same limitations described for the cereal system in Europe and the availability of increasingly scarce irrigation water. In the case of the Punjab, water tables have been declining as much as 1 m/year due to intensive use of tube wells and irrigation for both winter and summer crops. At this rate, water soon becomes too costly to pump for agriculture.

Competition for water from other sectors is a critical factor. It requires about 1,000 tons of water to produce a ton of grain (Gleick, 2000). Even with the current abnormal rise in basic cereal grain prices, our economic productivity per unit of water is far below that of other industries, and it is also impossible to compete with communities for water needed for public supplies. The real advantage of agriculture in use of water is the potential to intercept rainfall over an extensive area, store this in the soil profile, and use it to grow crops. Once that resource is concentrated—in a stream, reservoir, or groundwater aquifer—it is more valuable to other sectors of society. Even recreational uses and maintaining habitat for wildlife species have higher values for some human societies, at least with the current adequate levels of food production in most areas of the world. This could change as food becomes scarce and water is needed to help supply this basic human need.

**Advances in Rice**

Rice is another important cereal grain (see Figure 1.1, FAS, 2008), also with annual global production over 400 million tons (Virmani and Ilyas-Ahmed, 2007), and 90% grown in Asia. The crop can be grown from 35° south in Australia to 50° north in Mongolia, and from sea level to over 3,000 m elevation. Egypt and Australia have the highest levels of productivity, with average yields over 9 tons/ha. In the latter half of the past century, rice-growing area has increased almost 1.8 times, while yields per hectare have more than doubled on average, resulting in a fourfold increase in global production. Major technological advances have included breeding varieties that are insensitive to photoperiod, and thus can be planted in any month of the year where water and temperature conditions are favorable; semidwarf varieties that respond to fertilizer with more grain rather than vegetative growth; shorter maturity varieties that allow two or three crops per year if irrigation is available; and chemical nutrient and weed management to support the highly extractive practices associated with high yields and multiple crops per year.
In addition to limitations on water, one of the most bothersome issues to emerge over the last two decades with rice has been yield decline in Asia. Although a number of theories have been proposed, it now appears that nitrogen availability at the right times in the crop’s life cycle is one of the principal factors (Doberman et al., 2000). Research on this critical issue continues, since rice is such an important component of the diet throughout Asia. There have been a number of concerns, including the possibility of sub-detectable effects of soil pathogens, complex questions of nutrient availability in a continuous cultivation pattern of the same crop, and other potential soil nutrient reasons for the decline. It is essential that this problem be solved for the well-being of millions of people in Asia. The potential for solving the challenge through crop rotation is an obvious route to take, yet the suitability of these lands for rice cultivation and the continuing demand for this popular food crop are overriding reasons to find ways to make continuous cultivation sustainable, as difficult as this may be biologically.

**Advances in Maize**

Maize is the most important major global cereal crop in terms of total production, nearly 700 million tons annually (see Figure 1.1, FAS, 2008). This is an important cereal in much of Africa and Southeast and East Asia, far from its origin in Guatemala and southern Mexico. As the first cross-pollinated crop to receive major attention from plant breeders, maize has become a model for plant genetic improvement and the most important cereal grain in the United States and several other temperate countries. In addition to selection for crop yield, early efforts focused on increasing protein and oil concentrations in the grain with the hope that this would not reduce grain yields (Johnson, 2007). Development of inbred lines of maize and their heterozygous crosses became the standard for study of population genetics, testing methods, and more recently marker-assisted selection and other microbial techniques. Double-cross maize hybrids (four inbred parents) and then single-cross hybrids (two inbred parents) formed the foundation of the hybrid maize industry in the United States and a model for other countries seeking high yields and wide adaptation of new genetic combinations.

In addition to the hybrids based on inbred lines, pioneering plant breeders with maize introduced population improvement and other types
of varieties that could be grown and their seed saved by farmers. This concept was built on knowledge of the pollination habits of maize; 95% of the pollen fertilizing a given ear on a plant comes from another plant—we would say the crop is 95% outcrossing. Thus, 95% of the seed that comes from a variety in the field is a result of crosses with some other series of plants in that field or nearby. By mixing a population of plants with similar characteristics, including grain color and crop maturity, one can harvest seed from the “best” plants in the field and assure that the large majorities are hybrids between two parents in that same field. By starting with a relatively diverse and highly productive variety (population or synthetic variety), it is possible for the farmer to select an improved variety that will be even better for his or her specific farm conditions. It is important to do this selection of plants in the field, choosing those individuals that stand up well, have insect and pathogen tolerance, and are well adapted to the cropping system. Those farmers who select ears, after they are in storage, often have taken the largest ones in hopes that this will increase yields, only to find that these came from the latest maturing and often overly tall plants, both negative attributes not visible in the ears. The development of farmer varieties avoids the need to purchase hybrid seed anew each season, and the strategy has been used with success in a number of developing countries to increase maize production.

A relatively new development in crop improvement has been the introduction of transgenic hybrids of maize, rather mistakenly called GMOs, or genetically modified organisms. This is a misnomer because all of our domesticated crops have been genetically changed since the first farmers chose plants with larger seeds or good food quality to increase and plant near their homes. Transgenic hybrids are made from lines that have one or more genes introduced from another line or species through molecular transfer techniques. They have been used to confer resistance to specific insect pests or specific herbicides. This is an expensive but highly effective way to incorporate special traits into the genetic package, the seed, which can simplify management and possibly reduce input costs. One likely downside to the technology beyond its cost is the potential for developing insects or weeds with genetic resistance to a single type of control when the new hybrids are widely deployed. Farmers are currently urged to use diversity in their planting of these new hybrids and to combine them with other control strategies so that the technology will last longer.