



## The Dairy Industry: A Brief Description of Production Practices, Trends, and Farm Characteristics Around the World

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## *SPECIAL FEATURE*

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# The Dairy Industry: A Brief Description of Production Practices, Trends, and Farm Characteristics Around the World

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**ABSTRACT.** The global dairy industry is composed of a multitude of countries with unique production practices and consumer markets. The global average number of cows per farm is about 1–2 cows; however, as a farm business model transitions from sustenance to market production, the average herd size, and subsequent labor force increases. Dairy production is unique as an agricultural commodity because milk is produced daily, for 365 days per year. With the introduction of new technology such as the milking parlor, the global industry trend is one of increasing farm sizes. The farm sizes are the largest in the United States; however, the European Union produces the most milk compared with other global producers. Dairy production is essential for economic development and sustainable communities in rural areas. However, the required capital investment and availability of local markets

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and labor are continued challenges. Due to farm expansion, international producers are faced with new challenges related to assuring food safety and a safe working environment for their workforce. These challenges exist in addition to the cultural and language barriers related to an increasing dependence on immigrant labor in many regions of the world. Continued success of the global dairy industry is vital. Therefore, research should continue to address the identification of occupational risk factors associated with injuries and illnesses, as well as develop cost-effective interventions and practices that lead to the minimization or elimination of these injuries and illnesses on a global scale, among our valuable population of dairy producers and workers.

**KEYWORDS.** Dairy, international, worker health and safety

## **INTRODUCTION**

In many respects dairy production may be viewed as being in a unique position compared with other sectors of agriculture. Milk is harvested every day, and this continuous production provides a regular source of revenue to producers around the world. Milk production is labor-intensive and provides employment opportunities for agricultural workers globally. Dairy producers are challenged with meeting a growing demand for dairy protein and products among an increasing global human population. The number of dairy producers is decreasing while dairy herd sizes continue to increase. The risk for occupational injury and illness in the dairy sector is high among producers and hired laborers. In order to appreciate the health and safety risks associated with dairy production, a description of the current global dairy industry is needed. The objectives of this paper are to provide a brief description of the unique features of dairy production, as well as provide profiles of dairy industries in major dairy producing countries around the world. Subsequent papers in this special edition will address specific issues and challenges related to worker health and safety in dairy production around the world.

## **UNIQUE FEATURES OF DAIRY PRODUCTION**

The dairy industry has a number of features that distinguish it from the other sectors of agriculture. For example, milk is a liquid consisting of 87% water, which equates to a commodity

with substantial mass that is produced daily, 365 days a year. Therefore, milk requires high-cost transportation unless or until it is condensed or transformed into cheese or powder. Dairy production is labor-intensive because the production and harvest of milk involves the husbandry of animals. Furthermore, milk is a perishable product with a limited shelf life, which requires it to be shipped and processed daily, limiting the opportunity for delayed marketing to obtain better pricing. Additionally, milk is potentially subject to adulteration, whereas the composition and quality of fresh milk is highly dependent on farm management practices. Strict and comprehensive quality regulations and enforcement are therefore customary, which is often more far-reaching and comprehensive than in other agricultural sectors.<sup>1,2</sup>

Another unique feature of the dairy industry involves the socioeconomic position of dairy producers. The vast majority of global farmers are small-scale producers, with a weak and vulnerable position on the dairy market. The nature of the business (involving a high percentage of fixed costs) means that they are only able to adjust to market changes in a limited, slow, and gradual way. Milk is harvested every day and provides a daily source of income despite limited control of the production and marketing process by the producer. At the same time, milk production is labor-intensive and provides many employment opportunities, not only on the farm, but also in the transport and processing of milk and the agricultural supplies and services sectors. For that reason, in many countries the dairy industry is considered to be vital for the sustainability of rural areas. Due

to this factor and its economically vulnerable position (dairy producers are price takers not price setters), the dairy industry in several countries often enjoys the highest degree of economic protection. Additionally, dairy farming in several countries has come to be regarded as increasingly valuable in terms of nature and countryside conservation,<sup>1,2</sup> and a valuable source for agritourism.

Another unique feature of the dairy industry is the strong position held by cooperatives. Cooperatives often have different and varied functions. Some cooperatives receive, process, and market dairy products for producers. Many cooperatives provide very specific services such as distribution and retailing, whereas others only provide wholesale marketing of raw milk to other major processors. Producer-owned dairy cooperatives engage in a variety of activities to provide members an assured market for their milk. Cooperatives may negotiate prices for their processed products and assemble, haul, manufacture, and market dairy products to wholesalers, retailers, or in their own stores. For example, in the United States, milk marketing cooperatives have succeeded in building a strong position with a share of 80% of milk supply to the dairy processing industry, which consists mainly of private enterprises. Cooperatives, in addition to processing the milk, also have become increasingly alert to world market challenges and opportunities. Partnerships with large dairy product wholesalers and distributors are on the rise, mutually benefiting the producer and retailer. Producers and retailers benefit from the other's strengths in procurement or marketing. This is especially important with the short shelf life of fresh milk and the limited opportunities to defer sales. However, when milk is processed into various dairy products (butter, cheese, powder, etc.), deferred marketing to some degree becomes an option. As long ago as the 19th century, this market position led dairy producers to want a direct influence on the processing industry, on which their livelihood was, and still is, so crucially dependent. Any dairy operation, large or small, with such a vulnerable and difficult product as milk to deliver to market, still needs an assured outlet and guarantee of a known price.<sup>1,2</sup>

Some countries such as Canada and EU nations have developed supply management programs to minimize farm price fluctuations and guarantee access to domestic markets. According to the International Farm Comparison Network (IFCN), the top five milk processing countries in terms of volume of milk processed globally are the United States, Germany, China, France, and India.<sup>3</sup>

Lastly, and most certainly not of lesser importance, dairy production is unique in that dairy cattle are efficient converters of crops such as grasses and fodder that are not suitable for human consumption into a high-quality, nutritious food product for human consumption. Too often ruminant animals such as dairy cows are disparaged worldwide as inefficient as compared with other livestock species (poultry, swine, etc.). The unique aspect about a dairy cow is the ability of the animal, in a symbiotic relationship with rumen bacteria, to convert plant resources largely indigestible by humans into milk, which is a high-quality source of nutrients for human consumption. Many of the protein and energy supplements fed to dairy cattle are by-products of human food processing such as distillers grains, soybean meal, and other food processing waste. Plant nutrients, which otherwise would have remained inaccessible and unavailable, would eventually have been returned to the land without utilization. The dairy animal's digestive system accelerates the first step of the decomposition process of remaining nutrients into organic material, providing a high-quality fertilizer with soil-enhancing capacities back to the farming operation. All that remains for producers is to balance the nutrient cycle in an efficient and sustainable fashion. A particular challenge to modern dairy farms is managing farm waste (manure management) in a sustainable and environmentally sound manner. Owners of farms with 200 or more cattle are often required to create and follow farm nutrient management plans (Concentrated Animal Feeding Operation Plans), which may restrict further herd expansion.

Over the years, the aforementioned factors have helped to form the very special position the dairy industry today occupies among all other sectors of agriculture. However, the great

changes that are affecting the world as a whole are likewise leaving their mark on the dairy industry. The forces generated by these changes, such as increased world population, shifts in land use patterns, increased demands and competition for water use and water rights, increased demand for feedstuffs for ethanol production, a fast pace of technological progress, economic liberalization, increased regulatory pressure, privatization, horizontal integration and economy of scale, internationalization and globalization, and demographic shifts in immigrant workers, are also exercising a growing influence on the dairy industry.

### **MODERN DAIRY PRODUCTION AND PROCESSES**

Traditionally, dairy operations were located close to urban areas so that milk could be sold fresh daily into cities and excess milk could be converted to cheese and butter. With the development of refrigeration tankers capable of hauling milk long distances to be processed, the need for daily market access was diminished, and dairy operations could relocate to more remote areas with a more preferable climate, more affordable land, and ample water availability. This has allowed dairies to grow and develop without the constraints that typify operating an agricultural operation in close proximity to large urban populations. A significant problem with farms near urban (even suburban) areas is conflict with nonfarm neighbors. Issues include noise, odors, and farm traffic on local roads.

Modern dairy operations seek to maximize the efficiency of the conversion of resources to product where inputs such as water and energy (in the form of feed) are converted to animal protein in the form of dairy products and eventually meat, depending on the local circumstances (such as climate) and availability and accessibility of these resources. These operations, because of economies of scale, tend to be large to very large. Farms may range in size from those with hundreds of cows in areas where additional labor is expensive or unavailable, to those with 2000–3000 cows in areas with ample access to land and water in close proximity.

Increasingly, certain tasks on the dairy are being automated. New technologies range from automatic feeding systems to cow separation systems and robotic milking, all utilizing the premise of individual electronic identification of the cow. Electronic cow identification can decide which pen a cow should be housed, if she needs to be separated for treatment or reproductive reasons, or simply how much feed she needs to receive based on her level of milk production and consumed feed. Additionally, temperature, location, and movement sensors can provide management with information predictive of cow health status, for example, if she is eating or drinking, or if her activity level coincides with the probability of her reproductive status.

The cost associated with providing feed to many animals is a major planning consideration. Dairy owners and managers plan to grow the majority of their feed requirements in close proximity to the farm to minimize transportation costs, and consequentially must plan to accommodate the application of nutrients produced by such a large number of animals. However, many farms in the United States and other countries (Japan, Middle Eastern countries, and increasingly so in China) must purchase a significant portion of their animal feed. In different parts of the United States, feed costs can exceed 50% of total operating costs. A well-developed nutrient management plan is essential for the long-term sustainability of dairy operations. Since the costs of housing facilities for a dairy operation are the second largest investment (behind the costs of the milking parlor), many large operations are constructed in areas with climates that allow cows to be comfortably housed outside, with low humidity, and preferably with moderate temperatures and favorable temperature differentials between day and night. These environmental conditions allow cows to more effectively dissipate heat at night. Elevated desert climates are ideal for these kinds of operations. Key to the success of these operations is ample water availability to support the growth of crops to feed cows. Less than 2% of the total water needs for a dairy operation is used for drinking water and cleaning purposes, and the remaining 98% is needed to provide growth of forage crops.<sup>4</sup> In some of the large-herd



operations, adequate amounts of potable water can become a challenge. Another necessity on large operations is the availability of labor. As stated previously, about one employee is needed for every 80–100 cows on large US dairy farms.<sup>5</sup> Typically in the design of these operations, the number of animals is determined by the capacity of the milking parlor. Because of the high costs of a milking parlor, and in order to maximize return to investment, it is essential to maximize the throughput in a parlor in terms of cows per hour, accommodating time between pens twice a day for cleanup. Temperature-controlled bards to house cows can be built in areas where the climate is not conducive to large outdoor open-lot housing. Temperature is typically controlled by evaporative cooling of incoming air, systems that therefore are much more efficient in areas with low humidity versus areas with a high humidity. The investment costs per cow for these systems are much higher than open-lot housing systems, but can be offset by advantages in the operation such as lower feed costs due to water availability, land prices, or higher milk prices due to marketing advantages.

### ***Milking Systems and Processes (Inside the Milking Barn)***

Two types of milking systems are used in modern dairy production in industrialized countries: tie stall/stanchion and milking parlor systems. In stanchion systems, milking units are brought to a tethered dairy cow for milking, and milk is collected in a pipeline system. A worker stands between tethered cows where they kneel or squat to attach specialized milking equipment to the cow's udder. Tie stall/stanchion systems are common among farms with smaller herd sizes. In contrast, parlor systems involve cows being housed in dry-lot or loose housing facilities and moved into a milking parlor with stationary stalls where they are milked simultaneously with specialized milking equipment. Workers are located in a pit below the level of the milking platform. The number of cows milked at one time varies by parlor design. Parlor systems can accommodate large numbers of dairy cattle and therefore are used almost exclusively in large-herd dairy

operations.<sup>6</sup> Three configurations are commonly used in parlors: parallel, herringbone, and rotary. These configurations present different workstation designs and may create different worker demands. As dairy farms increase their milking herd sizes, questions arise regarding the occupational health and safety issues among parlor workers. Acceptable worker comfort and safety in different milking systems becomes an issue when considering higher cow throughput rates combined with larger herd sizes. Work demands may increase in large-herd dairy operations due to more cows being milked per unit time compared with small-herd operations.<sup>7</sup> Large-herd farms (>500 cows) often operate milking parlors 24 hours a day to maximize parlor efficiency. This may entail milking three or more times per day, thus requiring additional hired labor. Modern large-herd milking systems may increase the physical workload, thus having an effect on the development of musculoskeletal disorders. Changes in work organization and pace also contribute to increased stress among managers and workers, and technology may modify (increase or decrease) other health outcomes such as respiratory and zoonotic diseases. Robotic milking is gaining in popularity as a practical alternative not only in smaller herds with several robotic milking stations available at every hour to the cows' discretion, but also in rotary parlor designs where cows are still moved to the parlor for milking, but the actual task of attaching and detaching milking machines is automated and computer-controlled. This would maximize the return on investment by spreading the costs across as many animals as possible, while reducing labor costs and limiting direct exposure to animals by milkers. An additional motivation to employ robotic milking technologies is the uncertainty of the availability of skilled milkers in many regions of the world.

## ***GLOBAL MILK PRODUCTION IN SELECTED COUNTRIES***

### ***Farm Characteristics***

Dairy farms and dairy production systems around the world are vastly different due to

many of the external factors listed above, but one way to categorize and evaluate dairy production systems would be based on size either in terms of number of cows or volume of milk produced and sold. One approach to understand and appreciate the characteristics of modern dairy farms is to analyze farm sizes in different countries around the world. The International Farm Comparison Network (IFCN) Dairy Report of 2011 includes data and profiles for 90 countries, representing 98% of milk production worldwide. The top five milk-producing countries are India, United States, Pakistan, China, and Brazil; however, in countries such as India and Pakistan only a small fraction of that milk makes it to a processing facility. These 90 countries have an average herd size of only 3 cows per farm. This observation may be due to the fact that in developing and transition countries many small-scale dairy farms with 1–2 cows exist. Only 7 of the 90 countries have an average farm size of more than 100 cows. According to the IFCN Report, 78% of all farms and 56% of cows are represented by farm sizes of 1–2 cows. A large portion of milk produced on these farms is consumed by the family, with the remaining milk sold locally and often to an informal market. This selling of milk provides daily cash for family subsistence. Farm sizes of 11–100 cows represents 22% of all farms and 28% of cows. Most of these farms can be described as “family farms,” as most of the work is performed by family members. The economic aim of these farms is to generate a sufficient income for family members. Farms with more than 100 cows represent only 0.3% of dairy farms and 16% of cows. Although still family owned, these farms can be described as “business farms,” as most of the work is performed by hired labor coming from off the farm.<sup>8</sup> As farms continue to grow in size, the dependence on immigrant labor is a commonality globally, which presents new human resource management challenges related to cultural and language barriers.

Cow numbers in many parts of the world have decreased between 2007 and 2011 including the EU-27, the former Soviet Union, and Asia (China and Japan), which is more than likely a reflection of low milk prices worldwide in 2009 and first part of 2010. Cow numbers

in North, Central, and South America remained fairly constant, whereas New Zealand and India saw a 16% and 18% increase in cow numbers, respectively.<sup>9</sup>

### *Dairy Production in the United States*

The United States ranks second (behind EU-27) among major dairy (cow) producing countries in the world. The US dairy industry produces 14.6% of the world's milk supply, with an estimated 9.2 million cows.<sup>10</sup> The US dairy farm profile is unique as it relates to most other dairy regions of the world. Dairy production in the United States has steadily moved toward a large-herd, high-efficiency model due to associated economies of scale.<sup>11</sup> Milk production in the United States has essentially quadrupled since 1944, producing 59% more milk with only 36% of the cows.<sup>12</sup> Dairy operations have shifted from small dairy farms with minimal to no hired employees to large operations with many hired workers. Yet, despite the increasing size of the dairies, almost all (94%) of the dairies in the United States are family owned (79.1%) or in a partnership (14.8%), whereas only 6.1% is structured as a corporation and the remaining 0.5% is either in the form of a trust or an estate. Larger dairies in the United States will typically employ one person for every 80–100 cows, not including farm labor needed to grow forage crops. According to the 2007 US Census of Agriculture, the average herd size in the United States was 246 cows and ranged from 122 cows per herd in Pennsylvania to 1906 cows per herd in New Mexico.<sup>13</sup> Between 2005 and 2009, farms with fewer than 500 cows declined, whereas farms with 500–999 cows held steady. In contrast, farms with 1000 or more cows increased 20%, driven by significantly lower costs of production. In 2005, dairy farms with 1000 cows or more had average operating costs of production of \$13.59 per hundredweight of milk, 15% below the average for farms with 400–999 head, and 35% below costs for farms with 100–199 head. Average operating costs were much higher for even smaller operations.<sup>14</sup> In 1998, nearly 70% of milk produced in the United States came from small-herd operations (<500 head). By 2011, over 63% of

milk produced in the United States came from large-herd operations (>500 head), and 34.6% came from operations of 2000 head or more.<sup>15</sup> Combined, only 2.7% of dairies in the United States, representing large herds of more than 1000 head, produce 50.3% of US milk.<sup>15</sup> The largest milk producing states include California, Wisconsin, New York, Idaho, and Pennsylvania. The 10 largest dairy producing states accounted for nearly 74% of total milk production in the United States in 2009.<sup>16</sup>

Dairy housing systems in the United States largely depend on regional climate conditions and can range from traditional flat-barn housing in the winter and pasture grazing during the summer, to free-stall housing, to open dry-lot housing systems with or without a grazing component, to full acclimatized cross-ventilated barns in areas with relative low humidity.

### ***Dairy Production in Europe***

The composite European Union (EU)-27 is the largest dairy producer in the world, accounting for 25.2% of the world's milk production. Nearly 24 million dairy cows constitute the EU-27 dairy herd. Germany is the largest dairy producing country in the EU-27, accounting for 4.9% of global milk production with over 4 million milk cows. France is second in EU-27 production, accounting for 4.0% of global milk production with an estimated 3.7 million herd size. The United Kingdom ranks third in EU-27 production, accounting for 2.3% of global production with an estimated 1.8 million milk cows. These countries are followed by Poland, Netherlands, Italy, Spain, Ireland, Denmark, and Romania in the top 10 dairy producing countries in the European Union.<sup>10</sup> The average dairy herd size in the EU-27 is 9.8 cows per farm. Less than 2% of EU-27 dairy farms have 100 cows or more. Mean herd sizes in Germany, France, and the United Kingdom are 40.3, 41.0, and 69.4 cows, respectively. The percentage of farms with more than 100 cows in Germany, France, and the United Kingdom is 5.1%, 2.4%, and 27.3%, respectively. Denmark and Cyprus have the highest average herd sizes in the EU-27, with 101.4 and 94.4, respectively. The percent of dairy farms in Denmark and

Cyprus with more than 100 cows is 47% and 33%, respectively, but these countries have significantly lower numbers of dairy farms compared with the larger producing countries in the European Union.<sup>17</sup> Historical EU regulations have limited production on dairy farms by use of imposed quotas. Presently, many European countries are removing their quota systems, which may result in future farm expansion and larger milking herd sizes.

### ***Dairy Production in India***

India is considered a major global dairy producer, accounting for 8.0% of worldwide cow milk production. However, when combined with its massive buffalo dairy production, India can be classified as the global leader in liquid milk production (cow + buffalo milk), accounting for 17% of the world's total milk production.<sup>18</sup> India has 38.5 million dairy cows in its national dairy herd. There are approximately 70 million Indian dairy producers.<sup>10</sup> Indian dairy farms are characterized by small producers, which are mainly rural-based. In India, about 75% of the population lives in rural areas and about 38% of them are poor. Therefore, among this population, combined with the large vegetarian segment of the country's population, dairy products provide a critical source of calcium and animal protein to millions of people in India.<sup>18,19</sup> Unlike many developed dairy markets, India's milk production system is fragmented. Dairying is seen as small-scale industry carried on at home by family members using their own equipment, and is primarily a supplementary occupation for small landholders or landless laborers. Some estimates suggest that approximately 70 million rural households (primarily small and marginal farmers and landless laborers) are engaged in milk production. The average herd size is about two milking cows.<sup>20</sup>

### ***Dairy Production in China***

China produces 6% of the global milk supply, with a 12.6 million national herd size.<sup>10</sup> China's raw milk production has increased at a rate over 25% per year, placing China among the top five dairy producing countries in the world.<sup>21</sup> This



increase in milk production is fueled primarily by domestic demand. Local producers are slowly rebuilding the Chinese dairy herd following a nationwide melamine crisis in 2008 when 15% of China's dairy cows were taken out of production due to weak demand after the food safety scare. The Chinese dairy industry is primarily composed of backyard and small-herd operators. Seventy-six percent of dairy producers have a herd size of 1–4 cows. Less than 1% of producers have herd sizes of 100 or more. Larger operations continue to expand herd sizes, but the pace of increase in dairy cows is constrained by limited land resources.<sup>22</sup> However, dairy development in China is steadily picking up speed and changing from small subsistence farming to very large-scale high-efficiency models. The Chinese government has put an emphasis on dairy development and is buying not only the products, but also the technologies to fast track this process.

### ***Dairy Production in Russia***

Russia produces 5.5% of dairy cow milk worldwide, with an estimated 9.0 million herd size.<sup>10</sup> About 50% of Russian milk production comes from household farms (personal subsistence plots). Production on these farms is mainly consumed on the farm or sold at local farmers' markets. Some processing plants accept milk from these operations, but the small-scale production means that the quantities and quality of milk are generally lower than those from more modern farms with more advanced production processes. Seventy-three percent of household farms have only 1 cow each and 20% have 2 cows. In recent years, agricultural enterprises have produced about 45% of the raw milk output in the Russian Federation.<sup>23</sup> The majority of agricultural enterprises in the dairy sector are small farms with up to 500 cows. In the opinion of Russian dairy market experts, large dairy farms guarantee higher profitability and quicker return on investment. The largest dairy operations in the Russian Federation have more than 5000 cows. The National Union of Milk Producers<sup>23</sup> estimated that there is also a maximum size for a profitable dairy farm. Managerial problems arise on farms with more than

3000 head. The lack of skilled specialists who know how to manage such large farms is one of the main problems facing the animal husbandry industry in the Russian Federation. Additionally, difficulties exist in selecting locations for large farms, as they need large areas of land. Farms that are distant from population centers are confronted with difficulties with water and power supplies. Dairy farm size is also limited by a feed supply shortage. Another issue is the lack of qualified labor. All of these factors combined hinder the development of large enterprise farms in the Russian Federation.<sup>23</sup>

### ***Dairy Production in Brazil***

The Brazilian dairy industry accounts for 4.8% of worldwide dairy production. Approximately 21.8 million cows make up the country's dairy herd. Most dairy production is concentrated in southeast and southern regions (36% and 31%, respectively) of the country. Milk is produced on farms of different sizes, ranging from small farms that use little milking technology with daily production less than 10 L, to large farms with production over 60,000 L per day. There are approximately 1.3 million dairy producers in Brazil. Small producers (less than 50 L produced daily) are responsible for only 20% of milk production. Medium-sized producers (51–200 L per day) constitute 15% of farms, and are responsible for 20% of production. Larger farms producing more than 200 L per day constitute only 3% of all dairy farms, but account for 60% of milked produced in Brazil. Until 2004, Brazil was a major importer of dairy products. In recent years, Brazil became a major exporter, with exports surpassing imports in volume.<sup>10</sup>

### ***Dairy Production in Australia***

The dairy industry is one of Australia's major rural industries. Based on production value, the Australia dairy industry ranks third behind beef and wheat industries. Approximately 40,000 people are directly employed on dairy farms and processing plants. In 2012, owner-operated farms dominate the Australian dairy industry. Corporate farms make up only 2% of

the total number of Australian dairy farms. The number of farms has fallen by two thirds over the last three decades, from 22,000 in 1980 to roughly 7000 in 2011. The Australian national dairy herd is 1.6 million cows, with an average farm herd size of 230 cows. Fifty percent of Australian milk production is exported, making Australia the world's third largest dairy exporter.<sup>24</sup> Major export markets include Japan, Greater China, Singapore, Indonesia, and the Philippines.<sup>25</sup> Southeast Australia's climate and abundance of natural resources are favorable to dairy farming and facilitate the industry to be predominantly pasture-based, with 70–75% of cattle feed requirements coming from grazing. Most dairy production is located in coastal areas where pasture growth depends on natural rainfall. Feedlot-based dairy farming remains the exception in Australia, with the use supplementary feed being widespread and increasing significantly in recent seasons as farms have been forced to adapt to drier conditions.<sup>25</sup>

### ***Dairy Production in New Zealand***

Like Australia, the dairy industry is one of New Zealand's major agricultural industries. The dairy sector directly accounts for 2.8% of the New Zealand gross domestic product, equivalent to \$5 billion. Dairy provides 26% of New Zealand's total goods exports, equating to \$10.4 billion. The New Zealand dairy sector employs around 35,000 workers.<sup>26</sup> In 2011, the New Zealand dairy herd size was more than 6 million. In 2011, the average farm herd size was 386. Fifty-three percent of New Zealand dairy farms had 300 or more cows, 24% had 500 or more cows, and 4% had 1000 or more cows. The trend in New Zealand is one of decreasing numbers of dairy farms with increasing dairy herd sizes. Over the past 30 years, the New Zealand average herd size has tripled, increasing by more than 100 cows in the last 8 years.<sup>27</sup> The majority of dairy herds (76%) are located in the New Zealand North Island, with the greatest concentration (30%) situated in the Waikato region. Taranaki is the second largest region, constituting 15% of New Zealand dairy herds.<sup>27</sup> New Zealand is the world's largest dairy exporter, accounting

for over a third of international dairy trade and 95% of New Zealand's dairy products are exported.<sup>27</sup> Major dairy export markets include China, United States, Japan, European Union, Malaysia, Australia, Philippines, Taiwan, Singapore, Belgium, Venezuela, and Saudi Arabia.<sup>28</sup> Even though New Zealand's dairy production remains predominantly pasture-based, supplemental feeding strategies with concentrates are quickly aiding to increase production levels. Production has increased 15.5% in the last 5 years.<sup>9</sup> The vast majority of dairy farms in New Zealand produce milk on a seasonal basis. This allows dairy farmers to take full advantages of optimal grazing opportunities and low cost of production. Milking ceases during the winter months on most farms. New Zealand producers can economically use this type of production system, since the majority of milk is exported as manufactured products.

### ***Dairy Production in Developing Countries***

Livestock is vital to the economies of many developing countries. Animals are a source of food, specifically protein for human diets, income, employment, and possible foreign exchange. For low-income producers, livestock can serve as a store of wealth; provide draught animal power and organic fertilizer for crop production; and serve as a means of transport. Consumption of livestock and livestock products in developing countries is growing rapidly. As compared with mechanized milk production systems found in industrialized countries, dairy production systems in developing countries may be characterized by a few cows kept on mixed crop-livestock farms, in urban backyards, or extensive pastoral systems. Traditional milk producers in developing countries typically keep dairy cattle to meet a range of objectives, including savings for insurance and finance functions, to produce manure, and for social status. Sale of milk may not be the primary objective, and in many cases no milk is sold. Milk production is just one of many activities of the household, and may be integrated with other household/farm activities, particularly crop production. Dairy production in developing countries involves low levels of inputs and outputs. This characteristic

is associated with limited use of modern technology, low productivity of land and labor, and generally with an emphasis on labor-intensive technology, as cows are often milked by hand. Soil nutrient deficits remain the key production constraints for most small-scale farms in developing countries. Dairy farmers can partially offset these soil nutrient deficits by using cow manure.<sup>29</sup>

## CONCLUSIONS

The international dairy industry is composed of a multitude of countries with unique production practices and consumer markets. The global industry trend is one of increasing farm sizes with larger numbers of cows due to associated economies of scale. Due to farm expansion and increased production, international producers are faced with new challenges related to assuring food safety and a safe working environment for their workforce. Increased global competition for markets has also spurred a focus on milk quality, which national dairy industries are using to gain competitive advantages for their products. The increasing emphasis on quality standards puts additional pressure on dairy farmers and their labor force to meet these standards. These challenges exist in addition to the cultural and language challenges related to the increasing dependence on immigrant labor. As farms increase their herd sizes and modernize production practices, the continued success of the dairy industry is vital, globally. A common risk for dairy workers around the world is working in close proximity to large, dangerous animals. Workers on large-herd operations (500+) are exposed to large machinery, dangers associated with manure pits, respiratory exposures, and ergonomic risks such as repetitive motions or high muscle forces associated with parlor milking. Workers on medium-sized operations of a few hundred cows may be exposed to extreme trunk postures associated with milking tethered cows. Family workers who milk 1–2 cows for family consumption in developing countries are exposed to repetitive motions and awkward trunk postures associated with hand milking, as well as zoonotic diseases, which

may not be adequately controlled in developing countries. Research should continue to address the identification of occupational risk factors associated with injuries and illnesses, as well as develop cost-effective interventions and practices that lead to the minimization or elimination of these injuries and illnesses globally, among our valuable population of dairy farm producers and workers. Future research should address the unique features and risks of dairy production in different regions of the world.

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