



## Melamine in milk products in China: Examining the factors that led to deliberate use of the contaminant

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### ABSTRACT

On September 11, 2008, the Chinese government announced a recall of infant milk powder that was tainted by melamine, a chemical usually used in plastics. Consumption of melamine caused infants to develop kidney stones which, if left untreated, could cause renal failure and death. More than 290,000 people (most of them infant children) were poisoned and at least six babies are confirmed to have died from ingesting the melamine contaminated infant milk powder. The Chinese government imposed very high penalties on people and companies involved in the melamine scandal, including lifetime prison sentences and even executions. The problems in China's dairy industry were a result of rapid growth fueled by large investments from multinational dairy firms, development of a highly modern and concentrated processing sector that obtained its raw materials from millions of small, poor and uneducated traditional farmers and government support and encouragement for growth but with little emphasis on inspection and safety issues. The melamine crisis prompted the Chinese government to bring in a new food safety law, mandate regular inspections of all companies involved in the food business with no exemptions and set new allowable tolerances for melamine in dairy products.

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### Introduction

Like many other Asian countries, China has a short history of consuming dairy products. The high rate of lactose intolerance in Chinese people (Shukla, 1997; Greenfield, 2003; Pan, 2008), lack of refrigeration, extended periods of food shortages through several historical periods in the 20th century where animal production was discouraged (Fuller et al., 2007), and other factors led to a very small and disaggregated dairy industry and one of the lowest levels of per capita milk consumption in the world. On the supply side, introduction of improved-performance dairy animals and genetics from the United States, Canada, Europe, Australia and New Zealand, as well as adoption of improved feeding and management practices has greatly increased the productivity of China's dairy industry (Beghin, 2006). As a result, China's dairy production has surged from just over 10 million metric tons in 2001 to a level of nearly 39 million metric tons in 2009, making China the third largest milk producer in the world, trailing only the United States and India (USDA, 2008). This is an astonishing average annual rate of growth of 26% since 2001 (Qian and Guo, 2007).

Consumption of dairy products also has increased greatly in China. Per capita consumption of dairy products increased from 8 kg in 1996, one of the lowest levels in the world, to 25 kg in

2006 (Lu and Zong, 2008) although this still is far below the world average of about 80 kg per capita and the approximate consumption of 260 kg per capita in the United States (USDA, 2008; Lu, 2009). The rapid increase in milk consumption has been driven by factors such as rapid income growth that has allowed almost all urban residents to own a refrigerator, changes in urban lifestyles, and the development of more sophisticated marketing channels (Fuller et al., 2006). Introduction of modern processing technologies, including ultra-high temperature pasteurization has enabled inter-regional transportation of dairy products from areas of surplus production, generally in the north and west of China, to areas of very high population, especially in eastern China (Fuller and Beghin, 2004).

The rapid growth of China's dairy industry has stimulated a great deal of new investment in the industry, both domestic and foreign. Major dairy processing firms have been established in grassland areas of Inner Mongolia and around major cities. They have developed complex purchasing and distribution networks to enable quick and efficient movement of milk and dairy products to consumers across the country (even though milk still is regarded as a luxury item by most low income families).

On September 11, 2008, the Chinese government announced a recall of infant milk powder that was tainted by melamine, a chemical usually used in plastics (BBC News, 2010). The tainted product came from the Sanlu Dairy Company, which was based in Shijiazhuang, the capital city of Hebei province in northern China.

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Melamine is nitrogen-rich and was added illegally to watered-down milk to increase its apparent protein content since nitrogen content often is used to estimate protein levels. It was quickly revealed that melamine was causing infants to develop kidney stones which, if left untreated, could cause renal failure and death. Within days, four babies had died as a result of ingesting melamine-laced baby milk powder and 54,000 children had become sick, most of whom had developed kidney stones (Associated Press, 2008).

Fears were compounded when it was revealed that virtually all Chinese-produced dairy products, including ordinary milk, ice cream, and yogurt also contained melamine. Countries around the world announced bans on imports of products that contained Chinese milk, including bakery products and candies. Panic spread when news reports indicated that Sanlu Company officials had known about the problem for months and possibly as far back as December 2007 without taking any corrective actions (China Daily, 2008a; Wang, 2009).

How could this food safety problem have happened? Was the contamination confined or did it represent a systemic failure in the Chinese food quality inspection system (Hennessy et al., 2003)? The purpose of this paper is to examine the factors that led to the deliberate contamination of milk in the fast growing, modern dairy industry in China. A summary of health outcomes, financial losses and criminal penalties imposed on government and company officials are provided in 'Consequences of the melamine contamination.' The structure and major players in the Chinese dairy industry are described in 'The changing dairy supply chain in China.' This includes a discussion of the role of government in stimulating growth of the industry, regulating the firms and inspecting the products. The general availability of melamine and the profitability of adding it to milk are explained in 'Incentives and opportunities to add melamine to milk.' A new food safety law in China came into force on June 1, 2009. These and other actions taken by government in response to the melamine contamination are discussed in 'What the Chinese government has done to fix the problem.' The major findings and lessons learned are summarized and discussed in 'Conclusions.'

### Consequences of the melamine contamination

The most important consequence of the melamine contamination was that more than 290,000 people (most of them infant children) were poisoned and at least six babies died from consuming the melamine contaminated infant milk powder (Graham-Harrison, 2009; Jacobs, 2009). This does not count the emotional trauma faced by millions of parents who continue to live with the worry that their child might develop future health problems. It also does not count the added expenses faced by people who sought medical attention nor does it count the added expenses of parents who searched desperately for imported milk products that were hard to obtain and much more expensive than the domestic products.

Financial losses in the industry were devastating to firms whose products were found to be contaminated. Major dairy companies, such as Mengniu and Yili, lost 80% of their sales in the first 10 days after disclosure of the melamine contamination while demand surged for milk products from Beijing-based Sanyuan Company, whose products were unaffected (Lu, 2009). Dairy companies hastily recalled products, dumped huge quantities of milk, and consumers everywhere scrambled to find safe alternative sources of milk for their families. Sanlu, the large dairy company that produced and sold the products that were first identified as tainted, was declared bankrupt in December 2008 and its assets were sold to the Beijing Sanyuan Food Company for about 40% of their value before the company's bankruptcy (Ding, 2009). The New Zealand-based Fonterra Company came away with nothing from its invest-

ment of \$153 million in late 2005, in which it acquired 43% of the Sanlu Group (Jones, 2009). The bankrupt company was fined \$7.3 million by the Chinese government.

The international investment firm Morgan Stanley predicted that the two industry giants headquartered in Inner Mongolia lost close to half a billion dollars in 2008 (Mengniu \$130 million and Yili \$340 million) as a result of product recalls and destructions (China Retail News, 2008). Wang (2009) estimated the total direct losses to the dairy industry in China from the melamine scandal during the period September 11–December 31, 2008 of that year were RMB 20 billion or the equivalent of more than US\$3 billion. These included estimated costs of recalling and promoting dairy products.

Losses continued to mount during 2009 and possibly even into future years as many consumers remain wary about Chinese milk products. Sanlu, along with the other 21 dairy companies whose products were found to be contaminated by melamine, proposed a \$160 million compensation plan. More than 200 families filed suit demanding higher compensation and long-term treatment for their babies (Chang, 2009).

A high proportion of dairy production in China still is produced by small, traditional households. A survey of dairy farms in the rapidly growing dairy production belt in Inner Mongolia revealed that 73% of those dairy farms had fewer than 10 milking cows (Zhao et al., 2009). Revenue from the dairy enterprise accounted for total household income in 43% of those households and an additional 30% received more than half of their household income from dairy (Zhao et al., 2009). These small dairy farmers, of course, were directly exposed to the drop in demand (and price) of dairy products. Although firm estimates of the financial losses to millions of small farms are not available, their financial stress is obvious. A survey conducted by Yan and Xiu (2009) in Helinger County of Inner Mongolia in June 2009, where Mengniu Dairy Company is based, revealed that 34 milk collection stations were declared (by Mengniu Company) to be unqualified to accept milk and closed within the county's boundaries. As a result, 20% of small dairy farmers in the survey area were forced to move their cows to other locations where they could be milked. Many households had to resort to camping or even becoming nomadic farmers. Farmers in the survey reported that their daily operational costs were increased by at least 30%.

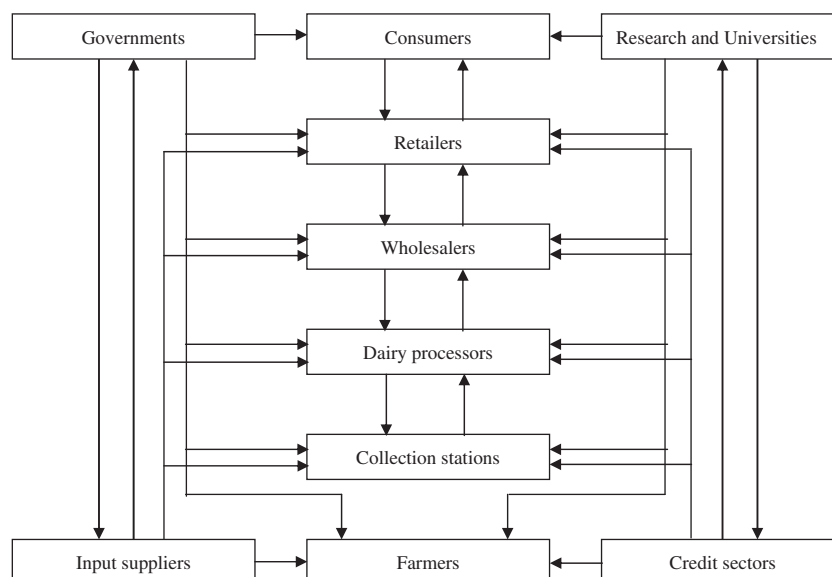
The Chinese government imposed what many would regard as harsh penalties on people and companies that were involved in the melamine scandal. Chinese courts sentenced two persons to death for being involved in mixing the industrial chemical in dairy products and then selling the tainted product to dairy companies. A third person involved in the scandal was given a suspended death sentence (which, in China, is commuted to life imprisonment) (Chang, 2009). Four other life terms were meted out including to Tian Wenhua, the former general manager and chairwoman of Sanlu Group Co., who was given a life sentence and fined \$2.92 million. During her one-day trial, Ms. Tian admitted she had known of problems with her company's products for months before informing authorities. Tian pleaded guilty to charges of producing and selling fake or substandard dairy products (Chang, 2009). A total of 47 suspected cases involving 142 persons were investigated and 60 persons were arrested. Six ministerial or municipal officials were dismissed or resigned, including Li Chiangjiang, the Director General of China's General Administration of Quality Supervision, Inspection and Quarantine (Dong, 2008).

### The changing dairy supply chain in China

Traditionally, the cattle industry in China was associated with the cropping industry as cattle were used as draft animals for cultivation and harvesting of crops. While a commercial livestock-meat industry developed slowly, the dairy industry remained mainly a

### Retailers and wholesalers

Two huge dairy enterprises (Yili and Mengniu) have been established near Hohhot in Inner Mongolia, with operations in other areas of the country as well. Mengniu (which means Mongolian cow) was established as a private company in 1999. In 2002, international investment firms Morgan Stanley, Dinghui Investment and British Union Investment invested \$26 million in the business.



**Fig. 1.** The dairy supply chain China. *Source:* Xiu (2008).

The company was listed on the Hong Kong Stock Exchange in 2004. The company owns only a small number of cows and contracts with about 3000 suppliers for most of its raw milk (Thompson and Oster, 2007). Yili (known abroad as Erie) was established as a state-owned enterprise in February 1993 and was partially privatized and listed on the Shanghai Stock Exchange in 1996. Yili received a lot of publicity as the only sponsor of dairy products at the 2008 Olympic Games in Beijing. Both companies have been innovative in development of new products and have grown rapidly (more than 20% per year in recent years). Their massive scale of operations led to a combined total revenue in 2007 of \$5 billion from sales of 10 million metric tons of milk (KPMG, 2007). Each of these companies has about 16% of the Chinese milk market, far surpassing its rivals. The next largest dairy company in China – Bright Dairy, formerly the state-owned Shanghai Dairy Corporation – has 8% market share. Prior to the melamine scandal, Sanlu had 5% market share. About 700 smaller companies cater mostly to local markets (KPMG, 2007).

In the less developed western provinces, the large dairy processing companies often are pillar enterprises for the provincial or local economy. They hire local farmers to work in their plants, play a role in restructuring local agriculture and are important contributors of taxation revenue. There has been intense competition among some local governments to have processing plants located in their cities or counties. Favorable terms for land acquisition, utility supply, and even tax reductions and exemptions have been offered as location incentives. Fast-paced growth of milk processing firms has been encouraged and applauded.

The large milk processing firms are extremely competitive as they fight for market share throughout the country and search for exporting opportunities. The large private companies acted differently from the state or collectively owned companies in the melamine event. It was mostly large companies that had melamine-contaminated products; small, local and state or collectively owned companies only rarely were found to have products that contained this additive (Jiang, 2010).

#### *Milk collection stations*

Milk collection stations are the locations where small dairy farmers move their cows for milking. An ordinary milk collection station is a big sheltered room with necessary equipment (including milking machines and simple quality inspection equipment) that can handle a certain number of dairy cows (usually less than 100) for milking. The regular activities of a milk collection station include sterilization of cows' udders, milking, milk storage and shipment. Quality inspections have not been part of their regular daily activities (Yan and Xiu, 2009). Only when the processor's feedback to the milk collection stations indicates some problem with quality do they trace back to determine which cow or activity caused the problem.

The number of milk collection stations in a specific region depends upon the total number of dairy cows: in general for every 200 cows there is one milk collection station. The relatively high start-up cost to establish a milk collection station (more than RMB 200,000 or \$30,000) inhibits farmer-based investments (Xiu, 2008). Although some milk collection stations are owned by the large dairy processors, most are separate operations that are owned and operated by private business investors who have contracts with the large processors. Regardless of ownership status, milk collection stations act like the agents of milk processing firms as they do not have the market power to negotiate effectively with the large processing firms nor do they have sufficient investment capability to replace them (Yan and Xiu, 2009). Their revenue comes from fees that are based on the amount of milk they handle and provide to the milk processing company. Generally, they have

no control over the fee level or quality inspection for the milk they take to the processor.

#### *Dairy farmers*

Many dairy farmers (at least those who are more than about 35 years of age) obtained most of their farming experience in the production of crops like wheat, rice, corn, sorghum, soybeans, and cotton. Almost all were subsistence farmers who lived in small rural villages and worked on large collective farms. Responding to facilitating policies, government programs, and processing company initiatives, many of these small farmers began to purchase and own cows to produce milk that could be sold to the newly emerging commercial dairy companies. In many cases, small dairy farmers purchased their cows with financing assistance from the processors; generally, the processors dictate the terms of the loans, including the interest rate and the payback period. The Sanlu Company provided dairy cows and technical advice free to small dairy farmers who paid off their loans with milk (Gale and Hu, 2009). This was seen as a very competitive strategy by large processing firms and government agencies as small farmers can produce at relatively low cost: they often can utilize self-produced feeds that are gathered with unpaid family labour (Gale and Hu, 2009).

Development of the fast-growing dairy industry has been promoted by government officials and academics as an important step in the transition from subsistence to a commercial, market-oriented agriculture. Without question, this transition has enriched participating farmers and helped to restructure the agricultural industry in China. While small farmers in some areas of the country had access to several buyers of their products, others were divided by local governments into specific groups based on their distance to mega processors and their history of connections with these mega processors. In the latter cases, each group of small farmers can sell their milk to only one specific processor. This practice was implemented by the milk collection stations and supervised by local governments.

Small dairy farmers are price takers with no power to affect terms of sale or matters such as quality inspections. Even in areas where dairy farmers have formed associations or cooperatives, they have little influence on terms of sale of their product. Most do not have the resources, even collectively, to credibly mount a serious challenge to the major milk processing firms. The relative weakness in bargaining power of small traditional farmers compared to the very large dairy processing firms (that strive to be competitive in a global market) is obvious. With little experience, lack of knowledge, and poor service available to the capital-intensive dairy industry, many small dairy farmers encounter difficulties in managing their dairy cow operations and could use better advice on how to use technologies and manage production and marketing (Ma et al., 2007). With no control over price, quality inspection and other conditions of sale, reduction of average costs has been the principal way that the small farmers could maintain or increase profits. As milk supply increased about 150% from 2003 to 2006, farm price of milk decreased and milk producers were faced with a major cost-price squeeze (Gong, 2008). Costs of key inputs, including feed, electricity and gasoline, rose with the commodity boom in 2007–2008 causing major financial losses to the small dairy farmers (Xiu, 2008).

#### *Research institutions, universities, input suppliers, and government agencies*

The newly emerging dairy industry in China is a highly capital- and knowledge-intensive business, especially compared with production of field crops and most other types of livestock. Purchasing cows for milk requires a level of investment that a typical farmer



household generally finds unaffordable. Data obtained by Yan and Xiu (2009) in a survey of small dairy farms in Helinger County of Inner Mongolia showed that the average price of a pregnant cow was equivalent to the yearly per capita net incomes of two or three members of a farmer's family. Owning and feeding a cow is another challenge for these farmers who used to cultivate crops and know little about the physical requirements and disease control of dairy cows. As a result, research institutions, universities, and input suppliers have played increasingly important roles by providing credit, feed, training and technical assistance to both farmers and local technicians.

Many local governments, particularly those in less developed regions, have regarded the dairy industry as the most important industry for developing the local economy. As a result, preferential policies and strategies have been designed to promote growth of the dairy industry. Under the centrally-planned economy (1949–1978), chronic shortages were the norm across China. Government planners focused, often unsuccessfully, on increasing production in order to meet the increasing demands for both consumer and capital goods. The role of governments did not change much in the years following the market-oriented reforms: governments at all levels have focused on means to ensure rapid economic growth in every industrial sector. The performance evaluation of senior government officials often is affected by the magnitude and growth rate of gross output/product within their jurisdictions.

On September 23, 2007, the Chinese government announced eight policy measures that were designed to assist development of the national dairy industry (Zhao et al., 2009). These programs (listed below) encouraged rapid growth of the dairy industry.

- (1) Subsidies for converting to better breeds.
- (2) Subsidies for increasing herd sizes.
- (3) Subsidies for purchase of dairy machines.
- (4) Subsidies for killing diseased cattle.
- (5) Subsidies for insuring animals.
- (6) Support to build standardized cow breeding areas.
- (7) Credit support to dairy farmers.
- (8) Improvements in industrial policies of the dairy industry.

While the dairy industry was encouraged to grow rapidly from small, locally-based production and consumption to a modern industry with huge processing plants and country-wide wholesaling and retailing, government attention to inspection and safety issues did not keep up. When the melamine event was first reported, the government did not even know which of its departments should be responsible for it.

Some have accused the Chinese government of negligence (or, at least, malfeasance) for the obvious lack of adequate inspection of dairy products and other foods; however, it was not an easy problem to solve. Prior to the melamine problem, China had 20,393 milk collection stations (China Daily, 2009b) spread across numerous local jurisdictions in an industry that had almost quadrupled its production in just 8 years (USDA, 2008). While governments were actively encouraging greater expansion of the dairy industry, China had adopted no national standards for raw milk and its products. All major dairy processors were given permission to set their own standards and implement their own inspections as they were labeled *exempt of inspection* (meaning there was no need for regular inspections after they were inspected at the outset of their businesses) (China Food Industry, 2004). The government did not intervene in the inspection of these exempt firms until after the problem was reported.

Prior to the melamine problem in China, there was a lack of understanding in China and, indeed, around the world, about the safe level of melamine in milk and dairy products. Following the discovery of melamine use in milk in China, it was revealed that

trace amounts of melamine were found in milk products in the United States (China Daily, 2008b) as well as in other countries (though these were trace amounts that were attributed to contamination from plastic tubing and other elements of the manufacturing process and there never was any hint of deliberate additions of melamine in other countries).

### Incentives and opportunities to add melamine to milk

It was relatively easy for anyone to contaminate the milk with melamine. While there has been no official report on who did what to introduce melamine into dairy products, ample evidence exists of easy availability of the contaminant. A survey in Helinger County of Inner Mongolia, where the large Mengniu Dairy Processing Company is based, found that melamine was sold in some of the local drug markets. Instructions for its usage were printed on the bottles with clear instructions of the proportions to mix melamine with water to raise the protein content level of milk (Yan and Xiu, 2009). The governor of Chengguan Township in Helinger County noted that “some illegal merchants added melamine into the milk that already was diluted with water in order to raise the protein content” but it was not mentioned who were the “illegal merchants” (Ren, 2008). A Wall Street Journal article reported that salespeople had been selling a “protein powder” additive to dairy producers for 2 years, which often would be delivered in unmarked 25 kg brown paper bags (Fairclough, 2008).

This means that everyone had access to melamine on the local open markets. Taking into account all possible actors who might benefit from this activity, farmers, milk collection station owners and all milk dealers were suspected of adding the contaminant to milk. Industry giants Mengniu and Yili were said by farmers and agents to have habitually purchased milk that failed quality tests for only two-thirds the normal price (Guo, 2008). The general manager of Sanlu admitted that she knew the fact that her company added melamine to milk (Gao, 2008), and even though farmers and other dealers did not admit that they did the same thing, they cannot be vindicated.

As for incentives, it is clear that adding melamine was a profitable activity. Rapidly expanding demand for milk products led to fierce competition for raw milk among big dairy processors and soaring raw milk purchasing prices after October 2007. All direct players in the raw milk supply chain were trying to find ways to reduce their costs or increase their sales for more profit, including dairy farmers, milk collection station owners, and top executives of milk processors. Apparently, executives at Sanlu allowed their own dairy farms to add water in raw milk while knowing that the content of protein could not be reduced. This means that they informally allowed their milk farms to add melamine to the milk (Zhu et al., 2009).

It certainly was a profitable activity (before the practice was revealed). It was reported that Yujun Zhang, a dairy farmer and also owner of a milk collection station, produced a total of 775.6 tons of the melamine mixture from September 2007 to August 2008. He sold this mixture at prices between RMB 8000 and 12,000 for total sales of RMB 6,832,120 – about \$1 million (Yi, 2009). Ye (2009) reported that, from August 2, 2008 to September 12, 2008, Sanlu produced and sold 904 metric tons of melamine-tainted milk powder for RMB 47.56 million – about \$7 million. Lutter (2008) estimated a 50-fold return from using melamine to contaminate milk in China and that the “aggregate gain from spiking 1 billion kg (3.7% of total) (was) \$87 million.”

### What the Chinese government has done to fix the problem

This was not the first time that Chinese food products have caused safety and health concerns around the world. In 2006, more

than 100 people died in Panama after consuming cough medicine that contained toxic diethylene glycol that was imported from China and mistaken for glycerol by a local manufacturer (Ramzy, 2009). In September 2007, the United States banned the importation of wheat gluten from China because they found it was contaminated by melamine. The adulterated wheat gluten was blamed for the death of thousands of pets in North America. Also in 2007, the United States Food and Drug Administration banned several types of Chinese seafood that repeatedly tested positive for banned veterinary drugs (Ramzy, 2009). The value of Chinese food exports has expanded by a factor of nearly 6 in just 20 years, from \$4.5 billion in 1986 to \$25.7 billion in 2006 (Ramzy, 2009).

Following the initial shock and panic that resulted from the sudden announcement of melamine in baby formula and other dairy products in 2008, the Chinese government was faced with strong demands from its own citizens (as well as governments around the world) to adopt strong measures that would ensure the safety and quality of their dairy products. In addition to the emergency measures taken, the government has acted in three main areas: strengthening food safety laws, enforcing stricter and more frequent inspections of milk collection stations, and setting maximum tolerances for melamine in dairy products.

#### *Improved food safety laws*

China has a new Food Safety Law that went into effect on June 1, 2009 (USDA, 2009). Though the Food Safety Law had been under development for several years as a result of previous food safety incidents, the new law was given increased urgency following the melamine problem. The new Food Safety Law sets up a national food safety committee and a national food risk assessment committee with mandates to develop unified national standards for raw agricultural products, food sanitation and quality of manufactured food products. The new law stipulates that no food products can be sold inspection-free and food manufacturers are responsible for immediate recall of any food product that does not conform to food safety standards. All additives used to prepare food products must be approved and listed in a government catalogue. One of the provisions in the new law states that healthcare food must not contain claims such as “disease prevention” or “treatment functions” in their specifications but rather must provide information on which groups of people can and cannot use the products. More severe penalties are in store for violators of the new Food Safety Law, including compensation to consumers of 10 times the value of their purchases of substandard products plus their economic losses.

The new Food Safety Law replaces the Food Sanitation Law that had been in effect since 1995. The change in emphasis from “Food Sanitation” to “Food Safety” emphasizes the priority the Chinese government has placed on improving the international reputation of the country’s food system. However, responsibility for food safety is divided among the General Administration of Quality Supervision, Inspection and Quarantine, the State Food and Drug Administration and the ministries of health, agriculture, commerce and industry, leading to concerns of possible jurisdictional conflicts over authority and potential revenues from fines (Ramzy, 2009).

#### *Improved inspections for milk collection stations*

The new Food Safety Law instituted a system of risk evaluation that includes monitoring about 500,000 food production companies with no exemptions (China Daily, 2009b). All of the 20,393 milk collection stations across China were inspected between November 2008 and April 2009. The inspections determined that 3908 milk collection stations lacked testing equipment or were not sanitary so were shut down. The remaining 16,485 stations

now are subjected to rotating inspections by provincial and regional agriculture departments (China Daily, 2009a).

#### *Tolerance standards for melamine in dairy products*

Although it has long been known that trace amounts of melamine occur in some food products (due to its use in certain industrial applications), the melamine scandal in China revealed that most countries throughout the world had no (or inadequate) tolerance standards for melamine in food products. Guidelines in Hong Kong and New Zealand stated that melamine in food products was considered safe at 2.5 ppm or less. Hong Kong had a tolerance level of one part per million for children under three and women who were pregnant. The Food and Drug Administration in the United States in an Interim Safety and Risk Assessment of Melamine and its Analogues in Food for Humans suggested guidelines of 2.5 ppm (USFDA, 2009).

Following “a rigorous health risk assessment using a consistent approach,” countries in Europe, North America and elsewhere quickly adopted “interim standards for melamine in products containing milk and milk-derived ingredients” that “will be re-examined as new data become available” (Health Canada, 2009). Canada set the maximum level of melamine in infant formula at 0.5 ppm and for other food products that contain milk and milk-derived ingredients at 2.5 ppm (Health Canada, 2009). In early December, 2008, the World Health Organization recommended the maximum daily intake of melamine for infants to be 0.2 mg/kg of weight per day. This tolerance level then was adopted by most countries (Health Canada, 2009).

It is clear that the melamine scandal in China caused health officials around the world to reexamine the level of melamine that could be considered safe in milk and milk products (and given the level of uncertainty about the tolerance level for various people, it would not be surprising if further refinements to the tolerance levels were made in the future). However, the relatively low tolerance levels adopted by most countries in the wake of China’s melamine scandal are miniscule when compared to the 6196 ppm discovered in some batches of milk powder in China (Ang, 2008).

#### **Conclusions**

The melamine scandal that caused such huge consequences for consumers and producers of China’s dairy products shocked the world. However, in retrospect, problems in China’s dairy industry should not have been a surprise: rapid growth fueled by large investments from multinational dairy firms based in New Zealand, Australia, Europe and elsewhere; development of a highly modern and concentrated processing sector that obtained its raw materials from millions of small, poor and uneducated traditional farmers; and government support and encouragement for growth with little emphasis on inspection and safety issues. Even before the melamine in milk scandal erupted in the fall of 2008, China’s manufacturing industry had been under intense scrutiny after melamine and other industrial toxins were found in exports of toothpaste and pet foods.

China’s government has acknowledged that the country’s dairy industry was chaotic and suffered from a grave lack of oversight. It has pledged to monitor milk products from dairies to store shelves. But, have lessons been learned? The melamine crisis prompted the government to fire local and high-level officials for negligence and to fine and imprison others. It rushed a new food safety law into force. It mandated regular inspections of all companies involved in the food business with no exemptions. It set new allowable tolerances for melamine in dairy products. But Li et al. (2009) question how effectively this can be done, given that there are

millions of small dairy farmers, tens of thousands of milk collection stations and hundreds of milk processors, large and small.

Food safety is a key issue for any society and it requires the attention and awareness of all stakeholders in the industry. Given the profit motivation of those in the private sector, the government needs to play its role in safeguarding the production, marketing and consumption of the products. Ways need to be found so that all participants in the supply chain have financial incentives to provide clean, safe and healthy products (Holleran et al., 1999). With China's economy transitioning from peasant-based to massive commercial production, the clear divisions of different sectors and efficient functioning of them are crucial for the long, stable and sustainable development of the economy.

Farmers' associations and milk collectors' associations can play an important role in strengthening internal supervision among their members to discourage and prevent illegal practices and, at the same time, to bargain with the mega milk processors for improved price and sales conditions (Xiu, 2008). Moral persuasion also can play a role in that it would raise the awareness of all stakeholders of the importance of smooth and effective operation of the whole system (Xiu, 2008). Transparent decision making and information provision would help firms along the entire supply chain. It also would improve confidence of consumers of the safety and healthfulness of the dairy products that are offered for sale.

However, it is likely to take some time for the dairy industry in China to recover fully. Despite actions taken by the industry and government to improve the safety of dairy products, periodic reports of melamine in milk continue nearly 16 months after contaminated milk products were first acknowledged. In February, 2010, news media have reported that a number of old batches of contaminated milk powder that were not destroyed as ordered by the Chinese government may still be on store shelves (Le and Hornby, 2010). One example cited was the closure of Tiantian Dairy in Ningxia after it was found to have repackaged and sold 170 metric tons of melamine-tainted milk powder. It is to be hoped that remedial measures that have been adopted will forestall another massive milk contamination incident.

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