

Intensive and Efficient Milk Production under Unfavourable Conditions: The Case of Israel.

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Global trends in the dairy markets

In the years 2007-2008 the international milk price climbed, due to a discrepancy between demand and production. The milk powder price increased from US \$2,000 to US \$4,500 per ton and the cheddar cheese price increased from US \$2,500 to US \$5,000 per ton. In September 2008, when this article was written, milk powder prices were decreasing, reaching US \$3,500 per ton, but still higher than the initial prices. The rising demand for milk occurs mostly in the expanding urban areas of new emerging economies, most of them located in the tropical and sub-tropical parts of the world. In China, for example, the urban population has increased from 160 million (19% of the total population) to 450 million (34% of the total population) over the last 30 years. Per capita milk consumption in China's urban areas has increased by 420% in the last decade, compared to only an 85% increase in the rural areas. The increasing demand in the emerging economies is mostly for fresh milk, milk-based beverages, and natural and flavoured yoghurts. These products are better prepared when using fresh milk. This will influence production in the new dairy farms established to supply this raw milk to urban markets. This trend will affect the genetic, feeding and management practices used, as well as environmental issues.

Feeding costs for milk production have increased all over the world in recent years. The price of livestock foodstuffs, which were stable until two years ago, have increased dramatically since then. In the last two years, the prices of corn and barley grains increased from 125 and 150 euros per ton to 250 and 275 euros per ton respectively, (1). The soybean price increased from 250 to 475 euros per ton in the same period (2).

Developments in the world dairy sector in recent years, characterized by the significant increase in international grain and milk prices, have led many countries in the emerging economies to consider the establishment of their own milk production units. They are seeking ways to produce milk at the lowest costs, while making use of local alternative feedstuffs. Similar conditions and production limitations have existed for many years in Israel.

Production system of the Israeli dairy sector

This article will describe the production system of the Israeli dairy sector, considered to be one of the most advanced and efficient dairy sectors in the world. We believe that the concepts on which the Israeli dairy sector is based can be widely adopted by new dairy systems in the world, especially in regions characterized by similar climatic and environmental conditions to those in Israel.

Israel is located to the east of the Mediterranean Sea. Israel's climate is considered subtropical and dry. It is characterized by moderately cool, rainy winters (November–March), with annual rainfall ranging between 500–1,250 mm in the north and 0–100 mm in the southern desert. The minimal precipitation needed for cultivating winter forage crops is 300 mm, and drought is not infrequent (2–3 times per decade). During the summer (June–October), the dry season, there is no rainfall. Summer is warm and humid along the coast (daytime temperatures averaging 30°C), and hot and dry in the inland valleys and southern desert (daytime temperatures averaging above 40°C).

Israel's population is approximately 7 million. Per capita annual milk consumption is about 180 liters. Most of the milk consumed is locally produced and only a small portion is imported from the US and EU, as part of bi-lateral trade agreements. Milk is consumed mainly in the form of liquid, milk beverages, yoghurts and soft cheeses. Market shelves hold over 1,000 different milk products, produced by more than 10 different processing companies.

The Israeli dairy sector consists of 115,000 *Israeli-Holstein*-breed cows on 1,100 dairy farms. These farms are distributed mostly on the coast and in the hot valleys. In 2007, average annual milk production was 11,300 kg per cow, with 3.50% fat and 3.15% protein. Dairy farmers in Israel are well-organized and supported by professional institutions related to the ministry of agriculture, universities, milk marketing board and farmer's cooperative companies who supply clinical veterinary care and AI services. Israel Cattle Breeders Association (ICBA) owns the local DHI services, with the participation of over 80% of all dairy farms, including all large farms. DHI services in Israel are based on automatic data flow from the computerized milking equipment, mostly Israeli-made. These online reports, elaborated on by the DHI center, together with a special Dairy Herd Management program (NOA), enable Israeli dairy farmers to make operational decisions and manage their farms efficiently.

Israel has a unique dairy sector and milk production concept, due to significant limitations caused by permanent water shortage, shortage of land for pasture or forage growth, high input costs and hot, dry summers that last for 4–6 months per year. These limitations, in addition to high prices of imported grains, fuel and machinery, relatively high labor costs, and the large investments needed to overcome climatic limitations, increase production costs.

In the early stages of the dairy sector development, special production conditions led Israeli dairy farmers to establish a unique and unconventional production concept. This concept is characterized by special and intensive feeding and management practices of cows living in total confinement and in relatively large dairy farms located close to the cities. The strategic decision, taken nearly 70 years ago, was based on the belief that, under Israel's special conditions, a maximization of per cow milk production would be most economically viable. Israel's unique feeding system is characterized by the use of relatively high quantities of agro-industrial by-products in cows' diets, substituting expensive imported grains and limiting the amount of roughage. Climatic limitations obliged dairy farmers to develop and implement new technological solutions and special management practices that would facilitate high milk yields in the hot, humid summers.

Reform in the Israeli dairy sector

In order to improve production efficiency and competitiveness of the Israeli dairy sector and eliminate the danger of air and water pollution, an agreement was signed between the Israeli government and dairy farmers. For a period of 7 years (1999–2006), the government contributed about 40% of the farmers' expenditure on renewing farm facilities and establishing solutions to the farm effluents. This reform, called “the reform in the dairy sector”, was implemented in over 95% of the dairy farms in Israel. During this period, the number of active dairy farms was reduced by 30% (from 1,500 to 1,100 farms), leading to an increase in herd size. Nearly US \$480 million were invested, of which almost 40% was government contribution. Per cow investment reached US \$4,200 (US \$0.4 for each liter of milk in quota). As a result, the Israeli dairy sector is now well-equipped for production for the next 20 years.

The Israeli unique feeding system is environmentally friendly

The unique Israeli feeding system allows the maximization of milk production per cow, while keeping dairy farms environmentally friendly, even when they are located near large cities.

The incorporation of agro-industrial by-products in dairy cows' diets, together with the use of recycled waste water when growing forage crops, reduces feeding costs. Total Mixed Ration (TMR) is the predominant feeding system used in Israel. TMR is prepared mostly in large-scale “regional feeding centers”. All small dairy farms in Israel (averaging 60 cows per herd), and over 70% of large dairy farms (averaging 400 cows per herd), make use of these feeding centers to buy TMR for their cows. In Israel, dairy cows' rations consist of 35% forage and 65% concentrates, most of which are agro-industrial by-products. Most of the forages are winter crops (mainly wheat silages), grown during the rainy season, stored in large cement bunkers, and fed all year around. Summer forages, mostly corn and sorghum silages, are generally grown using recycled waste water for irrigation. Less than half of the concentrates fed to dairy cows in Israel are imported cereal grains (corn, barley, sorghum and oats) and protein meals (sunflower, soybean and cottonseed meals). Agro-industrial by-products and silages are easily incorporated into cows' and heifers' diets through these feeding centers. Approximately half the concentrates (DM basis) in milking cows' TMR and almost all the concentrates in heifers' diets are based on agro-industrial by-products, including: dried distillery grains, corn gluten feed, brewer grains and cotton seeds (protein suppliers); dry beet pulp, bakery wastes and molasses (energy suppliers); and wheat bran and soy hulls (alternative fibre sources). A high proportion of wet by-products, like orange, potato and tomato peels, olive wastes, and fruit and vegetable surpluses are used in the Israeli cows' diets. The use of large quantities of agro-industrial by-products in cows' diets benefits the Israeli dairy sector in two ways. First, it reduces feeding costs. Second, additional expenditure on the treatment of these materials to avoid environmental pollution is avoided. In 2007, nearly 630,000 tons of fresh agro-industrial materials were used to feed dairy cows in Israel, with a total feeding value of US \$25.3 million. According to the Israeli environmental regulations, all these materials must be hidden in specified locations. An additional US \$14.3 million were saved because the expense of hiding these materials was avoided. Thus, the overall economic value of incorporating agro-industrial by-products into the cows' diets was nearly US

\$40 million per year (US \$360 per cow or 3.3 cents per liter); over 10% of the total annual feeding expenses per cow.

High productivity of Israeli dairy cows

The maximization of per cow milk production was achieved in Israel by genetic and management improvements. High milk production per cow increases production efficiency by reducing per liter feeding and labour costs, and by decreasing per cow veterinary care, housing and milking facilities costs. The amount of feed required to produce one liter of milk in a cow producing 45 liters per day is only 73% of that needed for a cow producing only 15 liters per day (0.52 and 0.94 kg DM per liter respectively). High productivity also reduces cows' contribution to global warming. Methane production per kg of milk produced is reduced from 41.1 liters (in cows producing 3,400 kg per year) to 24.8 liters (in cows producing 6,500 kg per day (3)). Preliminary results of the dairy sector's "carbon footprints" were presented by the IFCN institute in the first IDF conference. The conference, held in Edinburgh, Scotland, last June, dealt with the relationship between the dairy sector and the environment. The data presented indicates that methane production per kg of milk produced was 1.05 kg per high-producing cow in the US (10,000 kg per year), 1.35 kg per cow in New Zealand (4,000 kg per year), and 1.95 kg per cow in Peru (2,000 kg per year). Total CO₂ emission reached 0.55, 0.80 and 1.35 kg for each kilogram of milk produced in the US, New Zealand and Peru cows, respectively (4). It is expected that the total CO₂ equivalent emission per kg of milk produced by Israeli cows (11,500 kg per year) will be 80% of the CO₂ emitted by cows in West Europe, and only 40% of that produced by New Zealand cows.

Overcoming the effect of heat stress on dairy cows in Israel

Heat stress affects the production, fertility and health of high-producing dairy cows all over the world. According to a study published recently in the US (5), heat stress causes losses of US \$1.5 billion per year (US \$150 per cow) in the US dairy sector. According to this study, these losses can be reduced by 40% by using intensive cooling systems and special management practices. The summer heat in Israel is considered one of the most limiting factors in milk production. Cows' performance and production efficiency are negatively affected by summer heat, causing substantial financial losses to dairy farmers. The effect of heat stress on cows' fertility and productivity results in seasonality of milk supply, thus generating additional losses to the Israeli dairy sector. As in many hot regions in the world, global warming has aggravated the heat stress effect on Israeli cows in recent decades, since global warming reduces cows' ability to eliminate metabolic heat production. Israel has been developing heat stress relief methods for over 30 years, with the aim of allowing cows to manifest their full production potential. The cooling of cows in Israel is based on water evaporation, mainly from the cow's surface, by means of a combination of wetting and forced ventilation. The cooling effect was first studied under Israeli summer conditions in the early 80s (6). It was found that cows that have been cooled maintain normal body temperatures all day long, even during the Israeli summer.

A large-scale four-year survey confirmed these experimental results (7). Fourteen farms participated in the survey. They were all located in the coastal regions of Israel

and were classified into three different groups, according to the intensity of the cooling methods in use (intensive, moderate and minimal). Milk production (kg per day) and conception rates (%) were calculated for summer (July–September) and winter (December–February). The average daily milk production per cow in winter was only 0.6 kg higher than that obtained by cows that had been intensively cooled in the summer. However, when cows were cooled only minimally in the summer, the gap between daily winter and summer milk production was 3.6 kg per day. The summer to winter production ratio was 98.5% for intensively-cooled cows and 90.7% for minimally-cooled cows. The conception-rate of winter-inseminated cows ranged from 43% to 47% in cows of different groups. Intensively-cooled cows reached a conception rate of 34% in the summer, compared to a conception rate of only 17%, in minimally-cooled cows.

In another recent survey (8), intensively-cooled cows in "leading" farms (over 13,000 kg per cow annually), produced 42 kg per day, on average in both winter and summer, while moderately-cooled cows produced 3.5 kg less per day in the summer than in the winter. In a recent Israeli study (9), intensive cooling of cows in summer improved feeding efficiency. Cooled cows required 0.55 kg of feed to produce 1 kg of milk, whereas non-cooled cows required 0.61 kg of feed. This indicated a 10% improvement in feeding efficiency.

In short, the results of the studies presented here indicate that intensive cooling reduces summer losses in milk production drastically, increases feeding efficiency and minimizes the reduction in conception rate of summer-inseminated cows in Israel by half. The experience gained in Israel indicates that a high level of production should not necessarily be a limiting factor. On the contrary, when cows are intensively-cooled during heat stress conditions, high productivity and production efficiency can be obtained. Furthermore, similar results can be expected in other hot regions in the future.

How can Israeli experience contribute to the development of dairy sectors in the emerging markets?

The Israeli "production concept" is based on obtaining high per cow yields. This is done by overcoming imitations through the use of advanced technologies and management, and by the establishment of a comprehensive computerized database that provides highly- professional support to dairy farmers and related institutions.

The future development of the dairy sectors in the emerging market can be defined in the following way: It is expected that the majority of the demand will be from large urban populations, most of which are situated in tropical and sub-tropical parts of the world. Most of the milk supplied to these centers is likely to be produced in new, modern and well-equipped dairy farms which, due to high transportation costs and the demand for high-quality liquid products, will be established relatively close to the consumption centers. The high purchasing potential of consumers in these new consumption centers will allow milk producers to charge good prices for the supply of milk that is of a high quality and well-adapted to consumer tastes. Proximity to the large urban centers is advantageous for two reasons. First, large quantities of waste water will be available for the irrigation of forage crops. Second, cheap agro-industrial residues can serve as alternative foodstuffs for cows, thus reducing feeding costs and resolving pollution problems in large cities at the same time. Efficient cooling methods will minimize the negative impact of heat stress on the

cows' performance, thereby facilitating efficient milk production and preventing seasonality in milk supply. Adoption of Israeli experience in forage growing by residual waste water, use of agro-industrial by-products for feeding, improving feeding and management practices to overcome summer stressful conditions and using sophisticated management tools for efficient managing the farms, as well as the establishment of "supporting institutions" and organization like those operating in Israel, will help new dairy sectors to achieve the goal of efficient supply of milk products to their growing populations.

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