Study on Energy Saving and Consumption Reduction of Fresh Agricultural Products Cold Chain Logistics in China

Yong-jun ZHANG¹, Chang-feng ZHANG¹,²,³ and Sheng-gang WU¹

¹Shandong institute of commerce and technology, China
²The National Engineering Research Center for Agricultural Products Logistics, China
³Shandong Province Key Laboratory of Storage and Transportation Technology of Agricultural Products, China

*Corresponding author

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Abstract. Food cold storage is an important means to ensure the quality of fresh agricultural products. In transportation, storage and retail, fresh agricultural products needs to maintain a low temperature environment, which will result in a large amount of energy consumption. In this paper, the energy consumption link of cold chain is analyzed, and the application of new technology of energy saving and emission reduction is discussed and the countermeasure in each link is put forward. Finally the new energy saving technology of cold chain logistics is summarized, and it may provide reference for the development of food cold chain logistics.

Introduction

Cold chain logistics [1,2] is a supply chain system with low temperature environment as the core, which is higher, more complex, more investment and higher energy consumption than the ordinary room temperature logistics. 40% of the world's food needs to be refrigerated, while 11% of the world's electricity consumption is used for fresh agricultural products cold chain, and the energy consumption of cold chain logistics has attracted widespread attention. In the face of energy exhaustion and environment worsening the background, energy conservation and sustainable development is the main theme of energy consumption of cold chain logistics is an inevitable trend, has become a hot research topic, and has very important practical significance for the development of the whole society.

Cold chain logistics refers to the refrigerated and frozen fresh agricultural products in the production, storage, transportation, sales to the consumer terminal, each link is always in the cold and the provisions of the low temperature environment, in order to ensure food quality and reduce food losses in a system engineering. With the progress of science and technology, the refrigeration technology is undergone a great progress [3, 4]. Specifically, the use of the scope of the cold chain logistics [5, 6] that consists mainly of primary agricultural products (fruits, vegetables, meat, poultry and aquatic products), food processing (frozen food, cooked food, dairy and food packaging materials) and special commodity (pharmaceutical and biological products). The particularity of product quality, time, humidity, and temperature and hygiene environment is the most important factor of cold chain logistics, and its main characteristics are as follows:

- Timeliness, perishable products are not easy to store, cold chain logistics has certain timeliness;
- The complexity of the cold chain logistics using refrigeration technology, insulation technology, product quality change mechanism, temperature control and monitoring technology, cold chain products have different corresponding temperature control and storage time, and quality in the process of circulation with the change of temperature and time, these greatly increase the complexity of cold chain logistics the;
High cost, cold chain logistics cold storage construction and the purchase of refrigerated vehicles need huge investment, is 3-5 times of the general warehouse and its operation and management costs are high.

Energy Consumption Problems in Cold Chain Logistics in China

At present, China's cold chain logistics in the initial stage, there are still many shortcomings. The national cold chain logistics development and application of the standard is not perfect, there are many standard blank. Lack of infrastructure construction, equipment is relatively old, backward technology; the industry's overall management level is not high lack of professional personnel; the third party logistics development lags behind, only the whole logistics chain occupies about 20%, has led to food safety hazards and the massive losses. Table 1 lists the gap between the development of cold chain logistics in China and the developed countries at present [7].

<table>
<thead>
<tr>
<th>content</th>
<th>Domestic situation in China</th>
<th>The situation of developed countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold chain circulation rate (%)</td>
<td>Comprehensive rate 19%;</td>
<td>United States 87%; Japan 85%</td>
</tr>
<tr>
<td></td>
<td>fruits&amp;vegetables, meat were 5%, 15% and 23% respectively</td>
<td>Eastern European 50%;</td>
</tr>
<tr>
<td>Loss rate of fruits and vegetables after picking (%)</td>
<td>about 25-30</td>
<td>Less than 5</td>
</tr>
<tr>
<td>Pre-cooling preservation rate (%)</td>
<td>30</td>
<td>80-100</td>
</tr>
<tr>
<td>Cold chain transport rate (%)</td>
<td>15-30</td>
<td>80-90</td>
</tr>
<tr>
<td>Cold chain transport readiness rate (%)</td>
<td>70</td>
<td>United States 95%; Japan 90%</td>
</tr>
<tr>
<td>Proportion of refrigerated trucks(%)</td>
<td>0.3</td>
<td>American 0.8-1%; British 2.5-2.8%; Germany 2-3%</td>
</tr>
<tr>
<td>Cold storage capacity (million tons)</td>
<td>900</td>
<td>United States 2400, Japan 1800</td>
</tr>
<tr>
<td>Circulation link (individual)</td>
<td>&lt;4</td>
<td>United States 4, Japan 3-4</td>
</tr>
<tr>
<td>Proportion of fresh frozen foods (%)</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Freezing utilization rate of frozen food (%)</td>
<td>Less than 20</td>
<td>80-90</td>
</tr>
<tr>
<td>Proportion of cold chain cost to total cost (%)</td>
<td>50</td>
<td>70</td>
</tr>
</tbody>
</table>

From the energy point of view, the cold chain logistics of China's energy consumption [8] is high, low efficiency in cold storage and transportation, the unit energy consumption in China is 2-3 times that of developed countries, cold chain logistics costs accounted for the proportion of the total cost of up to 70%, as two times than that of the developed countries. That is specifically demonstrated as follows:

- China's cold storage equipment obsolete, refrigeration technology backward and poor sealing, resulting in high energy consumption of refrigeration, according to statistics, the average energy
- China's refrigerator mainly concentrated in the more economically developed eastern and southern regions, is a small refrigerator, and in the same area, the size of the cold storage configuration is not reasonable, lack of unified planning, resulting in the consumption of energy, and the transport of goods loaded rate cannot be fully guaranteed, the supply of the eastern region is sufficient, refrigerated cargo overload seriously, and parts of the western region is in short supply, refrigerator car is often a in half-load transport, unable to make full use of transportation resources, resulting in waste;
- Management is not in reasonable states, many cold storages ignored the temperature records, internal temperature regulation rely on intuition and experience, randomness, professional training of personnel is not enough, unreasonable operation, cleaning is not in place, maintenance error. In addition, the loading time interval control, stacking method and refrigeration system on the lack of effective management, causes the waste of energy. Therefore, China's cold chain logistics has a long way to go to realized the energy saving and consumption reduction.
Energy Consumption and Saving in Cold Chain Logistics Of Fresh Agricultural Products

Cold chain logistics energy saving to reduce the heat load, the use of energy-efficient equipment, refrigeration equipment, reasonable operation management, constantly study new energy saving and environmental protection type refrigeration and cold storage technology and other issues together, coordinate each link. In the whole cold chain logistics, the proportion of energy consumption of cold treatment, storage, transportation and sale is about 23%, 5%, 19% and 53%, respectively. The energy consumption and energy saving potential of each link are shown in table 2. This paper expounds the energy-saving measures [9] in each specific link of cold chain logistics, and focuses on the energy saving and consumption reduction of refrigeration system.

Table 2. Energy consumption and potential energy saving in cold chain process.

<table>
<thead>
<tr>
<th>Link</th>
<th>Discharge/ 10^3 ton [CO2] year^-1</th>
<th>Consumption/ Gwh year^-1</th>
<th>Percentage of energy saving/%</th>
<th>Energy saving/ Gwh year^-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>3100-6800</td>
<td>5800-12700</td>
<td>30-50</td>
<td>6300</td>
</tr>
<tr>
<td>Delivery</td>
<td>1200</td>
<td>4820</td>
<td>20-25</td>
<td>1200</td>
</tr>
<tr>
<td>Storage</td>
<td>500</td>
<td>900</td>
<td>20-40</td>
<td>360</td>
</tr>
<tr>
<td>Pre-cooling</td>
<td>20-330</td>
<td>310-610</td>
<td>20-30</td>
<td>180</td>
</tr>
<tr>
<td>Quick freezing</td>
<td>120-220</td>
<td>220-420</td>
<td>20-30</td>
<td>130</td>
</tr>
</tbody>
</table>

Cold Treatment Links

Cold treatment refers to the use of refrigeration cryogenic process food temperature quickly reduced to a suitable storage or transport temperature, inhibit respiration, reduce harmful microorganisms and bacterial growth and loss of food nutrients, prolong storage life, maximize the quality of food, including the pre-cooling and freezing, as a first step cold chain logistics, cold treatment has a non-negligible impact on the quality of cold chain products, on the follow-up process also plays a decisive role.

Storage Links

Cold chain logistics storage equipment is generally cold storage, processing and storage of product categories, in order to regulate the market supply. Typical cold storage includes civil type cold storage, assembly type cold storage, air conditioning cold storage, automatic three-dimensional cold storage and ice temperature cold storage. The heat load of the cold storage mainly includes the heat transfer from the maintenance structure of the cold storage to the heat of the storage room, the heat of the cargo itself, the heat of the cold storage and the heat generated by the equipment. In addition to the energy saving of the refrigeration system, the energy saving of cold storage should also be considered from the following aspects.

- Insulation material selection. Through the cold heat insulation layer into total heat load of 20%-35%, select the appropriate insulation materials can effectively reduce the heat from the outside into the refrigerator, insulation, wet insulation properties, thermal insulation layer thickness, the best economic new insulation materials is a hot research topic.
- Air curtain. In order to prevent the outside heat and humidity from permeating into the cold storage and reduce the cold load in the storehouse, the air curtain is usually set up in the cold storage door. Reasonable control of jet velocity, nozzle width, jet angle and hot pressing is beneficial to improve the efficiency of air curtain seal.
- Technology of peak shaving and valley filling. During the peak period of electricity price and the low period there is a great difference in our country Chinese industry, cold storage by using valley power cut during the peak cooling load, saving cost, and slow down the power supply system pressure, to achieve the purpose of energy saving. However, the sensitivity of food to temperature fluctuation must be considered, and food quality should be given high priority.
Transportation Links

The cold chain logistics transportation link is an important link to link the storage and the sales link, and is completed by the cold chain transportation equipment. Cold chain transport equipment refers to the facilities and the facilities that can provide and maintain a certain low temperature environment for transporting frozen food, mainly refrigerated vehicles, refrigerated trains, refrigerated ships and air transport. The energy consumption of refrigeration transportation mainly includes the energy consumption of refrigeration system and the energy consumption of transportation vehicle itself. Energy saving of refrigeration system in refrigerated transportation link can refer to refrigeration system energy saving in cold treatment link. Such all kinds of traffic tools include: saving energy saving technology of automobile engine are improved and new energy technology (electric vehicles, hybrid vehicles and clean fuel vehicles; the main direction of the train such electrical and high-speed ships are mainly used for energy saving; electrical components provided high thermal efficiency of ship engine, Energy reducing in air transport is the mainly in items of new energy, efficient operations, effective infrastructure means. Improving the management level, optimizing the traffic routes, multi-mode transportation, and improving the carrying rate are conducive to the realization of energy saving and consumption reduction of the transportation tools.

Sale Links

Sales is the last part of cold chain, fresh agricultural food after short or long distance transportation, sales in the supermarket or convenience store in the freezer for the sales process, the main equipment storage cabinets and cabinet freezer. Energy saving measures including supermarket cooling cabinet freezer, air curtain optimization design, optimization design, anti-condensation evaporator heater intelligent control, night cover use, parallel unit, liquid refrigerant sub cooling, the appropriate method of defrost and defrosting control, can greatly reduce the energy consumption of the supermarket. The energy saving of household refrigerators and restaurant freezers is mainly to improve the cooling efficiency of refrigeration system.

New Energy Saving Technology of Cold Chain Logistics

Cold chain logistics and refrigeration technology are complementary to each other to promote the development of the cold chain and promote the development of refrigeration technology, and the application of the new technique of refrigeration and ensure the cold chain logistics of energy saving and cold chain food safety. Therefore, the energy saving of cold chain logistics depends largely on the development of new technology, especially the new refrigeration technology. At present most of the refrigeration system using the circulating gas compression refrigeration cycle, but the consumption of a large number of high-grade electricity, also brought many environmental problems (the greenhouse effect, the destruction of the ozone layer, etc.) some of the alternative refrigeration cycle and new refrigeration technology has received extensive attention. In addition, the use of new food technology also has a positive impact on the entire cold chain logistics energy saving.

Summary

In the global advocacy of energy saving and emission reduction environment, energy conservation has become the main aim of social development. At present, the situation of energy conservation and emission reduction in China is very grim. China made a commitment at the 2009 international climate conference. By 2020, carbon dioxide emissions per unit of GDP decreased by 40%-45% compared with 2005. It is also a long and arduous task for the cold chain logistics to save energy and reduce consumption. Cold chain logistics in China started late, and there is still a big gap with foreign advanced level, energy saving has potential space to fill. Through the discussion of the energy saving potential of each link in the fresh agricultural cold chain logistics, only the fundamental principles of energy saving in all aspects of logistics management and the use of advanced technology to achieve
the best energy saving effect. The application of new technology can greatly reduce the energy consumption of fresh agricultural products in cold chain logistics, and also has many benefits for cold chain products itself, and it is imperative to increase the application of new energy-saving technology in cold chain logistics.

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References


