

Adisak Suvittawat<sup>1</sup>

## FOOD COLD CHAIN TRANSPORTATION: EASTERN THAILAND CASE STUDY

*The objective of this research is finding the food cold chain transportation variables which affect food quality and the holding period for cold chain logistics entrepreneurs in Eastern Thailand. Food cold chain transportation factors has been grouped in 4 types: controllable temperature in product shipment; packaging; processing and storage of products; distribution transportation and practices.*

*Keywords: food transportation; product storage; distribution; logistics; Thailand.*

Адісак Сувіттават

## ТРАНСПОРТУВАННЯ ПРОДУКТІВ ХАРЧУВАННЯ В ХОЛОДИЛЬНИХ ЛАНЦЮГАХ: НА ПРИКЛАДІ СХІДНОГО ТАЙЛАНДУ

*У статті виявлено фактори, що мають найбільший вплив на якість продуктів харчування при їх транспортуванні холодильними ланцюгами. Для збору даних для аналізу було опитано підприємців у Східному Тайланді. Фактори впливу проаналізовано за 4 ключовими групами: контроль за температурою при перевезеннях; пакування; переробка та зберігання; дистрибуція та транспортування.*

*Ключові слова: перевезення продуктів харчування; зберігання продуктів; дистрибуція; логістика; Тайланд.*

*Рис. 1. Табл. 4. Літ. 18.*

Адісак Сувіттават

## ТРАНСПОРТИРОВКА ПРОДУКТОВ ПИТАНИЯ В ХОЛОДИЛЬНЫХ ЦЕПЯХ: НА ПРИМЕРЕ ВОСТОЧНОГО ТАИЛАНДА

*В статье выявлены факторы, имеющие наибольшее влияние на качество продуктов питания при их перевозке холодильными цепями. Для сбора данных для анализа были опрошены предприниматели в Восточном Таиланде. Факторы влияния проанализированы по 4 ключевым группам: контроль температуры при перевозках; упаковка; переработка и хранение; дистрибуция и транспортировка.*

*Ключевые слова: перевозка продуктов питания; хранение продуктов; дистрибуция; логистика; Таиланд.*

**Introduction.** Logistics management is closely related to high competitiveness of food industries. Effective logistics management is providing not only competitive cost management but also food quality control. The food industry always has interest in transportation cost reduction while maintaining quality level since food is always requested fresh but is easy to perish. In the world today, nations are facing uncertainty of food availability which comes from many factors such as droughts, food safety concerns and food logistics management. The period of food quality depends mainly on temperature, moisture and the factors which affect the growth rate of microorganisms. Some food storage techniques such as drying and smoking are common for early food preservation, however new food storage technologies and new food transportation methods help solving the problem of food quality deterioration. The emergence of retailing in fresh agricultural products and the change in consumer behavior

<sup>1</sup> International College, Burapha University, Chonburi, Thailand.

for agricultural products consumption, the improvement of logistics and distribution have been increasingly important.

Material handling system providers are currently developing their expertise to assist food and beverage companies in their supply chain management. It is not a matter of the size of a company providing food and beverages to consumers, truck use is considered to be a universal cost challenge for everyone. Some food providers are choosing their logistics and distribution centers close to markets and use new logistics technology for their best facility use.

Currently with more pressure from consumers, producers and environmental risks, packaging industry is dramatically progressing focusing on food safety and environmental friendship. Traditional sustainable packaging is focusing on weight reduction materials, recycling available and wastes recovery. Transportation of food with new storage technologies help solving spatial and temporal fluctuations in production.

**Literature review.** Low temperature handling and storage have been widely applied as a postharvest treatment to delay ripening in fruits and enhance its quality. Inappropriate temperature causes chilling injury which have negative effect on quality (Aghdam and Bodbodak, 2014). Normally aquatic product cold chain logistics uses artificial refrigeration technology for low temperature requirement production through temperature control, automated monitoring systems which provide effective information management needed for effective cold chain logistics (Xiao et al., 2016).

Supercooling is a new technique of food processing which has high potential for food shelf life extension and reducing wasted food products. The removal of freezing process leads to shorter processing times and less energy consumption (Stonehouse and Evans, 2015).

Packaging can be considered as science, art and technology since it protects products for distribution, storage and shipment. Packaging is of vital importance for food business as it saves product from manufacturing to consumption. Food packaging objectives are to maintain food safety and food quality since the growing middle class income, trade liberalization and retail business development encourage the growth of food packaging sector. Most of food packaging materials are metal, paper, laminate, plastic and glass however the demand for laminates and co-extrusion has been growing (Ojha et al., 2015).

Demand for hygiene and safety of food products have been increasing which coincide with retailer cost effective demand for longer shelf life. Quality improvement in food packaging has been rapidly developed to satisfy customer needs. Modified atmosphere packaging is fit for food preservation and quality improvement but technological and logistical aspects must be considered here (Singh et al., 2011).

Normally, inside and outside pallet stack temperatures tended to be warmer than sidewall temperature in fall, winter and spring. However in summer the sidewall tends to be warmer than pallet stacks which give higher ambient temperatures and heat leakage through pallet stack walls. The results show that airflow within pallet stacks must be improved as refrigerated air moves to evaporators (Brown et al., 2016).

Vacuum-packaged meat freezer storage had no significant effect on meat weight loss but it tend to be increase throughout storage. Dramatic increase of protein has been recorded in meat storage within 6 weeks. The concentration of chemical compounds was not different. The spoilage of frozen meat and its quality deterioration

come from the interaction of many factors such as post-slaughter methods and microbial contamination, storage period, temperature and methods of storage (Jacky et al., 2011). Distribution of food downstream to retailers or drop points show its significant role in effective environmental control within the whole food supply chain. Effective logistics and appropriate technologies are critical for the success of supply chain system (Validi et al., 2014).

Food and beverage companies are looking for new methods to stay competitive and also are looking to stay ahead of food and beverage laws and regulations. They need to comply with legal requirements which effect their vehicle and other transportation equipments to ensure food and beverage quality during transportation (Andel, 2014).

**Problem statement.** Postharvest handling and cooling, material classification, receiving and shipment time as well as packaging variables are needed to be studied as those factors directly affect on vegetable and other food products qualities. Material classification, metabolite rate reduction, short period of storage, temperature and humidity variables are the factors which influence vegetable and other food logistics, thus, it is really important to study those factors for better management.

**Research objectives:**

1. To study the effects of controllable temperature of product shipment on product quality standards.
2. To find out the effects of packaging, processing and storage of products on product quality standards.
3. To study the effect of product storage and distribution practices on product quality standards.
4. To apply the research results for cold chain vegetable and food products transportation improvement.

**Methodology.** This is an exploratory research which focuses on cold chain vegetable and food products transportation. The research applies quantitative methods using questionnaires and also qualitative contextual tools. Secondary data have been taken from literature review and has been reconfirmed by research findings.

The research process started with literature review. Based on it parameter measurements for the key success related factors were created, consulting on their choice with experts was carried before starting the initial survey with entrepreneurs. The survey results were analyzed by using a mean and SD model.

The exploratory research has been focused on 32 entrepreneurs currently doing logistics. The questionnaires have been separated in 4 parts according to the research parameter measurements.

The first part was focused on postharvest handling and cooling, material classification, receiving and shipment time, packaging variables.

The second part was focused on material classification, metabolite rate reduction, short period of storage, appropriate temperature and humidity variables.

The third part was focused on specific temperature requirement, appropriate cooling system producer, appropriate air flow producer and some other material variables.

The last part was focused on specific transportation equipments, distance and spots with cool service areas.

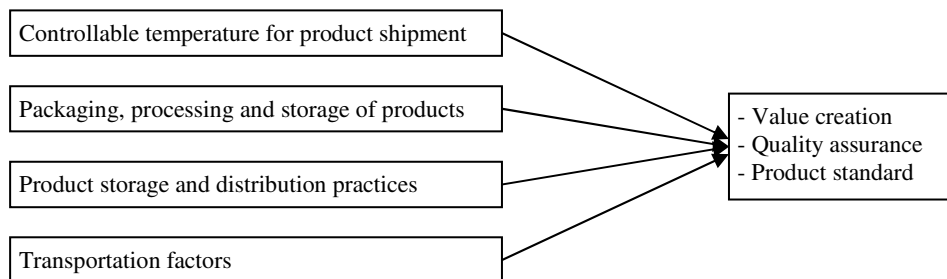


Figure 1. **Conceptual framework of the research**, author's

Table 1 shows the Mean and SD. results for the main variables under study. The results found that the entrepreneur responses were at the agreed level in which the Mean = 3.94 and SD = 0.77.

Table 1. **Variables for controllable temperature for product shipment**, author's

Variables	Mean	SD
1. Postharvest handling and cooling	4.21	1.06
2. Materials classification	3.96	0.35
3. Receiving and shipment time	3.87	0.97
4. Packaging	3.74	0.72
Average	3.94	0.77

Number of the respondents = 32.

Appropriately controlled and modified air temperature can be different for vegetable depending on specie, ripeness stage or different exposure period. Variety of product is difficult to handle since it requires different temperatures, transportation and retail display during storage (Brecht et al., 2003). In food preservation appropriate antimicrobial packaging could limit and inhibit the spoilage bacterial growth rate and thus improve the shelf life of food products. Silver-containing packaging preparation and antimicrobial characteristic provide higher efficacy against common meat spoilage bacteria (Kuuliala et al., 2015). Wireless sensor network (WSN) is mostly applied in food cold chain logistics, this technology reduces data traffics and communication systems overload. A good design of compressed sending model helps keeping cold chain logistics temperature controllable due to its accuracy in reconstructing temperature data. The method reflects on real time temperature change in refrigerate trucks during cold chain transportation and gives effective decision support for better quality and safety assurance (Xiao et al., 2016). Million tons of temperature sensitive goods are currently being produced, transported, stored and distributing therefore temperature and humidity control are very important. Goods quality control and monitoring during cold chain transportation are growing up for logistics of such products as fruits, vegetables, fish and meat since they might be easy perishable and their properties are affected by temperature changes (Badia-Melis et al., 2015).

Table 2 shows the Mean and SD results for the variables of material classification, metabolite rate reduction, short period of storage, appropriate temperature and humidity. The results show that the entrepreneur responses were at the agreed level in which the Mean = 3.81 and SD = 0.78.

**Table 2. Packaging, processing and storage of products, author's**

Variables	Mean	SD
1. Materials classification	3.97	0.92
2. Metabolite rate reduction	3.82	0.74
3. Short period of storage	3.81	0.86
4. Appropriate temperature and humidity	3.65	0.63
Average	3.81	0.78

Number of the respondents = 32.

Suitable ventilated packaging for fresh vegetables and fruits plays an important role in making food cold chains more cost effective and overall efficient. Analysis of packaging performance currently still lacks the integration of product cooling rate, product quality, box ventilation and shelf life. Relevant packaging functionalities should be covered in ventilated package performance analysis (Defraeye et al., 2015).

In the current state of trade, traditional packaging in a chain has little linkage between supply chain functions such as operations, purchasing and transportation. In the current model of supply chain management, each chain needs to participate and connect value with innovation, from manufacturing until consumers. Packaging gets involved in product development since food packaging safety is related with brand management, particularly brand equity, and packaging is considered to be rather a value than a firm cost.

Table 3 demonstrates the Mean and SD results for the variables of specific temperature requirement, appropriate cooling producer, appropriate air flow producer and material value. The results show that the entrepreneur responses were at the agreed level in which the Mean = 3.88 and SD = 0.76.

**Table 3. Product storage and distribution practices, author's**

Variables	Mean	SD
1. Specific temperature requirement	3.98	0.69
2. Appropriate cooling producer	3.95	0.82
3. Appropriate air flow producer	3.87	0.73
4. Material value	3.73	0.82
Average	3.88	0.76

Number of the respondents = 32.

Methods of vegetable and fruits preservations included storage in ventilated containers, storage under low temperatures, use of evaporative coolant system and chemical treatment. Refrigeration method is very popular for fruit and vegetable preservation but banana and mango, for example, could not be stored in refrigeration long as they are susceptible to chilling affect (Olosunde et al., 2009). Evaporative cooling techniques are thus used with controllable cooling containers which sometimes can even improve chemical qualities of product or hinder bacteriological growth in milk products.

Fruit, vegetable and meat qualities are rapidly changing under uncontrollable temperature and relative humidity during transportation and storage. Most of temperature variations happen during warehousing, product handling and transportation. Uncontrollable temperature is considered to be the main factor for foodborne illnesses, thus studying temperature changes and analyzing data on refrigeration rooms

is very important not only for food transportation but also for population health (Kim et al., 2015).

Table 4 shows the Mean and SD results for the variables of specific transportation equipment, appropriate cooling producers, economy of distance and spots with cooling service. The results found that the responses were at the agreed level in which the Mean = 3.94 and SD = 0.76.

*Table 4. Transportation factors, author's*

Variables	Mean	SD
1. Specific transportation equipment	4.02	0.73
2. Appropriate cooling producers	3.97	0.92
3. Economy of distance	3.95	0.65
4. Spots with cool service areas	3.84	0.75
Average	3.94	0.76

Number of the respondents = 32.

Mechanical refrigeration systems need to be simplified as they provide easier operations. Complexity of mechanical refrigeration and energy consuming machines are not suitable wither for small framers or for wholesalers and retailers (Yimer and Sahu, 2014). The results show the importance of equipment maintenance and appropriate monitoring to make sure that products are appropriately transported and arrived under suitable temperature. Transportation costs of logistics firms are influenced by fixed costs and variable costs involved in different transportation processes. Transportation costs are related to time-window constraints depending on customer arrival time. Logistics firms need to reduce time-window period of their transportation costs. Potentially, they have many ways for transportation costs reduction such as better vehicle management and optimum distance management (Yan and Zhang, 2015).

**Conclusions and suggestions.** Vegetable and with food products cold transportation chains are significantly important for Thailand since many regulations directly control food quality. This research finds the most significant parameters for Thai cold chain transportations such as controllable temperature during shipment, packaging, processing and storage of products, distribution practices and transportation factors.

Controllable temperature during shipment is one of the most important factors which has direct impact on food cold shipment. Postharvest handling and cooling have their effect on food quality as products must be well managed by a cooling system after harvested but some managers do not really understand this factor. Each product requires its own cooling temperature for better product quality management. Also both product receiving and shipment need their specific temperatures. Packaging is playing an important role for controllable temperature in product shipment as suitable packaging protects for humidity changes and food damage overall.

All materials and products need to be properly classified before doing packaging, processing and storage activities as every food product needs different activities.

Appropriate air flow reduces both temperature and humidity thus air flow equipment producers must be a good fit for a specific food cold chain transportation. Different food items are of different materials, thus suitable air practices must be considered each food material.

Transportation factors cover specific transportation equipment, appropriate cooling, economy of distance and spots with cool service areas. Economy of distance helps transportation providers consider shipment distances and truck load appropriately. In Thailand cool chain transportation depends mainly on roads, however, spots with service areas also help keeping truck temperature since truck will stop in each of these area for temperature check and be maintained if needed.

**Directions for further investigation.** This research finds the most significant parameters for Thai cold chain transportation such as controllable temperature for product shipment, packaging, processing and storage of products, distribution practices and transportation factors. Further research needs to consider suitable controllable temperatures for each food products as different food products require different suitable temperature for better quality control.

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