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Ideal Containers for Cold Chain Vegetable Transportation in Eastern Thailand

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Abstract: The objective of this research is to identify the cold chain container variables that most affect vegetable quality and preservation for entrepreneurs in eastern Thailand. Six types of cold chain containers are identified and analyzed: wood basket containers; paper-based containers; plastic containers; wood material containers; foam box containers; and molded paper pulp containers. Each container has different advantages. Wood basket containers are easy to buy, inexpensive and provide moisture protection. Paper-based containershave a smooth inner surface and can be recycled so, they are environmentally friendly. Plastic containers are very strong, stack available have a smooth inner surface and are moisture to lerant. Wood-based containers are inexpensive, easily available, strong and stackable. Foam containers are inexpensive, they provide moisture protection and are a good fit for retail businesses. Molded pulp containers are ideal for fragile products because they are stable and yet are also flexible enough to be modified to fit around a vegetable to prevent bruising and other damage. They prevent vegetables from touching each other during transportation.

Key words: Cold chain, vegetable, transportation, quality, Thailand

INTRODUCTION

Food packaging materials play a fundamental role in food quality and preservation because, they protect packaged food from uncertain external factors. This study examines the impact that different kinds of containers can have on cold chain vegetable transportation in Thailand.

Vegetables need to be transported in cool temperatures to maintain good quality and to keep them fresh. Vegetable transportation containers therefore, must be designed for specific temperature and transportation conditions. Vegetables also have a high water content that makes them vulnerable to moisture loss when they are transported. Vegetable containers and packaging must therefore be designed with cool temperature controls in mind and they should aim to preserve the highest moisture content possible.

Food transportation and food logistics have become increasingly important to Thailand's food industry as more and more consumers prefer to purchase food from retail shops rather than from a fresh market. The food processing business has also developed from these new habits as young people prefer to buy prepared meals rather than cook for themselves.

Thailand's vegetable exporters need to know which containers will keep their products at ideal temperatures to maintain freshness and quality. This research will help them to select the appropriate containers for their specific transportation conditions.

Literature review: If temperatures are not carefully controlled when food is transported from one place to another, the food can spoil, affecting not only sales but human health. Food packaging and temperature control considerations must play supporting roles in cold chain logistics. Standard packing containers are made from plastic, paper, pulp or wood and they all have limitationsin thermal buffering capacity.

In China, fruit exporters control storage temperatures and humidity levels to keep fruit fresh as long as possible. Litchi fruit exporters for example, have found that the ideal atmosphere and temperature can reduce the weight loss rate (Guo *et al*., 2015).

Different packaging management modes provide different total cost savings. When a supplier applies a dedicated mode, it will use its own packaging. A shared mode involves sharing packaging with other suppliers. The shared mode provides lower management costs than a dedicated mode but, there are still many factors to consider such as packaging demand in each area and time-savings for short distance transportation (Zhang *et al*., 2015).

Food processing operationscan influence the stability of phytochemicals in vegetables and this can affect the nutritional value. Levels vary according to harvesting practices. Different kinds of packaging can also affect phytochemical stability because they affect food storage performance. A zippered plastic package made from low-density polyethylene and a box made from polystyrene will affect the amount of polyphenol content

in the vegetables. Vegetables in a zippered package would contain a much higher amount of polyphenols and would have a higher antioxidant content compared to those packaged in a polystyrene box (Duch *et al*., 2014).

The low cost and good mechanical characteristics make polymeric material suitable for packaging vegetables and frozen products. However, this material is not environmentally friendly because, it takes a long time to biodegrade and it is difficult to recycle (Langley *et al*., 2011).

Modified atmosphere packaging will keep vegetables fresh and ensure they retain a high vitamin C content. It also helps to maintain proteinsolubility and will effectively delay ethylene production. In one study on pumpkin packaging, a modified atmosphere bag helped the pumpkin to retain its original quality and nutritional value (Guan *et al*., 2014).

Molded pulp products are usually paper products that are flexible enough to fit closely around the vegetable to provide cushioning during transportation. Molded pulp products have been made from recycled waste paper and cartons. They have the potential to replace EPS foam in the near future (Guo *et al*., 2014).

MATERIALS AND METHODS

This exploratory research focuses on cold chain vegetable containers for transportation. The research explored the impact that six different kinds of containers had on the quality of vegetables.

Quantitative methods were applied and questionnaires were also used as qualitative contextual tools. Secondary data was taken from a literature review which reconfirmed the research results.

The research process began with a literature review. Based on the literature review, a parameters' measurements of key success-related factors was created. Supervisors and experts were then consulted before starting to conduct the initial surveys with the entrepreneurs. The measures were applied to the results of the final version of the survey. The survey results were analyzed using a mean and SD model. The conclusions were drawn from the study's findings.

The research focused on 27 entrepreneurs who were involved in the cold chain logistics business. They answered the final questionnaires which were separated into 6 parts that applied the research parameter measurements.

The first part focused onvariables formaterials that were inexpensive; easy to buy; environmentally friendly; had good moisture retention; good ventilation and which could be easily modified into specific shapes.

The second part focused on variables for containers that had a smooth inner wall, protected vegetables from being damaged during the transportation process, absorbed moisture were not environmentally friendly and could be easily damaged from either water or poor ventilation.

The third part focused on variables for a container's durability, strength, moisture tolerance, moisture absorption, fascia surface and recyclability.

The fourth set of variablesfocused on strength, stackability, ease of ventilation design, moisture tolerance, recyclability and the potential for mold damage.

The fifth part focused on moisture protection, low costs, the supplier's preferred choice of container, the fit for the retail business, how easily the container could be damaged and how good a fit it was for short-term storage.

The final part focused on the suitability of containers for fragile produce, how easily the container could be reshaped to fit around the vegetable and how good it was at protecting vegetables from moving around during the transportation process.

RESULTS AND DISCUSSION

The conceptual frame work are shown in Fig. 1. Table 1 shows the mean and SD results for these variables: low cost material, easy to buy, good water protection, good ventilation, modification flexibility and environmentally friendly. The results found that the entrepreneurs' responses were in the agreed level in which the mean = 3.93 and SD = 0.87. The mean of low cost material was 4.12. The mean of easy to buy was 4.05, the mean of good water protection was 3.96, the mean of good ventilation was 3.92, the mean of modification flexibility was 3.81 and the mean of environmentally friendly was 3.72.

The appropriate container for root vegetables should have good ventilation which requires specific temperature and humidity controls. Different products require different temperatures and humidity levels therefore, different kinds of containers are suitable for different vegetables (MacKenzie, 2011).

Table 2 shows the mean and SD results for these variables: smooth inner wall, prevents movement, recyclable, moisture absorber, easily damaged by water and poor ventilation. The results found that the entrepreneurs' responses were in the agreed level in which the mean = 3.62 and SD = 0.91. The mean of smooth inner wall was 3.95. The mean of prevents movement was 3.72. The mean of re-cyclable was 3.72. The mean of

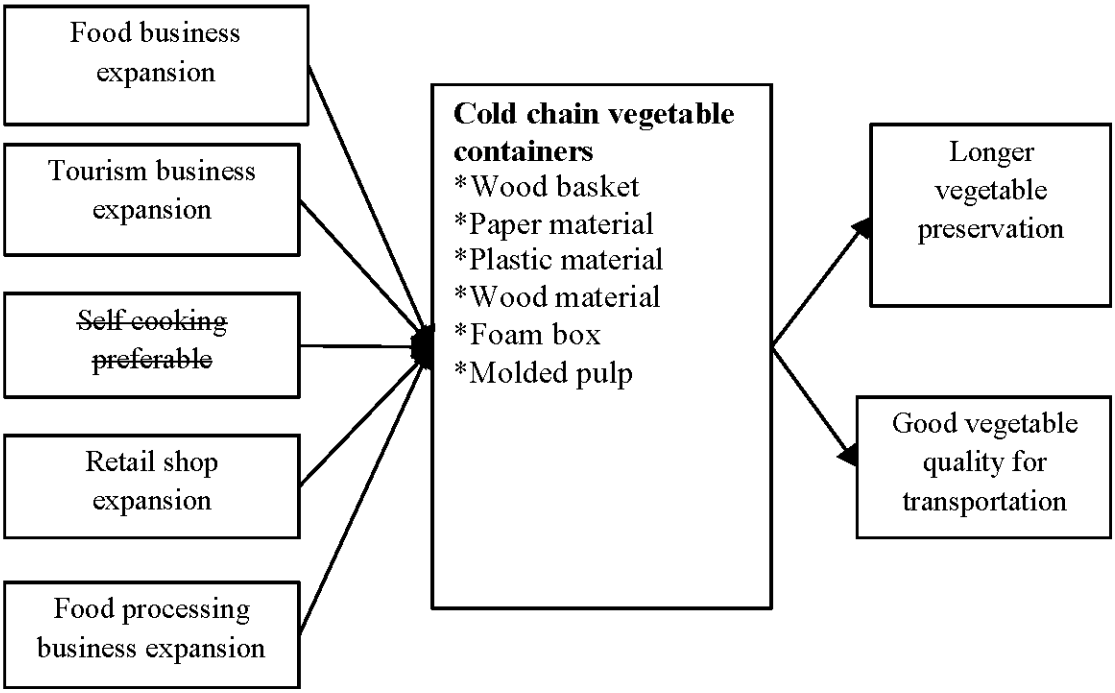

Fig. 1: The conceptual frame work model

Table 1: Wood basket container

Variables	Mean	SD
Low cost material	4.12	0.85
Easy to buy	4.05	0.96
Good water protection	3.96	0.73
Good ventilation	3.92	1.02
Modification flexibility	3.81	0.75
Environmentally friendly	3.72	0.93
Average	3.93	0.87

Table 2: Paper-based containers

Variables	Mean	SD
Smooth inner wall	3.95	0.94
Prevents movement	3.74	0.85
Recyclable	3.72	0.97
Moisture absorber	3.54	0.92
Easily damaged from water	3.53	0.83
Poor ventilation	3.26	0.95
Average	3.62	0.91

* Number of respondents = 27

moisture absorber was 3.54. The mean of easily damaged by water was 3.53 and the mean of poor ventilation was 3.26.

Paper pulp molding products that are flexible enough to fit around a specific shape are characterized by three features: intensity, deflection and tenacity. The structural shape must coincide with the contact parts of the vegetable to ensure stability during transportation. Paper molding products must be flexible enough to be molded around each vegetable to protect vegetables from movement and vibrations during transportation (Wu and Wang, 2012).

Table 3: Plastic containers

Variables	Mean	SD
Durability	4.12	0.98
Strength	3.98	0.75
Moisture tolerance	3.72	1.05
Moisture absorber	3.63	0.89
Fascia surface	3.57	0.97
Recyclability	3.33	0.79
Average	3.72	0.90

* Number of respondents = 27

Table 3 shows the mean and SD results for these variables: durability, strength, moisture tolerance, moisture absorber, fascia surface and recyclability. The results found that the entrepreneurs' responses were in the agreed level in which the mean = 3.72 and SD = 0.90. The mean of durability was 4.12. The mean of strength was 3.98. The mean of moisture tolerance was 3.72. The mean of moisture absorber was 3.63. The mean of fascia surface was 3.81 and the mean of recyclability I was 3.33.

Environmental sustainability considerations havean impact on container development. Recyclability is important, particularly for plastic container development. It affects plastic container design and waste management. Since, plastic containers can be recycled this extends the packaging life cycle (Accorsi *et al*., 2014).

Table 4 shows the mean and SD results for these variables: Strength, stackability, good ventilation design, moisture tolerance, recyclability and mold damage. The results found that the entrepreneurs' responses were in

Table 4: Wood-based containers

Variables	Mean	SD
Strength	3.98	1.07
Stackability	3.86	0.85
Good ventilation design	3.72	0.95
Moisture tolerance	3.67	0.97
Recyclability	3.59	1.08
Mold damage	3.47	0.99
Average	3.71	0.98

Table 5: Foam box containers

Variables	Mean	SD
Moisture protection	3.97	0.97
Low cost	3.83	0.99
Most common to use	3.79	0.86
Good for retail business	3.77	0.95
Easily damaged	3.53	0.92
Good for short term storage	3.47	0.95
Average	3.72	0.94

Table 6: Molded pulp containers

Variables	Mean	SD
Good for fragile products	3.95	0.87
Easy to reshape	3.94	0.85
Prevent movement	3.79	0.97
Average	3.89	0.89

* Number of respondents = 27

the agreed level in which the mean = 3.71 and SD = 0.98. The mean of strength was 3.98. The mean of stackability was 3.86, the mean of good ventilation design was 3.72, the mean of moisture tolerance was 3.67, the mean of recyclability was 3.59 and mean of mold damage was 3.47. Transportation vehicles are limited by their stability capacity because of height and width restrictions. The vehicle that can hold more than one stackable layer will be less efficient because, it cannot deliver as much at one time. This means there should ideally be multiple or heterogeneous models for effective transportation (Iori and Ledesma, 2015).

Table 5 shows the mean and SD results for these variables: moisture protection, low cost, most common to use, good for retail business, easily damaged and good for short term storage. The results found that the entrepreneurs' responses were in the agreed level in which the mean = 3.72 and SD = 0.94. The mean of moisture protection was 3.97. The mean of low cost was 3.83, the mean of most common to useis 3.79, the mean of good for retail business was 3.77, the mean of easily damaged was 3.53 and the mean of good for short term storage was 3.47. In China, lychee fruit is easily damaged during transportation because, it is vulnerable to high temperatures and high humidity. Foam boxes filled with ice are the most popular lychee containers because the fruit does not move around when transported and the controlled temperature keeps the fruit fresh (Yang *et al*., 2014).

Table 6 shows the mean and SD results for these variables: good for fragile products, easy to reshape and prevent movement. The results found that the entrepreneurs' responses were in the agreed level in which the mean = 3.893 and SD = 0.89. The mean of good for fragile products was 3.95, the mean of easy to reshape was 3.94 and the mean of prevent movement was 3.79. Molded pulp product is considered a form of green packaging and is widely used in distribution chains of products as it has the advantage of providing a cushioning effect. The cushioning of molded pulp containers comes from its structure. Molded pulp products are currently used to protect products from potential damage from vibrations and other movement during transportation (Wang and Li, 2014).

CONCLUSION

Wood basket containers use local materials and arethe most common vegetable container. They are easy to find and buy. They are good for transporting agricultural products because, they are well ventilated and do not absorb moisture. Wood basket containers can also be easily reshaped. The dis advantages however include a weak structure and an inability to protect vegetables in some cold chain transportation situations. Vegetables can also be damaged by therough inner surface, particularly thin-skinned vegetables.

Paper-based containers are increasingly used for vegetable cold chain transportation because, they can be customized for specific capacities and strength requirements as well as different sizes. These considerations will also determine the ideal kind of materialthe container should be made from. The advantages of a paper-based container are the smooth inner surface which does not damage thin vegetable skins, the flexibility to be reshaped around a vegetable to prevent movement and its recyclability which makes it environmentally friendly. The disadvantages include moisture absorption, poor ventilation and these containers can break easily during transportation.

Plastic containers arealso popular for vegetable cold chain transportation. The advantage of plastic is that it is very strong so the containers can be stacked in layers. Plastic is also moisture tolerant, recyclable and easy to clean. The disadvantage is its high cost.

Wood-based containers are easy to find and can be made from inexpensive materials. The advantages include strength, stackability, moisture tolerance and they can be reshaped to improve ventilation. The disadvantages are the rough inner surface which can damage vegetable skins and these containers also make vegetables more susceptible to mold.

Foam box containers are currently very popular for vegetable cold chain transportation as they are easy to

designand are inexpensive. The advantages of foam boxes are moisture protection, the low cost and they are also a good fit for retail businesses because the vegetables are well-protected. The disadvantages are that they can be easily damaged and are best suited for short term storage.

Molded pulp containers are made from high quality paper that can be shaped into a three-dimensional container. They are well suited for fragile produce can easily be reshaped and the sturdy material prevents vegetables from moving against each other during transportation.

The containers studied in this research are the most popular in vegetable cold chain logistics. The ideal container will depend on the kind of vegetable to be transported and the transportation practices and regulations in both the importing and exporting country. Containers are very importantin cold chain transportation because they have a direct affect on vegetable quality and preservation.

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