AN OPTIMIZATION APPROACH FOR SCHEDULING FRESH FRUIT EXPORTING OPERATIONS WITH QUALITY LOSS DUE TO TRANSPORTATION AND HOLDING

KAMHANGWONG Damrongpol[1], SEKHARI Aicha[1], NEUBERT Gilles[2], SUREEPHONG Pradorn[3]
[1]Université Lumière Lyon 2, France.
[2]emlyon business school, France.
[3]Chiangmai University, Thailand

ABSTRACT
Purpose: The quality loss of fruit due to the mechanical injuries and the physiological change during storage and transportation is an important cause of downgrading and wastage of fruit exportation (5% to 60%). The objective of this paper is to propose the optimization approach for scheduling fresh fruit exporting operations which consider the cost of quality loss based on the above-mentioned cause.

Design/methodology/approach: The methodology is divided into 3 phase. Firstly, the damage cost due to mechanical injury(MI) and holding cost due to physiological change are estimated by using linear regression. Secondly, mathematical modelling of exportation costs for the exporter considering the damage and holding cost is developed to formulate objective functions. Lastly, solution spaces of models are analysed by numerical study to determine two decision variables: the quantity of fruit exported in each day and on hand inventory duration.

Findings: In case study of mangoesteen exportation, the damage and holding cost of fruit exportation can be considered as a linear function with time. This can be used to determine markdown policy with steeper discount and develop the mathematical model via linear regression approach to optimize scheduling fresh fruit exporting operations.

Practical implications: The model provides important improvement in profit and cost of fruit exportation. This improvement is more significant for the logistics exporter to make decision in part of export planning, choosing the appropriate distribution scheme, and mark down policy under uncertainty of demand. rate.

Originality/value:
This paper is a combination the cost of quality loss from MI and physiological change of fruit, which has appeared in single mathematical models. To the best of the authors' knowledge, no mathematical model has yet been proposed.

Keywords: Fruit exportation, Food Quality, Holding Cost, Perishable products, Transportation

Introduction

The management of fresh fruit distribution is distinct and more enormously complicated than the distribution of other foods because most of the fruits are highly perishable nature, variable to militate against simple solutions, rarely to give the best results in terms of preserving the quality of the crop, high fluctuations in demand and prices, increasing consumer concerns for food safety and dependence on climate conditions)Van der vorst and *et.al*, 2007 .(In the supply chain of fresh fruit, large quality losses)5 %to 60 (%are incurred between farm to fork .All partners have to a shared responsibility of minimizing quality losses to deliver high-quality products to the consumer which also they must be faced with the challenge of increasing its handling efficiency and minimizing post-harvest food losses .The quality losses of fruits or fruit spoilage refer to the decrease in edible food mass which is largely based on the subjective consumer evaluation of a complex of quality attribute)such as color, firmness, and appearance (which depended on the characteristics of product properties, and the social and economic back ground and their intended usage of the product .The losses of quality can be seen resulting from concerted action or action on either side of the major contributing factors that include MI, the natural decay of the fruit, and contamination by micro-organisms .Quality losses of fruit are not constant :the quality of a food changes over time in various pattern depend on type order reaction which are usually modeled by means of a zero-,1st-, or 2nd-order reaction)Labuza,1984 and Saguy and Karel 1980 .(In general, the losses of food quality and affecting on cost of fruits are difficult to predict correctly, due to the range and dynamics of product characteristics, transport and storage conditions, supply limitation, and market demand .Over the years, there is a significant increase in research on modeling and optimization of perishable food supply chain system focusing on operational issues causing perishable food loss or waste .Most research refers to loss which is occurs at high rate in the production, transportation and inventory activities throughout the food supply chain with different mathematical tools, as shown inliterature . However, most of literature regarding quality loss in food supply chain management focuses on assessing food quality loss by considering only one factor that does not cover all major factors caused food spoilage .In practice, they cannot be applied to some produce which quality losses resulting from concerted action of several factor . The objective of this paper is to propose a quality losses assessment of fresh fruit and the optimization approach for scheduling fresh fruit exporting operations which consider the cost of quality loss based on all major factors caused spoilage.

In this note, we give mangosteen exported from Thailand to China as a case study. The note is organized as 3 phase. In phase 1, we show how one estimate the cost of quality loss from MI and the natural decay which are two major factors caused mangosteen spoilage. In phase 2, mathematical modelling of exportation costs for the exporter considering the cost of quality loss from phase 1 is developed to formulate objective functions. Finally, we present a numerical study to determine two decision variables: the quantity of fruit exported in each day and on hand inventory duration.

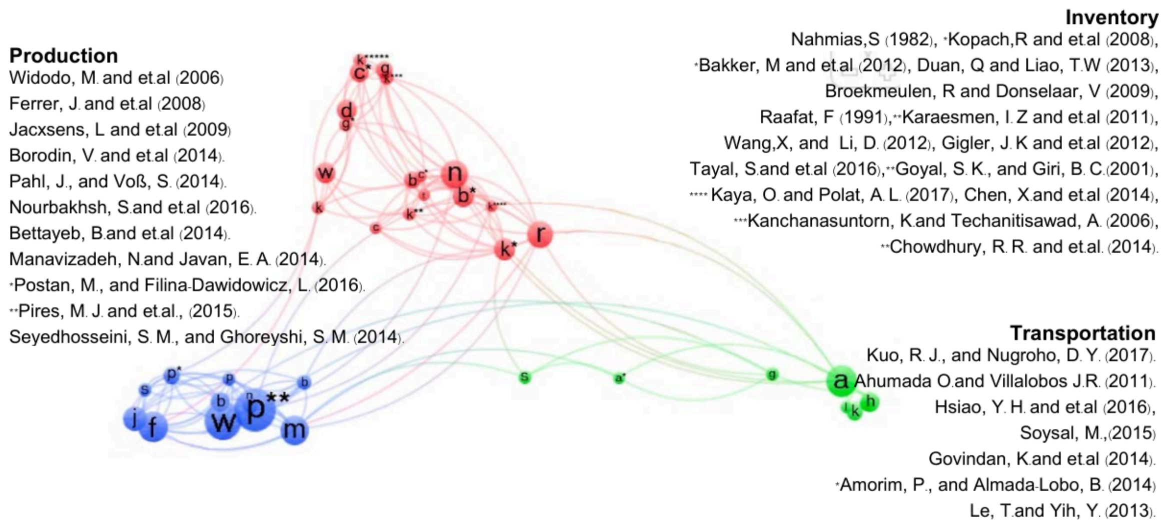

Figure 1: Research cluster of modeling and optimization for perishable food supply chain system
*Research cluster is analyzed by VOS viewer version 1.6.5

Estimating the cost of mechanical injury

The degree of fruit damage is not a static parameter but is a highly dynamic variable depending on the vibration level that fruits suffer during transport from farms to market, increasing the vibration frequency and acceleration increase the total percentage of damage to fruits. In Figure 2 [left], the mangosteens were simulated transportation condition in laboratory with various vibration level (Grm level) by the vibrator to study the relation of vibration level and the percentage of MI in fruit during handling and transportation (Damrongpol, K. 2016) Consider 10 Kg of mangosteen at maturity were packed in packaging system: non-returnable polypropylene box with internal dimension (33x44.5x16 cm) supported in both bottom and top with sponge (polyurethane), as a cushion system. The first period 0-A, the fruit is bruised by mechanical force but there are no discernible changes and the apparent quality stability. In the second period A-B (Grm level >1.0), the bruising of the fruit can be noticed and fruit quality is not acceptable by consumers. %MI of fruit per unit expresses a linear relationship with Grm level each route of transportation (G_j) that product have been received according to $\%FD_j = a * G_j - c$, where a and c are constant, which can be confirmed by the positive correlation coefficient value (r^2)of 0.9878. If we know the vibration level of transportation route, we can determine the percentage of fruit damage and cost of fruit damage per unit which varies according to route of transportation and material price (δij = *PMi* %FDj*)/100, where *PMi* is material price at day of fruit exported, and also lead this cost of the fruit damage incorporated into model, as shown in Figure 2 [right].

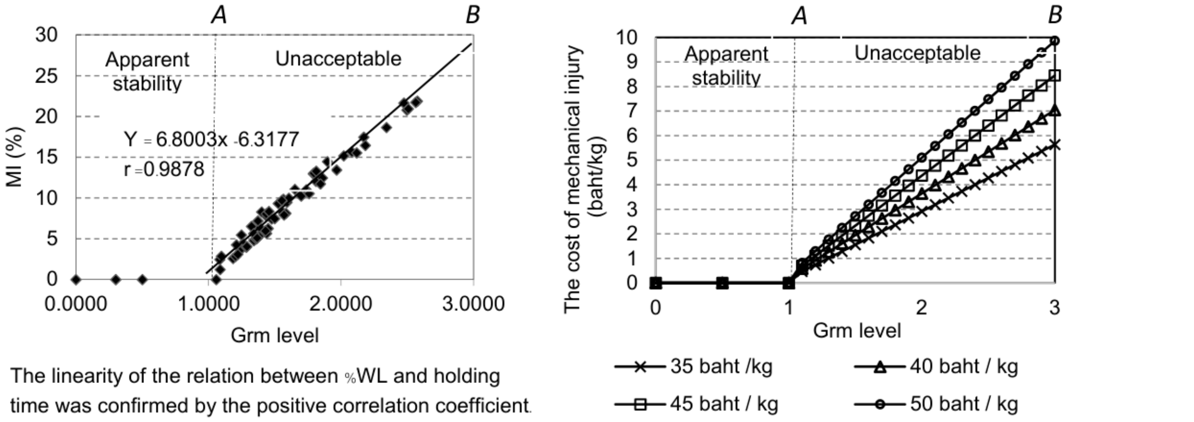

Figure 2: The relation of vibration level and % MI of mangosteen, [right] The relation of vibration level and the cost of MI in mangosteen at various material price.

Estimating the cost of natural decay

Fruit after harvest, they continue to respire, losing water through their skin .This moisture loss is most noticeable in fruits that contain large amounts of water, and over time the skin becomes flaccid and leathery .Moisture loss may also cause the fruit to shrink in size .**Error! Reference source not found.**]left [shown the example of zero-order reaction for weight loss of mangosteen)WL (at various holding time*) .Damrongpol, K .2016(

In period 0-A, the quality of fruit is stable and freshness loss of the fruit can be noticed by consumer .After that the fruit quality is not acceptable by consumers in period A-B% .WL of mangosteen can be considered as a linear function with holding time, according to %WL=1.1916t-0.1619)r^2 = 0.9872 (which can be applied by using linear least square regression to find cumulative holding cost of fruit per unit increasing with the time)ϖ_{ij}^k (and material price that fruit has been in transit and stored, according to ϖ_{ij}^k =η_i) Lj+k (– γ_i, where η_i and γ_i is constant value which they depend on material price each day) **Error! Reference source not found.**] right([

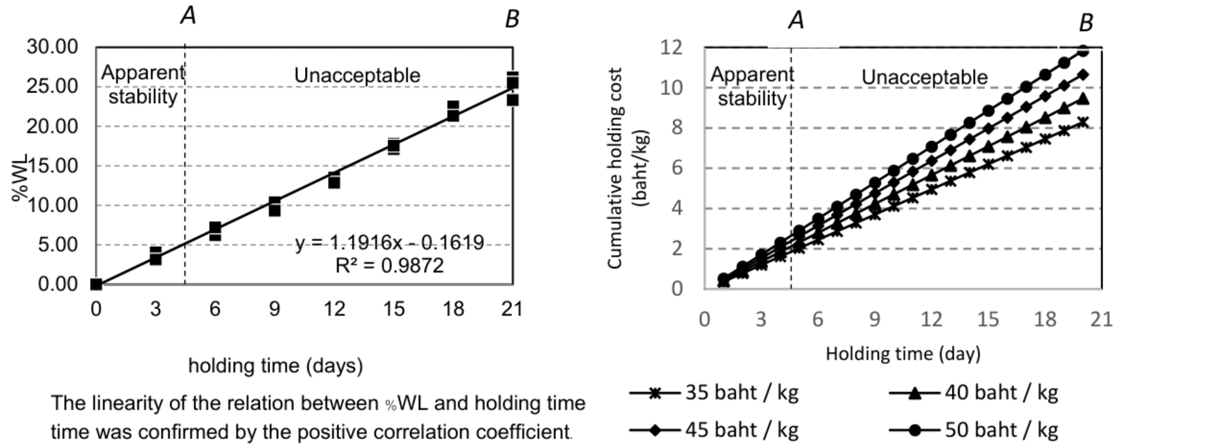

Figure 3 : [left] WL (%) mangosteen stored at 13°C/75%RH at various holding time, [right] the convex approximation for cumulative holding cost of mangosteen stored at 13°C/75%RH at various holding

Mathematical modeling
To develop the proposed model, we adopt assumptions and notation in the following Table 1, Table 2, and Table 3.

Decision variables	
r_i the revenue derived from the sale of export fruit in day *i* m_i the material handling cost of export fruit in day *i* ci the material cost of export fruit in day *i* di the transportation cost of export fruit in day *i* bi the communications and the others cost of fruit in day *i* h_i total storage cost of fruit in day *i* g_i the cost of MI of fruit due to handling and transportation in day *i* q_i the cost of WL of fruit in day *i* x_{ij} the quantity of fruit in day *i* that is exported by route *j*, and will be sold immediately at destination market.	y_{ij}^{k} the quantity of fruit in day *i* that is exported by route *j* and will stored for *k* days after the fruit is transported to the destination market. s_{ij} the quantity of fruit exported by route *j* that is sold immediately at destination market in day *i*. w_{ij} the quantity of fruit exported by route *j* in inventory that is sold in day *i* V_i the quantity of fruit feed in inventory Ii *the inventory level* in day i

Table 1 : Decision variables

Parameters	
ms_j the maximum storage of fruit each route S_i total fruit supply each day D_i total consumer demands each day CP_i the capacity of inventory SP_i selling price of fruit per unit each day MH the cost of material handling MPi the price of fruit material per unit each day TC_j transportation costs per unit for route j	CO the communications and the others cost of fruit per unit SC_k storage cost of reefer container per unit per day PP_i purchasing price of fruit material per unit at orchard each day L_j lead time of each route j

Table 2 : Parameters

Assumptions
1. Fixed product have deterministic shelf life 20 days after fruit harvested and the company has policy of holding time of fruit is not more than 10 days after fruit have been exported. 2. Shortage or backordering is allowed. 3. First – In- First- Out *(*FIFO*)* issuing policy is used 4. Product are perishable*:* they have to be produced, transported, stored and sold to retailer by 10 days in order to guarantee the final customer a product with a sufficient residual life.

Table 3: Assumptions

Based on the above assumptions a mathematical model, the design of the model is illustrated in Figure **.** 4 **.**We consider the supply chain of fruit exportation with one collector, multiple route of transportation, one inventory and one distribution center**)** whole sale market **.(**The fruit must be distributed direct from collector to distribution center by various export routes each day **.**In order to maximize total profit from sale to retailer each day, exporter need to decide to sell fruit as soon as the fruit is transported to destination market if the sell price of fruit at that time is high, and**/**or to store in reefer container to wait price increasing if the sell price of fruit at that time is low **.**

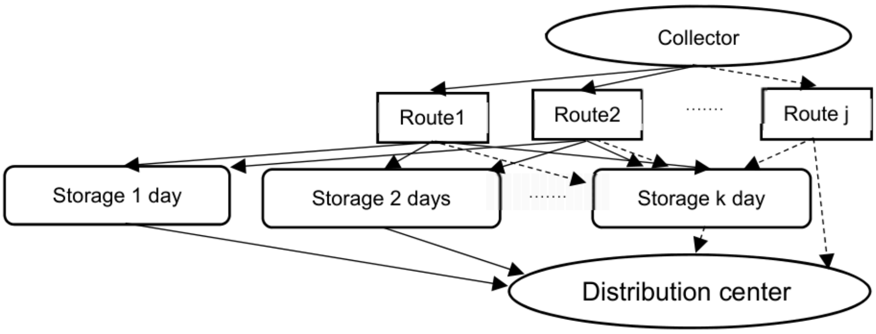

Figure 4 : Behavior of the model in a season of fruit exportation

We propose a LP model The LP model considering total revenue)r_i(, the total cost of fruit exportation, and quality loses, in which an exporter has to decide how many fruit to be exported to distribution center, which route of transportation, and transportation time .The objective of exporter is to optimize the scheduling fresh fruit exporting operations under maximize the net profit)NP (for fruit exporter which is expressed as the follow :

$$Maximize \quad NP = \sum_{i=1}^{n=1} r_i - \left[\sum_{i=1}^{n=1} m_i + \sum_{i=1}^{n=1} c_i + \sum_{i=1}^{n=1} d_i + \sum_{i=1}^{n=1} b_i + \sum_{i=1}^{n=1} h_i + \sum_{i=1}^{n=1} g_i + \sum_{i=1}^{n=1} q_i \right] \quad (1)$$

Subject to:

$$s_{i,j} = \begin{cases} 0 & : i < L_j + 1 \\ x^k{}_{(i-L_j),j} & : i \geq L_j + 1 \end{cases} \quad (2)$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} x_{i,j} = \sum_{j=1}^{n} \sum_{j=1}^{m} s_{i,j} \quad (3)$$

$$w_{i,j} = \begin{cases} 0 & : i \leq L_j + ms_j + k - 1] \\ \sum_{k=1}^{ms_j} y^k_{i-L_j-(ms-k+1),j} & : i > L_j + ms_j + k - 1 \end{cases} \quad (4)$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{k=1}^{o} y^k_{i,j} = \sum_{j=1}^{n} \sum_{j=1}^{m} w_{i,j} \quad (5)$$

$$S_i \geq \sum_{j=1}^{m} x_{i,j} + \sum_{j=1}^{n} \sum_{k=1}^{o} y^k_{ij} \quad (6)$$

$$D_i = \sum_{j=1}^{m} s_{ij} + \sum_{j=1}^{m} w_{ij} \quad (7)$$

$$CP_i \geq \sum_{j=1}^{n} \sum_{k=1}^{o} y^k_{ij} \quad (8)$$

$$r^k_{i,j} = \left[s_{i,j} + w^k_{i,k} \right] * SP_i \quad (9)$$

$$m_i = \left[\sum_{i=1}^{n} x_{i,j} + \sum_{i=1}^{n} y^k_{i,j} \right] * MH \quad (10)$$

$$c_i = \left[\sum_{j=1}^{m} x_{i,j} + \sum_{j=1}^{m} y^k_{i,j} \right] * MP_i \quad (11)$$

$$d_i = \left[\sum_{j=1}^{m} s_{i,j} * \sum_{j=1}^{m} w_{i,j} \right] * TC_j \quad (12)$$

$$b_i = \left[\sum_{i=1}^{n} x_{i,j} + \sum_{i=1}^{n} y^k_{i,j} \right] * CO \quad (13)$$

$$h_i = \sum_{j=1}^{m} \sum_{k=1}^{o} y^k_{ij} * SC_k \quad (14)$$

$$g_{i,} = \begin{cases} 0 & : L_j + k \leq 4 \\ \left(\sum_{j=1}^{m} x_{ij} + \sum_{j=1}^{m} \sum_{k=1}^{o} y^k_{ij} \right) * \delta_{ij} & : L_j + k > 4 \end{cases} \quad (15)$$

$$q_{i,} = \begin{cases} 0 & : L_j + k \le 4 \\ \sum_{j=1}^{m}\sum_{k=1}^{o} y_{ij}^{k} * \left(\eta_i * (\mathrm{L_j} + \mathrm{k}) - \gamma_{\mathrm{i}},\right) & : i > L_j + k > 4 \end{cases} \quad (16)$$

$$V_{i,} = \begin{cases} 0 & : i \le L_j \\ \sum_{j=1}^{m}\sum_{k=1}^{o} y_{(i-L_j),j}^{k} & : i > L_j \end{cases} \quad (17)$$

$$I_{i,} = \begin{cases} 0 & : i = \{< Lj, 40\} \\ I_{(i-1)} + I_i - \sum_{j=1}^{m} w_{i,j} & : i \ge L_j \end{cases} \quad (18)$$

In (2), if $i \ge L_j+1$, the quantity of fruit is exported by without storage plan in day $i - L_j$ must be equal the quantity of fruit that is sold at arrival time in day *i*, while, if $I < L_j+1$, there are no fruit sold in market ($s_{ij} = 0$), due to being transportation and no fruit in stock. In (3), to make sure that the quantity of fruit exported by without storage plan in day *i* will have to be sold out at arrival time. In (4), if $i > L_j+ms_j+k-1$, the quantity of fruit in inventory sold at day *i* (w_{ij}) must be equal the quantity of fruit that is exported in day $i - L_j$ and stored for k days after the fruit is transported to the destination market, while if $i < Lj+ms+k-1$, there are no fruit in inventory sold due to being transportation. In (5), to make sure that all fruit in inventory will have to be sold out. In (6), total quantity of export fruit each day cannot be greater than the fruit supply each day. In (7), total quantity of export fruit that was sold each day cannot be greater than consumer demands each day. In (8), available total storage space is limited. In (9), the revenue of fruit exportation each day is calculated by the summation of the revenue from fruit sales immediately arrives at destination market (s_{ij}) and the revenue from sale of fruits stored in inventory (w_{jj}). To compute total logistics costs, we formulate the exporter's expected total cost based on logistics activities of fruit farmers consisting of material handling cost in eq.10, the material cost in eq.11, the transportation cost in eq.12, the communications and the others cost in eq.13, and storage cost in eq.14, respectively.

To set mark down policy that corresponds to the change of actual cumulative holding cost over time of transportation and storage (g_i+w_i), the cost of MI and WL were formulated in eq.15 – 16. In (15), if holding time (L_j+k) >4 days, the cost of MI will be considered, while if $L_j+k \le 4$ days, the quality appearance is stable, and also the cost of MI = 0. In (16), if holding time (Lj+k) > 4 days, the cost of WL per unit which is given as a function with holding time (Lj+k) and material price each day will be considered, while if Lj+k ≤ 4 days, the quality appearance is stable, and the cost of WL = 0). To be able to control the storage of fruit in inventory, we formulate eq.17 and eq. 18 which represent the quantity of fruit input in inventory (*Vi*) and the instantaneous value of fruit in inventory (*Ii*). In (17), if $i > L_j$, the quantity of fruit input in inventory each day must be equal the summation of y_{ij}^k which arrived at destination market, while if $i \le L_j$, there are no fruit stored in inventory due to being transportation. In (18), if $i > Lj$, the instantaneous value of fruit in inventory is equal to the initial value of the inventory on previous day (I_{i-1}) plus the quantity of fruit input in inventory that day i minus the quantity fruit in inventory that will be sold at that day i, while if $i \le L_j$, there are no fruit stored in inventory due to being transportation.

Numerical study

In this section, we present a numerical study based on historical data of mangosteen exportation from Thailand to China. We choose normal pattern of demand rate (SC1) to compare with two different patterns of demand rate (SC2-SC3), as shown in **Error! Reference source not found.** In SC1, we give the high demand rate at two periods of seasonal time. At the first period, the demand rate is high because the total quantity of mangosteen and the other seasonal fruits of China released on market at that time are low. At the second period, fruit consumption increase again due to the effect of Chinese festival which stimulate higher customer demand. In SC2 and SC3, we consider high demand rate of consumer at beginning season and at end of season respectively. To compare net profit and cost of exportation each scenario in the same situation, all simulation data patterns are settled the total quantity of fruit supply at 800ctn and fruit demand at 200ctn with three replications.We fix three parameters of exportation route in our analysis: delivery time (2 and 4 days), delivery charge (90,000 and 50,000 baht/ctn and δ_j (route1 = 0.02 and route2 = 0.04), which we justify as the follows. A completely randomized design was used with all scenarios. All decision variable and cost in each scenario were subjected to analysis of variance (ANOVA) and mean comparisons were carried out by Duncan's multiple range testing (DMRT) IBM ILOG CPLEX Optimizer 12.7.1 is used to solve the optimization models with various constraints and variables.

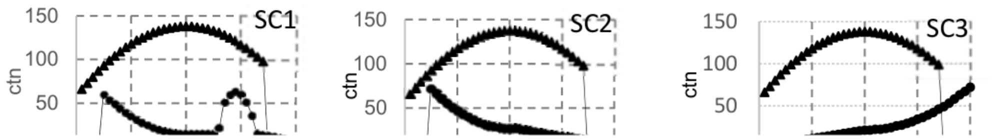

Figure 1 simulations with various levels of demand rate SC1: normal demand rate, SC2: high demand rate at early season, SC3: high demand rate at end of season

Simulation results

This section presents result from numerical analysis to develop insight into the benefit of the for scheduling fresh fruit exportation with quality loss due to transportation and holding. The primary focus of this section is two folds. Firstly, we show that the proposed model provides significant improvement in part of export planning and choosing the appropriate distribution scheme to maximize net profit of fruit exportation under various situation. Secondly, we demonstrate the effect of demand rate uncertainty on the inventory operation, holding cost and mark down policy. In considering the effect of demand rate on net profit, we found that SC2 have the highest net profit, whereas the net profit of SC3 is the least. This result can be seen that as demand rate at the end of season is getting higher and supply rate for SC3 is getting lower, the fruit needs to be stored up to meet such demand under limited supplies, as shown in Table 4 . This affect not only the increase of the cost of quality loss and storage cost, but also the decrease of total net profit, when we compare to SC1. To maximize the net profit of fruit exportation, under the demand rate change, choosing shorter transit routes in both x1 and y1 is the way to achieve the desired results. To show the relationship of the net profit and the appropriate distribution scheme, we found that SC1 and SC2 have total value of x more than total value of y ($p < 0,05$), while SC3 is opposite. This result can be described that the proposed model tries to find the maximum profit and the minimum cost of storage by choosing to sell the fruit as soon as it arrives at destination market, rather than to store it in reefer container, while in SC3, fruit needs to be store for sale during the off-season. Furthermore, we observe that there is a statistically significant interaction between value of x1 and net profit, while the main effect of the other decision variables on net profit was not significant. This can be indicated that choosing shorter transit routes have the effect on the increment of net profit.

SC	**decision variable**				**Cost (bath)**			**Net profit****
					quality loss of fruit		**Storage**	
	x_1**	**x_2**	**y_1**	**y_2**	**MI**	**WL**		
1	124b	33a	5c	38a	7,925,217a	10,848,000b	72,000b	323,914,783b
2	171a	11c	18b	0b	7,462,633b	7,864,350c	14,400c	361,997,367a
3	60c	15b	125a	0b	5,111,972c	12,095,700a	100,000a	238,388,028d

Table 4: Summary statistics for the quantity of fruit exported, net profit, and cost in each scenario

*For all decision variable and cost of exportation, a, b different letters within a column indicate significantly different ($P < 0.05$) ** There are interaction between these factors

To study the effect of demand rate uncertainty on the inventory operation, we consider the cost of total quality loss from MI and WL, and storage cost of fruit exportation in each scenario in table 6. We found that SC3 has the highest quality loss of fruit from WL and storage cost, while SC1 is lower, and SC2 has the lowest. The results are consistent with total inventory level of fruit (y), which found that SC3 has the highest inventory level compared to other SC. The appearance of quality loss depends on holding time. In the case of sc3, the fruit must be stored to meet the demand of the consumer at the end of the season, and also the exporters need to consider mark down policy that corresponds to the change of actual cumulative holding cost over time of transportation and storage.

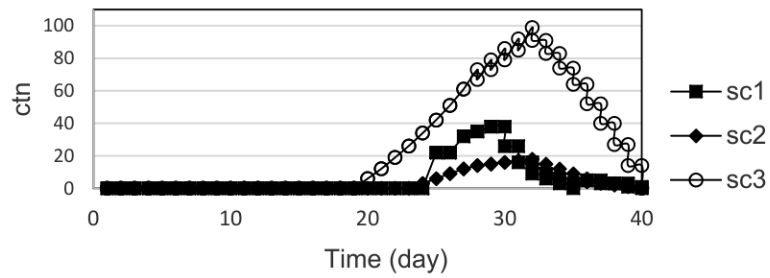

Figure 2: Inventory level of fruit in each day

Concluding remark

The vibration level that fruits suffer during handling and transport from farms to market and holding time due to delivery and storage can be considered as a linear function with the cumulative cost of quality loss due to MI and WL of fruit**.** This can be used to determine the number of markdown, **%** discount in each period of holding time, and lead it to incorporate into mathematical model via linear regression approach to optimize scheduling fresh fruit exporting operations**.** The proposed model can help exporter to prevent unnecessary quality losses of fruit and improve in profit and cost of fruit exportation throughout the supply chain. This modification is more significant not only for the logistics exporter can make decision in part of export planning, choosing the appropriate distribution scheme, and mark down policy under uncertainty of supply and demand rate but also the customers can buy fruit at reasonable price that match the actual quality of the fruit versus customer demand ratio at that time. However, this paper considered only a single product and quality loss in the distribution network**.** Future work could therefore include the regard of multiple products and interactions between the different products**.**

Acknowledgement

The author would like to thank Université Lumière Lyon 2 Lyon, France and the Erasmus Mundus Programme for financial support.

References

- Ahumada O., and Villalobos J.R. (2011), "Operational model for planning the harvest and distribution of perishable agricultural products", *International Journal of Production Economics*, Vol.133, No. 2, pp.677-687.
- Amorim, P., and Almada-Lobo, B. (2014), "The impact of food perishability issues in the vehicle routing problem", *Computers & Industrial Engineering*, Vol.67, pp. 223-233.
- Bakker, M., Riezebos, J., and Teunter, R.H. (2012), "Review of inventory systems with deterioration since 2001", *European Journal of Operational Research*, Vol. 221, No.2, pp. 275-284.
- Bettayeb, B., Bassetto, S. J., and Sahnoun, M. (2014), "Quality control planning to prevent excessive scrap production". *Journal of Manufacturing Systems,* Vol.33, No.3, pp. 400-411.
- Borodin, V., Bourtembourg, J., Hnaien, F. and Labadie, N. (2014), "A quality risk management problem: case of annual crop harvest scheduling". *International Journal of Production Research*, Vol. 52, No.9, pp. 2682-2695.
- Broekmeulen, R. A., and van Donselaar, K. H. (2009). "A heuristic to manage perishable inventory with batch ordering, positive lead-times, and time-varying demand". *Computers & Operations Research*, Vol.36, No.11, pp. 3013-3018..
- Chang, C. T. (2016), "Inventory models with stock-and price dependent demand for deteriorating items based on limited shelf space". *Yugoslav Journal of Operations Research*, Vol. 20, No.1.
- Chen, X., Pang, Z., and Pan, L. (2014), "Coordinating inventory control and pricing strategies for perishable products. *Operations Research*, Vol. 62, No. 2, p.284-300.
- Chowdhury, R. R., Ghosh, S. K., and Chaudhuri, K. S. (2014), "An inventory model for perishable items with stock and advertisement sensitive demand". *International Journal of Management Science and Engineering Management*, Vol.9, No.3, pp.169-177.
- Damrongpol, K., Gilles, N., and Pradorn, S., 2016. The logistics cost of fruit exporter and Quality Loss Assessment of Fresh Mangosteen in Thailand. 6th International Conference on Information Systems, Logistics and Supply Chain ILS Conference 2016, Bordeaux, France, June 1 – 4.

- *Damrongpol, K., Aicha, S., Gilles, N., and Pradorn, S., 2016. Quantification of Freshness Loss and an optimization approach for managing fresh fruit exportation. 10th International Conference on Software, Knowledge, Information Management & Applications (SKIMMA), Cherngdu, China, December 15-17.
- Duan, Q., & Liao, T. W. (2013), "A new age-based replenishment policy for supply chain inventory optimization of highly perishable products". *International journal of production economics*, Vol.145, No.2, pp. 658-671.
- Ferrer, J., Cawley, M., Maturana, S.,Toloza, S. and Vera, J. (2008). "An optimization approach for scheduling wine grape harvest operations, International Journal of Production Economics, Vol.112, No.2, pp.985-999.
- Gigler, J. K., Hendrix, E. M., Heesen, R. A., van den Hazelkamp, V. G., & Meerdink, G. (2002), "On optimisation of agri chains by dynamic programming". *European Journal of Operational Research*, Vol.139, No.3, pp.613-625.
- Govindan, K., Jafarian, A., Khodaverdi, R., and Devika, K. (2014), "Two-echelon multiple-vehicle location–routing problem with time windows for optimization of sustainable supply chain network of perishable food", *International Journal of Production Economics*, Vol.152, pp. 9-28.
- Goyal, S. K., and Giri, B. C. (2001), "Recent trends in modeling of deteriorating inventory", *European Journal of operational research*, Vol.134, No.1, pp.1-16.
- Hsiao, Y. H., Chen, M. C., and Chin, C. L. (2016), "Distribution planning for perishable foods in cold chains with quality concerns: Formulation and solution procedure". *Trends in Food Science & Technology.* Vol.61, pp.80-93.
- Jacxsens,L., Luning,P., Vorst,V., Devlieghere, F., Leemans, R.and Uyttendaele, M. (2009), "Simulation modelling and risk assessment as tools to identify the impact of climate change on microbiological food safety – The case study of fresh produce supply chain", *Food Research International*, Vol. 43, pp. 1925–1935.
- Kanchanasuntorn, K.and Techanitisawad, A. (2006), An approximate periodic model for fixed-life perishable products in a two-echelon inventory–distribution system. *International Journal of Production Economics*, Vol.100, No.1, pp.101-115.
- Karaesmen, I. Z., Scheller–Wolf, A., and Deniz, B. (2011), "Managing perishable and aging inventories: review and future research directions". *In Planning production and inventories in the extended enterprise.* Springer US. , pp. 393-436.
- Kaya, O. and Polat, A. L. (2017), "Coordinated pricing and inventory decisions for perishable products". *OR spectrum*, Vol.39, No.2, pp.589-606.
- Kopach, R, Balcioglu,R and Carter,M. (2008), "Tutorial on constructing a red blood cell inventory management system with two demand rates", *European Journal of Operational Research*,Vol. 185, No. 3, pp. 1051-1059.
- Kouki, C., Jemaï, Z., and Minner, S. (2015), "A lost sales inventory control model for perishables with fixed lifetime and lead time". *International Journal of Production Economics*, Vol.168, pp.143-157.
- Kuo, R. J., and Nugroho, D. Y. (2017), "A fuzzy multi-objective vehicle routing problem for perishable products using gradient evolution algorithm". *In Industrial Engineering and Applications (ICIEA), 2017 4th International Conference on. IEEE*. pp. 219-223.
- Labuza TP. (1984), "Application of chemical kinetics to deterioration of foods". *J Chem Ed*, 61:348–58
- Le, T., Diabat, A., Richard, J. P., and Yih, Y. (2013), "A column generation-based heuristic algorithm for an inventory routing problem with perishable goods", *Optimization Letters*, Vol.7, No.7, pp.1481-1502.
- Manavizadeh, N.and Javan, E. A. (2014), "A New Approach in Joint Optimization of Maintenance Planning, Process Quality and Production Scheduling", *International Journal of Research in Industrial Engineering*, Vol.3, No.2, pp.24.
- Nahmias, S. (1982), "Perishable inventory theory: a review"," *Journal of operations Research*, Vol. 30, No. 4, pp. 680-707.
- Nourbakhsh, S. M., Bai, Y., Maia, G. D., Ouyang, Y., and Rodriguez, L. (2016), "Grain supply chain network design and logistics planning for reducing post-harvest loss", *Biosystems Engineering*, Vol.151, pp.105-115.

- Pahl, J., and Voß, S. (2014), "Integrating deterioration and lifetime constraints in production and supply chain planning: A survey. European" *Journal of Operational Research*, Vol.238, No.3, pp. 654-674.
- Pires, M. J., Amorim, P., Martins, S., & Almada-Lobo, B. (2015), "Production Planning of Perishable Food Products by Mixed-Integer Programming". *In Operational Research*, pp. 331-352.
- Postan, M., and Filina-Dawidowicz, L. (2016), "May. Dynamic Optimization Model for Planning of Supply", Production, and Transportation of Perishable Product. In *TranSopot Conference*. Springer, Cham. pp. 235-244.
- Raafat, F. (1991), "Survey of literature on continuously deteriorating inventory models" *Journal of Operational Research Society*, Vol. 42, No. 1, pp. 27-37,
- Seyedhosseini, S. M., and Ghoreyshi, S. M. (2014),"An integrated model for production and distribution planning of perishable products with inventory and routing considerations" *Mathematical Problems in Engineering*, 2014.
- Soysal, M., Bloemhof-Ruwaard, J. M.and Haijema, R. and van der Vorst, J. G. (2015), "Modeling an Inventory Routing Problem for perishable products with environmental considerations and demand uncertainty", *International Journal of Production Economics*, Vol.164, pp.118-133.
- Tayal, S., Singh, S. R., and Sharma, R. (2016), "An integrated production inventory model for perishable products with trade credit period and investment in preservation technology". *International Journal of Mathematics in Operational Research*, Vol.8, No.2, pp.137-163.
- Van der Vorst, J. G., van Kooten, O., Marcelis, W. J., Luning, P. A., and Beulens, A. J. (2007), "Quality controlled logistics in food supply chain networks: integrated decision-making on quality and logistics to meet advanced customer demands. *The 14th International annual EUROMA CONFERENCE*, 17-20 JUNE, Ankara, Turkey.
- Wang, X, and Li, D. (2012), "A dynamic product quality evaluation based pricing model for perishable food supply chains". *Omega*, Vol. 40,No.6, pp.906-917.
- Widodo, M., Nagasawa, H., Morizawa,H., Ota, K. (2006),. "A periodical flowering harvesting model for delivering agricultural fresh products," *European Journal of Operational Research*, Vol.170, No.1, pp. 24-43.