Indicators for supply chain management of vegetables with Good Agricultural Practice standard in Chiang Mai Province

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ABSTRACT: The objective of this study was to construct and assess Good Agricultural Practice (GAP) vegetable management indicators according to Supply Chain Operations Reference Model (SCOR Model). Data were collected in the form of interviews with questionnaires and focus groups in the study area. The sample groups were 166 farmers who produced GAP vegetables under GAP standard in ocimum, sweet pepper, goat and guinea pepper, *solanum melongena*, and other GAP vegetable groups. The result was analyzed through factor analysis, leading to key management indicators of GAP vegetable supply chain. Findings showed that the management in each GAP vegetables group was composed of two important components which should be emphasized according to SCOR process. It is found that input provision and recognition of GAP standard were important in sweet pepper, goat and guinea pepper, and *solanum melongena* groups. Delivery by trucks from assembly sources to markets and rotation planting were important in other GAP vegetable, goat and guinea pepper, ocimum, and *solanum melongena* groups. GAP vegetable production extension and efficient farm-to-assembly delivery were found to be important SCOR processes. This study shows that GAP vegetable management should focus on certain key SCOR processes contributing to the effective management to provide safe and quality products for consumers and farmers.
Keywords: Good Agricultural Practice (GAP) vegetables, supply chain management, SCOR processes, indicators

Introduction

At present, consumers realize that food safety plays an important role for the selection of food (Dimitric and Greene, 2002). In Thailand, the government encourages farmers to reduce the use of chemicals and to increase agricultural areas which are used to produce safe food for good health. In 1993, the government had the first project on the reduction of chemical use. This project was a starting point for food safety management by the government. In 1998, Good Agricultural Practice (GAP) standard was introduced under the agricultural and food standards called “Q Mark”. The GAP standard has been established by the Food and Agriculture Organization of the United Nations (FAO). It intends to have farmers who adjust their production to reduce chemical use. Although, GAP helps to reduce impact on health and environment from chemicals, in the past 10 years (1997-2010), pesticide use was up to more 11% of total quantity per ha per year (Suwanna et al., 2011) and in terms of pesticide handling, no significant differences were found between farmers who do and do not follow the Q-GAP guidelines (Schreinemachers et al., 2012).

Vegetables have a high risk for chemical contamination because of farmers’ production practices and consumers’ consumption behavior (Prathanthip et al., 2010). In 2010, European Union customs officials detected pesticide residues in Thai vegetables. They were found to have chemical residue in excess amount (the

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maximum residue limits (MRLs) by 55 times) of GAP vegetables 5 groups, i.e., ocimum, capsicum, *solanum melongena*, momordica charantia group, and eryngium foetidum groups (Sirinad, 2011). In early 2011, Thailand voluntarily suspended exports of sixteen types of these GAP vegetable groups to the EU, after the EU threatened to ban imports of Thai vegetables due to pest and pesticide residues found (Schreinemachers et al., 2012). The Thai government negotiated this situation before the EU banned imports. Furthermore, the government has since helped farmers who register in GAP guidelines. They should receive technical assistance from the government agencies, integrated crop management, and organic compost making. In reality, inadequate technical assistance was provided to the farmers because of the lack of staff giving the information and farm audit. The situation mentioned above poses problems concerning supply and demand imbalance, high product price, insufficient marketing channels, and a lack of confidence on the quality mark. These cause a lack of cooperation among the GAP vegetable supply chain stakeholders who hold differences in perceptions, attitudes, values, and motivation. The Thai government must continue to improve the process of farm control, strict auditing and serious control of the GAP supply chain management. At the same time, the Thai government should emphasize support for farm management and add alternative choices to farmers to eliminate pests and chemical residue in the outputs before being distributed. Moreover, solving these problems must be an integrated management from upstream, midstream, to downstream levels in supply chain of GAP vegetables. The management can be explained by means of Supply Chain Operations Reference Model (SCOR Model). The SCOR Model is the tool to manage production and marketing processes related to cultivation in fields, harvest, postharvest (trimming, grading, and packing), and distribution, both domestic and international markets. The SCOR Model is the standard process for management (Sanan and Rapeepan, 2012), comprising 5 processes. i.e., plan, production, source, delivery, and return. Each process was related to many variables which might result in the troublesome and inefficient management. Therefore, construction and assessment of GAP vegetable management indicators according to SCOR process were evaluated by means of factor analysis leading to the better management with the certain key indicators. The factor analysis is an analytical technique that has been extensively used to reduce the data which many variables are chosen initially and they are explained by a few factors or components. Each factor is composed of a group of variables that will be a subset of highly correlated variables from the original set of variables, while there is a low correlation between the factors.

Chiang Mai province was selected as the study area since there has been the food safety campaign by the Department of Agriculture to encourage farmers and consumers related to the danger of chemical residue. Moreover, Chiang Mai has the largest GAP vegetable areas in the country: 178,000 rai from 1.05 million rai (17% of all GAP vegetable areas). There are also a large number of farmers who receive the GAP certification in Chiang Mai: 28,000 farmers from 127,000 nationwide farmers (22% of all GAP vegetable farmers) (DoA, 2012).

Material and Methods

Materials: The data collection was obtained from questionnaires and focus groups from farmers who produced GAP vegetables under GAP standard in 5 groups, i.e., (1) ocimum group, (2) sweet pepper group, (3) goat and guinea pepper group, (4) *solanum melongena* group, and (5) other GAP vegetable group (*Momordica charantia, Eryngium foetidum*, yard long bean, and brassica). The samples were divided into 22, 16, 41, 45, and 42 farmers in each GAP vegetable group (166 farmers) randomized by means of stratified random sampling from districts, subdistrict to communities, according to database of the Office of Agricultural Research and Development Region 1.

Method: Many variables involved in the SCOR Model were reduced by factor analysis to evaluate the SCOR indicators of GAP vegetables in five groups mentioned above plus the sixth group being all vegetables in group 1-5. The factor analysis will reduce SCOR variables of each SCOR process to a small number of important determining factors, leading to the management efficiency of each GAP vegetable group.

Results and Discussion

1) Each process in SCOR Model was rPlan process is the balance between demand and supply, depending on product order, production, and product delivery. Variables related to this process were production types (Monoculture or rotation planting) and plan types (contract, no contract, or mixed).

2) Source process is input provision to produce products to respond the production plan or demand with reasonable price, in high quality, and on time. Variables related to this process were the input provision and input sources recommended.

3) Production process is the transformation from inputs to products corresponded with production plan or demand. Variables related to this process were knowledge levels of farmers who produced GAP vegetables under GAP standard.

4) Delivery process is the transportation of products to customers under budget and time constraints concerning the management of order, delivery, and distribution. Variables related to this process were grading and delivery types from farms to assembly sources, from assembly sources to markets, and from farms to markets.

5) Return process is the action of giving the products back to marketing channels since they are low in quality, do not correspond with demand, and are delivered later than the time designated. Variables related to this process were output correspondence with GAP standard and the recognition of GAP importance.

As shown in **Table 1**, it indicated that the management according to SCOR Model led to the high profit in each GAP vegetable group since farmers produced them under GAP standard by using a limited amount of chemical substances. However, the SCOR Model can be improved by changing the management. The changed management can contribute to the optimum and efficiency when the management in each SCOR process is precisely adjusted with reduced SCOR variables.

Table 1 Profits of each GAP vegetable group in the management according to SCOR Model

GAP vegetable group (i)	Area (rai)	Total Cost (baht/rai)	Total Revenue (baht/rai)	Profit (baht/rai)
1. Ocimum	0.47	13,399.36	78,920.93	65,521.56
2. Sweet pepper	1.37	132,153.29	283,688.17	151,534.87
3. Goat and guinea peppers	1.09	7,453.75	69,124.79	61,671.04
4. *Solanum melongena*	0.87	15,562.01	53,837.65	38,275.64
5. Other GAP vegetables	0.57	14,125.02	142,015.61	127,890.60
6. All GAP vegetables	0.84	24,146.89	105,402.03	81,255.15

The SCOR process can lead to the better management when many variables involved in the model are reduced to evaluate the SCOR indicators according to factor analysis procedures as follows;

1) SCOR variables in each process are analyzed by correlation matrix, Measure of Sampling Adequacy (MSA), and Kaiser-Meyer-Olkin (KMO) statistic and Bartlett's Test of Shericity which can conclude whether the variables can follow an agreement of factor analysis.

1.1 MSA is tested to analyze the adequacy of sampling that is more than 0.5 in each variable. If MSA in each variable is less than 0.5, it should be immediately eliminated to test the factor analysis again. The elimination of variables requires a minimum value. (Saengla, 2011). According to the analysis mentioned above, SCOR variables could be grouped according to MSA criteria and they were used to test the correlation matrix indicating that the relationship each pair of variables were less than the significant level of 0.01 and 0.05, as shown in **Table 2**.

Table 2 SCOR variables whether they follow MSA criteria, KMO statistic and Bartlett's Test of Shericity values of GAP vegetables in each group

No.	SCOR variables	Ocimum	Sweet pepper	Goat and guinea pepper	*Solanum melongena*	Other GAP vegetables	All GAP vegetables
1	Monoculture vs rotation planting	✓	✓	✓	✓	✓	✓
2	Contract vs no contract vs mixed	✓	✓	✓	✓	✗	✓
3	Input provision	✗	✓	✓		✗	✗
4	Input sources recommended	✓	✗	✓		✗	✓
5	Knowledge levels	✗	✗		✗	✓	✓
6	Grading	✗	✗	✓	✓		✓
7	Delivery types from farms to assembly sources	✗	✓	✗	✗	✓	✓
8	Delivery types from assembly sources to markets	✓	✗	✗		✗	✓
9	Delivery types from farms to markets	✓	✗	✓	✓	✓	✗
10	Output correspondence with GAP standard	✓	✓	✗	✓	✓	✓
11	Recognition of GAP importance	✗	✓	✓	✓		✗
Number in couples of variables was less than the significant level in correlation matrix. (**, *)		7	6	9	13	5	19
Kaiser-Meyer-Olkin (KMO)		0.7165	0.7479	0.6266	0.7210	0.5937	0.6750
Bartlett's Test of Approx. Chi-square		38.1496	50.1675	50.7912	71.0571	32.8387	179.0363
Sphericity df.		15	15	21	21	10	28
Sig.		0.0009**	0.0000**	0.0003**	0.0000**	0.0003**	0.0000**
Number of samples		22	16	41	45	42	166

1.2 According to **Table 2**, it was found that the SCOR variables in each GAP vegetable group were in accordance with the criteria of KMO statistic and Bartlett's Test of Shericity. It indicated that the KMO statistic in each group was more than 0.59, while Bartlett's Test using the approximate Chi-square was above a critical value and its significant level was under 0.01 in each group. Therefore, these variables could be grouped by means of factor analysis.

2) Factor extraction is calculated to find the component factors explaining relationship among variables. The component factors are considered by Eigen values. Eigen values can explain variance in a set of variables which are component factors when Eigen value is above 1 (Numchai, 2005). In this study, component factors can be analyzed by Principal Component Analysis (PCA) method to reduce the SCOR variables with the lowest variance value since the relationship among SCOR variables are the linear combination, explained from the highest, to the second highest, and then to the least of total variance. The variance among variables related to common factors is explained by communality values in each group. It was found that many SCOR indicators can be grouped as they showed high communality values.

As shown in **Table 3**, GAP vegetables of every group composed of 2 important components with eigen values were more than 1. The percentage of each component factor explained the variation of the SCOR variables by the percentage of variance for the first and second component factors. The outcomes of the first and second component factors showed the total of variation for SCOR variables of each GAP vegetable group. In addition, the cumulative variances of each component factor in GAP vegetable group 1-6 were 66.85%, 78.04%, 55.74%, 58.18%, 68.08%, and 47.48%, respectively.

Table 3 Extraction Sums of Squared Loadings in each GAP vegetable group

GAP vegetable group (i)	Extraction Sums of Squared Loadings				
	Initial Eigen values (λ_i)		Percentage of variance		
	Component 1	Component 2	Component 1	Component 2	Cumulative variance
1. Ocimum	2.79	1.22	46.47	20.38	66.85
2. Sweet pepper	3.48	1.20	58.06	19.98	78.04
3. Goat and guinea peppers	2.30	1.60	32.87	22.87	55.74
4. Solanum melongena	2.87	1.20	41.00	17.18	58.18
5. Other GAP vegetables	1.81	1.60	36.16	31.92	68.08
6. All GAP vegetables	2.29	1.50	28.68	18.81	47.48

3) Factor loading describes component variables in each factor with higher value of 0.40, which is significantly considered to be grouped in the same factor (Saengla, 2011). The factor loading sometimes needs the adjustment by means of axis rotation since factor loading values of some variables are similar. The varimax method is used to rotate axis since each variable is independent (Kanlaya, 2009), as shown in **Table 4**.

New names in each factor are set to represent variables in the same group. The results given in **Table 4**, the first and second component factors were called Farm-to-Market Delivery and Assembly-to-Market Delivery in ocimum group, Attitude and Access to Inputs and Farm-to-Assembly Delivery in sweet pepper group, Access to Inputs and Markets and Attitude and Production Types in goat and guinea pepper group, Quality and Attitude in *solanum melongena* group, Delivery and GAP Knowledge in other GAP vegetable group, and Mode of Production and Delivery and GAP Knowledge in all GAP vegetables group, respectively.

Table 4 Factor loading of rotated components in each GAP vegetable group

SCOR process	SCOR variables	Ocimum group		Sweet pepper group		Goat and guinea peppers group		Solanum melongena group		Other GAP vegetable group		All GAP vegetable group	
		Farm-to-Market Delivery	Assembly-to-Market Delivery	Attitude and Access to Inputs	Farm-to-Assembly Delivery	Access to Inputs and Markets	Attitude and Product-ion Types	Quality	Attitude	Delivery	GAP Know-ledge	Mode of Product-ion	Delivery and GAP Know-ledge
Plan	Contract vs no contract vs mixed				-0.7954	0.6803		0.7411				0.6549	
	Rotation planting		0.7282	-0.9374			0.7401	0.6731		0.7554		0.6689	
Source	Input provision			0.9369		0.6025							
	Input source recommended	-0.6716					-0.7161	-0.7814				-0.7180	
Production	Knowledge levels										0.8000		0.6424
	Grading					-0.7821		0.6837				0.4171	
Delivery	Delivery types from farms to assembly sources				0.8410					-0.6880			-0.6737

Table 4 (continued)

SCOR process	SCOR variables	Ocimum group		Sweet pepper group		Goat and guinea peppers group		Solanum melongena group		Other GAP vegetable group		All GAP vegetable group	
		Farm-to-Market Delivery	Assembly-to-Market Delivery	Attitude and Access to Inputs	Farm-to-Assembly Delivery	Access to Inputs and Markets	Attitude and Product-ion Types	Quality	Attitude	Delivery	GAP Know-ledge	Mode of Product-ion	Delivery and GAP Know-ledge
	from farms to markets					7				7			
Return	Output correspondence with GAP standard	-0.7930		-0.7295					-0.8604		0.8182	-0.6456	
	Recognition of GAP importance			0.8913			0.7455		0.8639				

4) Calculate of component score is created from $F_{ik}=W_{i1}Z_{1k}+W_{i2}Z_{2k}+\ldots+W_{ip}Z_{pk}$ (applied from Babu and Sanyal, 2009) ; k=1,2,…,n, i=1,2,…,m, j=1,2,…,p

When Z_i is the value of SCOR variables in each factor for the k^{th} case, n is observation, m is the number of common factors, p is number of GAP management indicators, W_{ij} is the factor loading for j^{th} variable in i^{th} component factor value, and F_{ik} is the i^{th} factor score value for k^{th} case.

Comparing different GAP vegetable groups, it is found that the goat and guinea pepper group has the highest score in the delivery and GAP Knowledge components. In this group, trucks were used to deliver the outputs from assembly sources to markets and the knowledge level of famers who produced GAP vegetables under GAP standard was in the range of 80-100% (**Figure 1**). The sweet pepper group has the lowest score in the attitude and access to inputs component being predominantly monoculture as opposed to rotation planting and it has the lowest score in farm-to- assembly delivery component. On the other hand, the high factor loading scores for this group lie in input provision and recognition of GAP standard (**Table 4**), therefore, to enable effective management in sweet pepper group, the input supply could be provided by cooperation among agricultural cooperatives, Royal Project development centers, chemical shops, and farmers and the output should be produced observing GAP standard. The difference of management can be compared using factor loading scores taking *solanum melongena* group as an example since the outputs can be processed in many forms to sell in each market. Here, it is found that farmers who are members of the GAP vegetable groups had the high component score of quality component as farmers here do more trimming and grading in factories before being distributed compared with non-members, or members of the Royal Project Foundation or members of company production. On the other hand, farmers who independently produced GAP vegetables in the group had the lowest component scores of quality and attitude components (Figure 2). In all groups, input supply recommendation is important, implying that extension services are still needed. In this Figure 2, attitude component shows negative value, indicating that farmers do not think attitude about their output being inspected to correspond to GAP standard that is important. From farmers' interview, they were confident that their output was corresponding to GAP standard as they had obtained already GAP certificate.

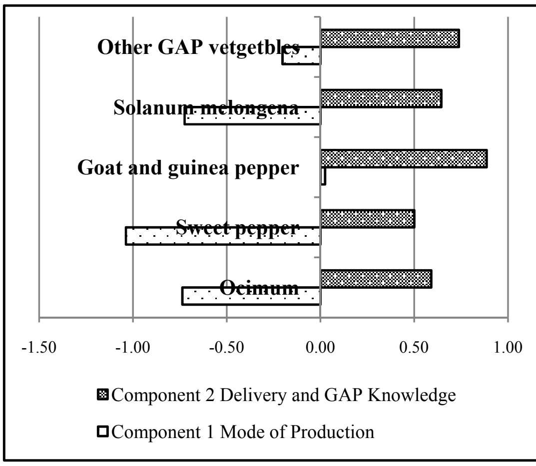

Figure 1 Management of each GAP vegetable group by component

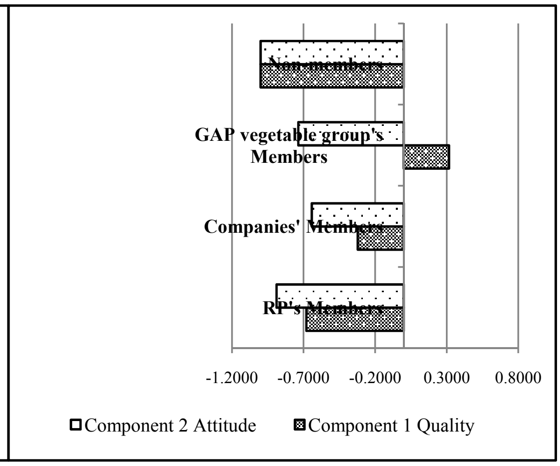

Figure 2 Management of *solanum melongena* group by component

Conclusion

(1) In conclusion, GAP vegetable management indicators could be evaluated by factor analysis according to SCOR process to manage the supply chain. The management should emphasize the positive values of factor loading in each indicator, resulting in an improved management as followsPlan process implied that a mixed plan between contract and no contract should be made in *Solanum melongena*, goat and guinea pepper, and all GAP vegetable groups and rotation planting should be practiced in other GAP vegetable, goat and guinea pepper, ocimum, and all GAP vegetables groups.

(2) Source process implied that cooperation among agricultural cooperatives, Royal Project development centers, chemical shops, and farmers could provide the input sources for GAP vegetable production in sweet pepper and goat and guinea pepper groups.

(3) Production process implied that the process should address knowledge levels of farmers who produce GAP vegetables under GAP standard in other GAP vegetable and all GAP vegetable groups.

(4) Delivery process implied that outputs should be trimmed and graded in factories before being distributed in *Solanum melongena* and trucks should be used to deliver the outputs from farms to assembly sources in sweet pepper group, from assembly sources to markets in ocimum and in all GAP vegetable groups, and from farms to markets in ocimum, other GAP vegetable, and goat and guinea pepper groups.

(5) Return process implied that the output correspondence with GAP standard should be observed in other GAP vegetable group and the recognition of GAP importance should be focused in sweet pepper, *solanum melongena*, and goat and guinea pepper groups.

Construction and assessment of GAP vegetable management indicators according to SCOR Model using factor analysis lead to reduced sets of indicators which were conducive to the effective management. Reduced costs for output delivery by trucks from assembly sources to markets and rotation planting were found to be important supply chain processes. The vegetable production should practice in accordance with the GAP requirements contributing to output correspondence with GAP standard and GAP vegetable production extension and efficient farm-to-assembly delivery should also be emphasized.

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