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Analytic hierarchy process-based evaluation of quality control of agricultural products cold-chain logistics

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ABSTRACT

Along with the development of logistics industry and the continuously improved living standard of consumers, consumer demand for fresh fruits and vegetables and other agricultural products has been growing year by year, imposing more demanding requirements for the quality of agricultural products cold-chain logistics (APCL). Based on the APCL quality control theory, this paper proposes the structure, key elements and indicators of APCL quality control system. Using analytic hierarchy process (AHP), APCL quality control system was built. Last, using cold-chain logistics of fresh agricultural products in area A as an example, this paper provides an evaluation of APCL quality control system in area A and proposes practical and feasible APCL quality control measures, thus validating the operability and reasonableness of the indicators of such control system.

KEYWORDS

Agricultural products; Cold-Chain logistics; Quality control; Analytic hierarchy process.

INTRODUCTION

LaLonde and Zinzez(1976) defined logistics services as " activities undertaken to meet the customer needs, ensure customer satisfaction and win recognition of companies". This definition, although heightened to the level of marketing, is still given from the perspective of logistics providers instead of customers. Mentzes, Gomes and Krapfe(1989) filled this gap by arguing that logistics services should comprise two layers of meaning: customer marketing service and physical distribution service ("PDS"). They selected three factors of goods availability, timing and quality from 26 factors as measures of PDS. But these three indicators actually measure physical distribution only and can not represent the quality of whole logistics services. A rather complete definition of overall quality of logistics services is the research findings from Tennessee University in 2001. After surveying and analyzing major third-party logistics providers and customers, they came up with nine measures of quality of logistics services from the perspective of customers: quality of personnel communication, quality of order release, information quality, ordering process, order accuracy, goods integrity, quality of goods, error treatment and timing. John T.Mentzer, Matthew B.Myers and Mee-Shew brought forward customer-oriented logistics service quality model in 2004 and examined the role of quality of logistics services in the global market segmentation.

Currently, most of literature involving development of logistics quality control system is not item-specific, but this might lead to the non-applicability of indicators of logistics quality control system. It is necessary to build a logistics quality control system applicable to different kinds of goods. Therefore, the purpose of this study is to structure indicators of APCL quality control system in light of the characteristic of APCL and evaluate real-life cases to verify the operability and reasonableness of these indicators.

CONTENTS OF APCL QUALITY CONTROL

Quality of APCL can be divided into quality of agricultural products and quality of cold-chain logistics process[1].

Quality of agricultural products

Product quality aspect of APCL process is required to not only ensure the quality of agricultural products but also continuously improve it, that is to say, preserving products and transferring the original quality of products through warehousing, handling, transport and distribution while improving the product quality to the maximum extent and constantly increasing its added value.

Quality of cold-chain logistics process

APCL process refers to a set of interrelated resources and activities required to ensure each part of cold-chain logistics process meets various explicit and implicit needs, such as temperature and humidity control and ventilation, which is the important characteristic of quality of cold-chain logistics process.

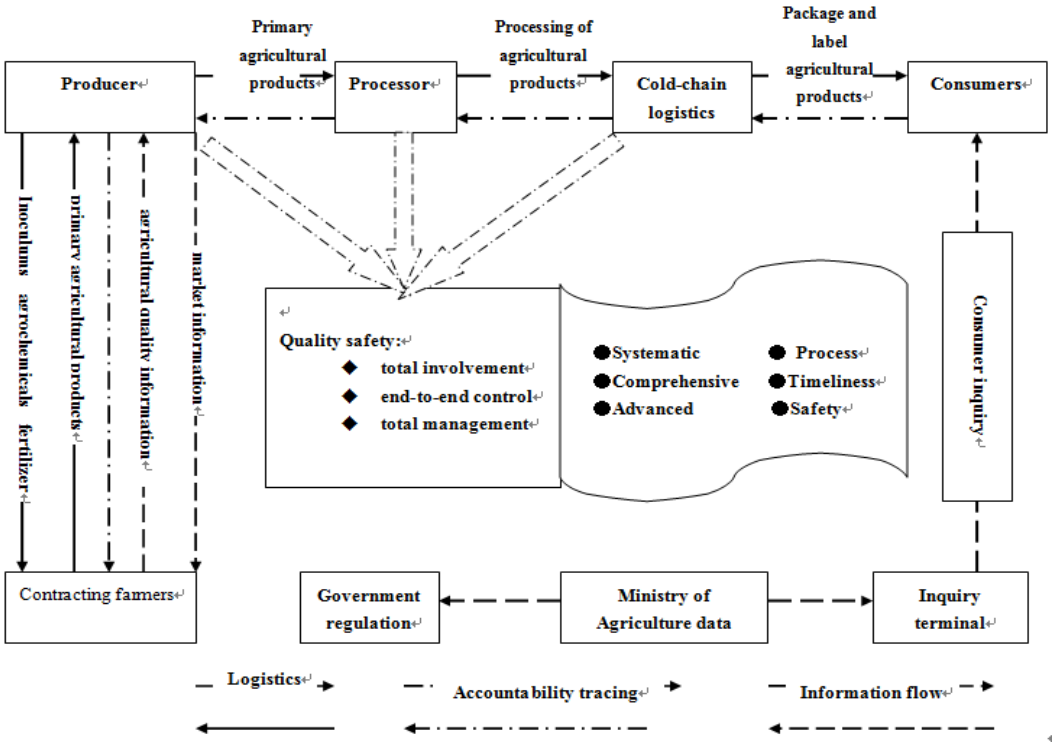

Figure 1. Diagram of APCL quality control system

Due to the special nature of cold-chain logistics products and demanding requirements for environmental conditions, there are different requirements for the contents of APCL quality control[2]. Figure 1 shows APCL quality control system, where the quality of APCL is divided into quality of agricultural products and quality of cold-chain logistics process, both of which is controlled to ensure the proper functioning of APCL quality control system[3].

DEVELOPMENT OF AHP-BASED APCL QUALITY CONTROL SYSTEM

Development of key elements of APCL quality control system

In light of APLC quality control system and the main methods used to improve APCL quality control system[4], it is possible to apply these methods to five key factors affecting APCL quality control process, i.e., operators, operating mechanism, technical equipment, working efficiency and environmental control. Table 1 shows the key elements of APCL quality control system and various applicable controls.

Table 1. Development of key elements of APCL quality control system

Factor	Affected item	Control
Operator	Dependence upon people, Dynamic and complicated nature of cold-chain logistics quality.	Impart health knowledge, Improve quality awareness and sense of responsibility.
		Vocational training for improved knowledge structure and skill sets.
Operating mechanism	Systematic, comprehensive and dynamic nature of cold-chain logistics quality control; Contingencies in cold-chain logistics process.	Well-conceived cold-chain logistics strategy and development plan.
		Well-structured cold-chain logistics leadership, organizational structure and working system.
Technical equipment	Uncertainty of cold-chain logistics quality standard; Development of freezing and refrigerating process and technology.	Ensure technology and suitability, maintenance and compatibility of equipment.
		Build modern cold storages.
		Adopt modern technology and management practice.
		Improve cold-chain packaging and processing techniques.
Working efficiency	Complicated nature of cold-chain logistics process; Demanding requirements of agricultural products for safety and efficiency of logistics services.	Exert rigorous control over each part of the process.
Environmental control	Special requirements of APCL.	Upkeep of areas surrounding warehouses, corridors inside and outside warehouses, stations and platforms and elevators.
		Environmental protection including ingress and egress of logistics personnel.
		Sanitation and hygiene of tools and instruments used.

Development of indicators of APCL quality control system

Collect related data and conduct baseline surveys according to the rationale, structure and key elements of APCL quality control system to be built. Subdivide the five key factors (i.e., operator, operating mechanism, technical equipment, working efficiency and environmental control) into a hierarchical structure according to the affiliation and degree of importance of interplay and in light of the characteristics of APCL.

CASE STUDY——USEING THE EVALUATION OF APCL QUALITY CONTROL PROCESS IN AREA A AS AN EXAMPLE

Brief description of APCL practice in area A

Along with the growing level of urbanization and the improved living standard of consumers, consumer demand for fresh agricultural products has been growing steadily. The government of the area A pays more attention to safety of frozen food and has been committed to building a safety net for fresh agricultural products by promulgating a series of government

policies such as “local code of practice for storage and transport of frozen food” and “fresh food safety supervision guidelines”, with greater efforts of quality control.

Evaluation of APCL quality control system in area A.

(1) Steps of AHP-based evaluation of APCL quality control system in area A

In light of the physical circumstances in area A and the survey findings, the AHP-based evaluation of APCL quality control system in area A consists of the following steps:

Build a hierarchical structure model of the key factors affecting APCL quality control system in area A.

First, a questionnaire was developed to solicit input from experts about the relative importance of factors affecting APCL quality control system in area A, which divides area A into six districts of I, II, III, IV, V and VI according to geographic location and covers experts from district-level logistics associations, college teachers of logistics and business executives of cold-chain logistics companies. A total of 90 copies of the questionnaire were distributed, of which 68 copies of valid questionnaire were received. Ten copies of valid questionnaire were selected randomly from each district, resulting in a total of 60 copies of valid questionnaire. After data collation and analysis, the hierarchical structure of target decision-making problems was built, as shown in Figure 2.

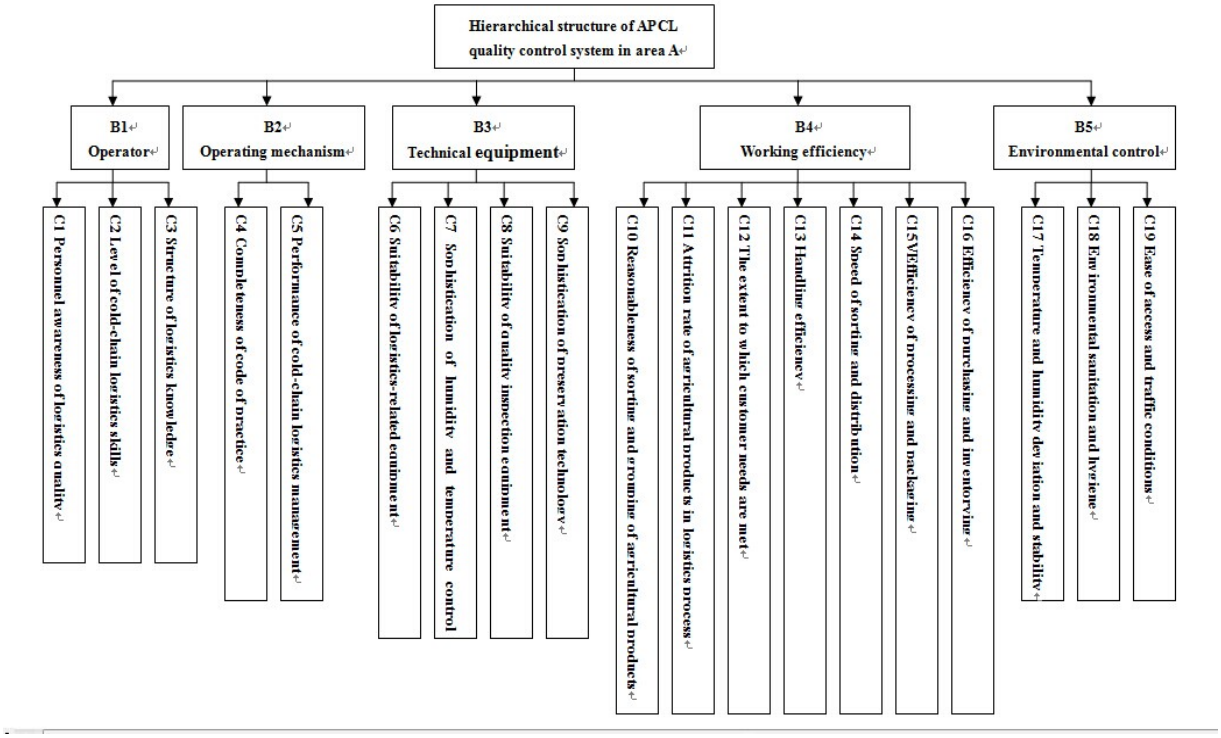

Figure 2. Hierarchical structure of APCL quality control system in area A

(2)Structure a judgment matrix at each of three levels according to the expert ratings.

(3)Validate the consistency of judgment matrix and conduct single hierarchical arrangement for each level.

Calculate the data in each judgment matrix and inquire about the consistency indictor. The consistency ratio coefficient CR in each matrix meets the condition $CR \le 0.1$, meaning the consistency of judgment matrix is acceptable. Therefore, after validation process, the aforesaid judgment matrix meets the consistency requirement and can be used for sequencing analysis for degree of importance of influencing factors.

(4)Generate total hierarchical arrangement results and consistency check of total hierarchical arrangement

Based on the calculation of consistency check indicators of total hierarchical arrangement and by inquiring into the consistency indicator lookup table, the results of total hierarchical arrangement are generated, as shown in Table 2.

Assessment of APCL quality control system in area A

With the aforesaid calculation, the results of sequencing of key influencing factors involved in AHP-based evaluation of APCL quality control system in area A can expressly generate the following conclusions:

(1) Table 3 above indicates that the factors affecting APCL quality control system in area A rank according to degree of importance as follows: suitability of logistics-related equipment, temperature and humidity deviation and stability, performance of cold-chain logistics management, advanced nature of preservation technology, advanced nature of temperature and humidity control devices, suitability of quality inspection equipment, environmental sanitation and hygiene,

ease of access and traffic conditions, completeness of code of practice of logistics, personnel awareness of logistics quality, structure of logistics knowledge, attrition rate of agricultural products in logistics process, level of cold-chain logistics skills, the extent to which customer needs are met, efficiency of purchasing and inventorying, reasonableness of sorting and grouping of agricultural products, handling efficiency, efficiency of processing and packaging and speed of sorting and distribution.

Table 2: Total hierarchical arrangement of key factors affecting APCL quality control system in area A.

Hierarchy of B Hierarchy of C	B1	B2	B3	B4	B5	Total hierarchical arrangement	
	0.0778	0.1450	0.4595	0.0653	0.2524		
C1	0.4000	0.0000	0.0000	0.0000	0.0000	0.0311	10
C2	0.2000	0.0000	0.0000	0.0000	0.0000	0.0156	13
C3	0.4000	0.0000	0.0000	0.0000	0.0000	0.0311	10
C4	0.0000	0.2500	0.0000	0.0000	0.0000	0.0362	9
C5	0.0000	0.7500	0.0000	0.0000	0.0000	0.1087	3
C6	0.0000	0.0000	0.3976	0.0000	0.0000	0.1827	1
C7	0.0000	0.0000	0.1988	0.0000	0.0000	0.0914	5
C8	0.0000	0.0000	0.1672	0.0000	0.0000	0.0768	6
C9	0.0000	0.0000	0.2364	0.0000	0.0000	0.1086	4
C10	0.0000	0.0000	0.0000	0.1084	0.0000	0.0071	16
C11	0.0000	0.0000	0.0000	0.2642	0.0000	0.0172	12
C12	0.0000	0.0000	0.0000	0.1963	0.0000	0.0128	14
C13	0.0000	0.0000	0.0000	0.0982	0.0000	0.0064	17
C14	0.0000	0.0000	0.0000	0.0889	0.0000	0.0058	19
C15	0.0000	0.0000	0.0000	0.0982	0.0000	0.0064	18
C16	0.0000	0.0000	0.0000	0.1459	0.0000	0.0095	15
C17	0.0000	0.0000	0.0000	0.0000	0.5396	0.1362	2
C18	0.0000	0.0000	0.0000	0.0000	0.2970	0.0750	7
C19	0.0000	0.0000	0.0000	0.0000	0.1634	0.0413	8
$\sum$	1	1	1	1	1	1	

The APCL quality control practice in area A can be improved in light of the relative importance of influencing factors so as to rapidly and efficiently improve the quality of cold-chain logistics as well as the hardware system and environmental control capabilities and management structure while ensuring the operators become more knowledgeable and efficient in practice.

(2) The sequencing results at the first level suggest that technical equipment has the greatest impact on APCL quality control practice in area A and that only by improving the cold-chain logistics infrastructure in this area can the quality of cold-chain logistics be brought under effective control and fresh agricultural products be delivered to consumers safe and sound. Second, other key factors affecting the quality of cold-chain logistics are environmental control, operating mechanism and maintenance of hygienic and low-temperature environment for fresh foodstuff. This, in conjunction with effective supervision on the company side, can effectively ensure the functioning of cold-chain logistics and product quality. For cold-chain logistics, operators and working efficiency are also important contributors. For area A where logistics system is growing mature, the improved professional competency of operators and the significantly improved working efficiency due to advent of new cold-chain logistics techniques can help ensure the quality of cold-chain logistics.

(3) It is possible to build APCL quality control system in area A by making improvements in five aspects of APCL practices, i.e., operator, operating mechanism, technical equipment, working efficiency and environmental control. By judging, analyzing, estimating and ordering these influencing factors, effective measures can be developed to better control the quality of APCL practices in area A, including putting into use more advanced logistics-related equipment and temperature and humidity control devices and setting up easily-accessible cold-chain distribution centers to reduce the working hours of logistics activities; improving personnel awareness of quality and operational capabilities through vocational training and developing a reasonable and well-conceived logistics code of conduct to ensure the whole logistics process will run efficiently.

CONCLUSION

Based on five factors of operator, operating mechanism, technical equipment, working efficiency and environmental control involved in APCL practices, 19 key factors affecting APCL quality control process were identified and analyzed and an APCL quality control system developed. Using AHP process and based on the empirical analysis of APCL practices in area A as well as expert input, the relative importance of these 19 factors were identified and effective measures for evaluation of APCL quality control process were proposed, in order to improve APCL quality control practices. A point of reference was provided for improving the local cold-chain logistics practices, and the application of AHP process was demonstrated in the evaluation of APCL quality control.

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