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Study on the Environment of Strawberry Exports to Russia for Which an IoT-based Reefer Container Monitoring System is Used

Young Sik Moon[1], Jun Woo Jung[2], Sung Pill Choi[3], Jae Joong Kim[4], and Hyung Rim Choi[5]

[1,2,3,4,5] Intelligent Container R & D Center, Dong-A University, Korea
[1]tambagu@dau.ac.kr, [2]jwjung@dau.ac.kr, [3]shippill@naver.com, [4]jjkgb@dau.ac.kr, [5]hrchoi@dau.ac.kr

Abstract. Along with improving the quality of life in Russia, its consumption of fresh fruits is increasing daily, and its demand for strawberries produced in Korea is also increasing. Currently, strawberries produced in Korea are mainly exported via air transport for rapid small-quantity transportation. In order to satisfy the Russian demand for Korean strawberries, container-based and large-volume maritime transports are needed. However, for maritime transport, there is a need to identify the stage at which the decomposition of strawberries occurs during the transportation of fresh cargo. Accordingly, this study introduces an "IoT-based Reefer Container Monitoring System," and identifies the point of time at which the decomposition of strawberries started during transportation through a monitoring of the ambient temperature and humidity of strawberries while they were actually being transported via ocean and air.

Keywords: IoT, Reefer Container Monitoring, Strawberry Exports to Russia

1 Introduction

In order to satisfy the Russian demand for fresh strawberries, maritime transports are needed for the low-cost transport of large-volume cargo. In addition, a monitoring of the transported strawberries is needed, so that they can remain fresh during export transportation and upon arrival in Russia.

To assure that the strawberries do not decompose during transport, it is important to identify the condition in which they are transported. However, the development of technologies that enable real-time monitoring of agricultural products exported overseas is not yet much progressed. [1] [2]

Accordingly, this study introduces an "IoT-based Reefer Container Monitoring System" that enables monitoring of the inside condition of reefer containers during the maritime export transportation of strawberries. With the Reefer Container Monitoring System, temperature conditions were monitored for strawberries that were exported via maritime and air transports from Korea to Vladivostok, Russia.

In Chapter 2 of this study, the maritime and air transport paths of strawberries are identified. In Chapter 3, the "IoT-based Reefer Container Monitoring System" that

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was developed by the researchers is introduced. In Chapter 4, the result about the conditions of the strawberries analyzed using the data of the system is described. Lastly, in Chapter 5, the conclusion is presented.

2 Paths of strawberry exports to Russia

The paths of strawberry exports from Korea to Russia comprise the maritime transport wherein strawberries loaded in reefer containers are shipped at Donghae Port and transported via ferries; and the air transport wherein strawberries loaded in reefer containers are shipped at Incheon Airport and transported via cargo planes.

In maritime transport, strawberries are loaded into reefer containers, which can maintain the proper temperature during transportation. Then, they are trucked to Donghae Port, shipped onboard, and transported to Vladivostok Port. In this case, the strawberries are transported for 4 to 5 days, while their temperature is maintained at the proper temperature of 2℃ in the reefer containers of which the power is supplied by trucks and ships.

In air transport, the strawberries are moved to a logistics warehouse near an airport, repackaged into containers (ULD) and transported via cargo planes to the Vladivostok International Airport. In this case, the strawberries are transported for two to three days while they are repackaged in the logistics warehouse, as they are exposed to room temperature.

Therefore, there is an average difference of two days between that of the maritime transport wherein the strawberries are transported while their temperature is maintained at the proper temperature, and that of the air transport wherein the strawberries are exposed to room temperature for some time during transportation.

3 Introduction to the IoT-based Reefer Container Monitoring System

There are two methods for the monitoring of reefer containers one is the PCT (Power Cable Transmission) method and the other is the 4-pole method. However, they are not currently utilized because they can only be used at places that are furnished with monitoring infrastructure.[3][4] Recently, a method has been developed for the monitoring of reefer containers by collecting information via the data port of reefer containers and via wireless communications technology. [5]

The “IoT-based Reefer Container Monitoring System” introduced by this study comprises a sensor that is mounted inside the reefer container and detects the inside temperature and humidity of the container as shown in Figure 2; an information transmission device that is mounted inside the enclosure of the control unit of the reefer container, collects cargo transportation environment data that are sent by the sensor via 433 MHz RF communications, adds global positioning information that is acquired through the GPS, and transmits information using the telecommunications technology that enables automatic roaming even in overseas and a monitoring program.

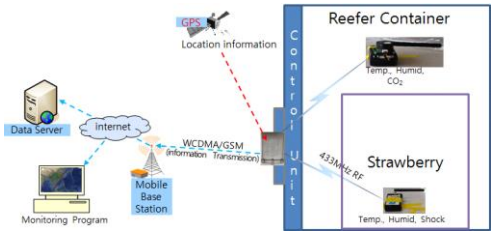

Fig 2. Reefer Container Monitoring System

4 Monitoring of the environment of strawberries exported to Russia

The monitoring of the environment of strawberries exported from Korea to Russia was carried out for one shipment of maritime transport and one shipment of air transport with a sensor tag installed inside the reefer containers in order to measure the temperature and humidity.

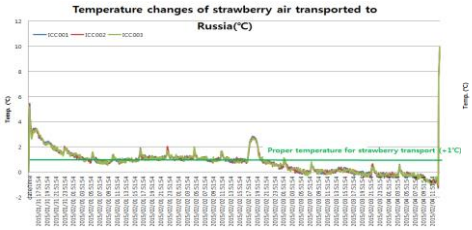

Fig 3(a) For maritime transport

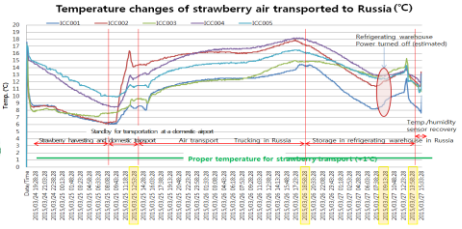

Fig 3(b) For air transport

Fig 3. Result of temperature monitoring for maritime transport and air transport

The maritime transport approximately took 4 days. The temperature changes during the said transportation period were as shown in Figure 3(a). In the maritime export transportation of the strawberries, the inside temperature of the reefer container was set at 1℃, and the cold chain was maintained at the entire export sections. Meanwhile, the temperature was maintained at between -0.5℃ and 3℃, which was close to the proper storage temperature of 2℃, during the actual inland transportation from Korea to its arrival at the storage warehouse of the local buyer in Russia.

The air transport approximately took 3 days. Also, the temperature changes during the transportation process were as shown in Figure 3(b). During the air export transportation of the strawberries, they were not maintained at the proper storage temperature of 2℃ at some transportation sections, because they were exposed to room temperature at the domestic logistics warehouse near the airport.

In particular, the cold chain was not maintained at the logistics warehouse near Incheon Airport, during air transportation, and in the in-land transportation section in

Russia, because the strawberries were exposed at room temperature between 6.2℃ and 18.2 ℃. In addition, after they reached the storage warehouse of the local buyer in Russia, their storage temperature was not rapidly lowered to the proper level.

As a result, even though the air transport took a shorter time than that of the maritime transport by approximately two days, the merchantability of the strawberries was lower.

5 Conclusion

This study monitored the export transportation condition of strawberries through the IoT-based Reefer Container Monitoring System that was developed by the researchers for the two exporting paths of maritime transport and air transport.

As a result, in the case of air transport, the proper temperature of 2℃ was not maintained for the storing of strawberries in most of the transportation sections between the domestic warehouse near the shipping airport and the warehouse of the local buyer in Russia. In particular, the strawberries were exposed to room temperature for an extended period while they underwent customs clearance, because the Russian airport was not furnished with proper refrigerating system.

On the contrary, even though the maritime transport took longer time than that of maritime transport by approximately two days, the proper storage temperature was maintained for the strawberries in the entire logistics sections, except in a handling section, because they were kept in the reefer container during the transportation.

As analyzed above, in the transportation of strawberry, which is a fresh agricultural product, the maintenance of the cold chain is more important than reducing the transportation time.

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