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REVIEW

# Development and Adaptability of Individual Packaging Containers for Strawberries

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## Abstract

We have previously reported on the design of individual packaging containers for strawberries to prevent the degradation of quality. The container is bivalve-shaped and the two “shells” of the bivalve grip the peduncle of the fruit, thereby allowing packaging without the fruit coming into contact with the packaging material. We observed that the rate of weight loss and the extent of damage were lower for strawberries packed in individual containers than for strawberries packed in conventional packages. Thus, these containers preserve the quality of strawberries more efficiently (Konya et al. 2015). This review reports on the development of a practical-type container with improved shape and material. We measured the container’s basic performance, such as temperature following capability and peduncle grip force, and also conducted vibration and dropping tests to examine its practical utility. As a result, we observed that the practical-type container is resistant to vibration during transport, but vulnerable to dropping when the peduncle is positioned at the top. Thus, in case of long haul or transshipment transportation, the peduncle should be positioned at the bottom.

**Discipline:** Postharvest technology
**Additional key words:** damage, grip, peduncle, quality

## Introduction

Because strawberries are easily damaged, it is extremely important to develop a packaging technique that can prevent bruising or the degradation of quality. In conventional two-layer packaging, strawberries are reportedly damaged not only by the load of stacked fruits but also by contact with other fruits, the packaging, and film covering the fruit. The bottom part of strawberries can also be damaged by the weight of the fruit (Konya et al. 2007, Konya & Omori 2008).

In addition to conventional two-layer packaging, other techniques have recently been adapted, such as the flat package (in which strawberries are arranged horizontally) and the buffer package (which employs a hole-shaped sponge made of polyethylene foam). In particular, the buffer package is reportedly more effective in minimizing damage than conventional two-layer packaging. However, high levels of damage resulted from a specific vibration test (Nakamura et al. 2008). Kitazawa developed a novel packaging technique whereby strawberries are held horizontally on a sponge, thus reducing damage by minimizing contact with other fruits and packaging materials (Kitazawa et al. 2008).

New hammock-type packages have also been developed and employed. These consist of a case covered by a film propped up with poles. Both the case and poles are made of polyethylene terephthalate, whereas the film is made of polyethylene. The film is therefore flexible and its strawberry shape allows it to hold a strawberry, thus acting as a hammock. The strawberries are not in contact and cannot rotate, thereby reducing the possibility of damage (Baba et al. 2012).

This review describes the development and adaptability of individual packaging containers for strawberries, with the objective of preventing any degradation of quality.

## Original individual packaging container

The container is bivalve-shaped and the two “shells” of the bivalve grip the peduncle of the fruit, thereby allowing packaging without the fruit coming into contact with the packaging material (Fig.1).

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In order to evaluate the quality preservation performance of individual packaging containers, we conducted a storage test where strawberries were stored in individual packaging containers and conventional two-layer packaging in a refrigerator set at 5°C.

We found that the rate of weight loss and the extent of damage were lower for strawberries packed in individual containers than for strawberries packed in conventional packages. Thus, the individual packaging containers proved more efficient in preserving the quality of strawberries (Konya et al. 2015).

**Fig. 1. Individual package containers**
(left: original; right: practical-type)

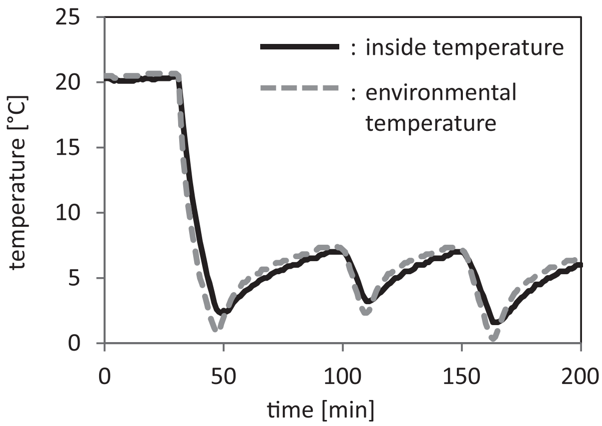


**Fig. 2. Temperature following capability**

## Practical-type individual packaging container

The practical-type individual packaging container is shaped similar to that of the original container. However, one of the shells of the practical-type container is nearly spherical, reflecting a strawberry image (Fig.1, right). Moreover, the shape of the peduncle-grip part is modified to secure a tighter grip on the peduncle, with one side having a small projection and the other side having a concave portion. We expect the small projection to stick to the peduncle, while the peduncle-grip part can grip it tighter.

The inner dimensions of the practical-type individual packaging container are 56 mm in width, 60 mm in height, and 50 mm in depth. PET material is used with a sheet thickness of 0.3 mm.

## Basic performance of the practical-type individual packaging container

### 1. Temperature following capability

After harvest and packaging, strawberries must be stored in a refrigerator in a farmhouse or at the market. The fruit may also be transported in refrigerated trucks. Both cold storage and refrigerated transportation can reportedly maintain the quality of strawberry fruit, thereby preventing the loss of such components as moisture and sugar, changes in appearance (e.g. color, burnish), and reduction in hardness (Seyama 2010).

Because the individual packaging container encases a strawberry, we were concerned about whether the container's inside temperature could be maintained in the refrigerator. In order to evaluate the temperature following capability of the individual packaging container, we measured the inside temperature as the containers stored in the laboratory at 25°C were moved into the refrigerator at 5ºC. We also placed a small button battery thermometer (KN Laboratories, Inc. Hygrocron) at the bottom of each of the five containers.

The test confirmed that the inside temperature smoothly follows the surrounding temperature (Fig. 2). Thus, the practical-type individual packaging container has no negative effect on refrigeration.

### 2. Measurement of the peduncle grip force

A digital force gauge was used to measure the maximum resistance to pull the peduncle gripped inside the container.

First, a kite string is passed through a side hole along the top edge of the container. One end of the string is attached to an alligator clip inside the container. Next, the peduncle is anchored at the clip and peduncle-grip part of the container. The other end of the kite string is attached to a digital force gauge outside the container (Fig. 3). Finally, the kite is pulled until the peduncle is disconnected from the container, at which point the maximum resistance is measured.

The average maximum resistance was found to be 4.1 ± 0.6 N (Fig. 4), which is higher than that of the original container. Hence, the practical-type container proved to have adequate grip force.

### 3. Effect of vibration or dropping

We conducted a vibration test at 3.0 $m/s^2$ acceleration and 2 Hz frequency for 60 minutes, with reference to the vibration conditions of a highway truck. Specifically, we

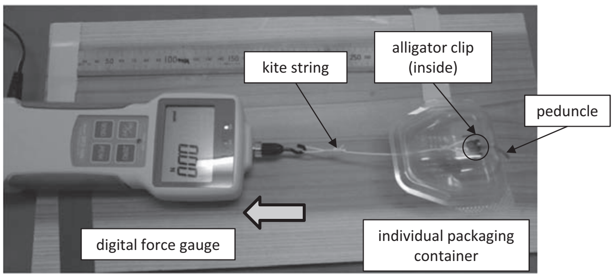


**Fig. 3. Peduncle grip force measurement**

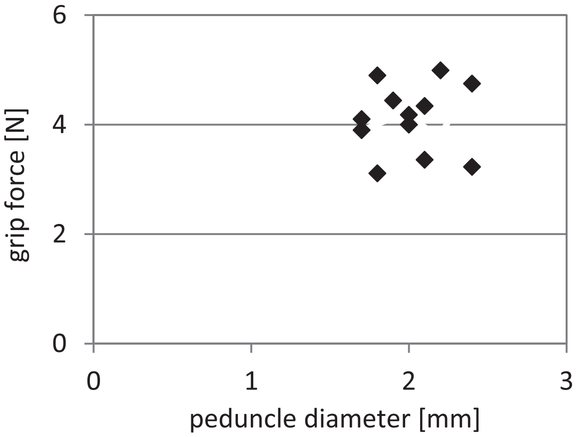


**Fig. 4. Peduncle grip force**

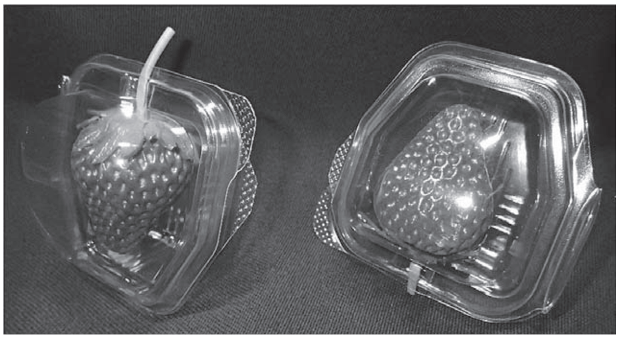

**Fig. 5. Two poses in the vibration and dropping test**
(left: peduncle grip part at the upper position;
right: peduncle grip part at the lower position)

tested practical-type containers with the peduncle-grip part at the upper position and those with the peduncle-grip part placed upside down (Fig. 5).

The test results in both cases revealed no declination or separation of the peduncle.

A dropping test involving the practical-type containers in a shipping cardboard box was conducted. Details of the box were reported in a thesis presented by the Japanese Society of Agricultural Machinery and Food Engineers (Konya et al. 2015). In this test, the divider plate was reassembled in order to set the practical-type containers in the two poses described above. Table 1 shows the dropping heights.

The dropping test revealed no declination or separation of the peduncle with the peduncle-grip at the lower part, whereas some declination and separation was found with the peduncle-grip at the upper part (Table 1). The acceleration within the shipping cardboard box (as measured by an acceleration meter) was in the range from 98 to 254 $m/s^2$. As the strawberries had a total weight of about 30 g, a force between 2.94 and 7.62 N was calculated to act on the grip force part. When the force exceeded the grip force of the container, peduncle declination and dropping were consequently observed.

From these tests we concluded that the practical-type container is resistant to transport vibration, but vulnerable to dropping. Therefore, the peduncle-grip should be positioned at the lower part in case of long haul or transshipment transportation, whereas no restrictions are imposed in case of private truck transport.

Practical-type containers have been commercially available as of the year 2014 CE, and are expected to preserve the quality of strawberries during transport.

## Conclusions

We developed a practical-type individual packaging container for strawberries. This container has the following features:

**Table 1. Dropping test results**

Pose : peduncle grip at the upper position n = 17

| test procedure / dropping height | 10 cm | ⇒ | 20 cm | ⇒ | 30 cm | reclip 30 cm | reclip 10 cm *2 | ⇒ | 10 cm × twice |
|---|---|---|---|---|---|---|---|---|---|
| appropriate *1 [%] | 100.0 | | 35.3 | | 0.0 | 11.8 | 100.0 | | 29.4 |
| declination [%] | 0.0 | | 52.9 | | 17.6 | 70.6 | 0.0 | | 41.2 |
| separation [%] | 0.0 | | 11.8 | | 82.4 | 17.6 | 0.0 | | 29.4 |

*1 A visual check has confirmed no declination or separation.
*2 All fruits are appropriate, but slightly declinated in this trial.

1) Given the container's adequate temperature following capability, it has no negative effect on precooling.
2) The container has adequate grip force, with average maximum resistance of 4.1 ± 0.6 N.
3) The container is resistant to transport vibration, but vulnerable to dropping.

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