

# PHYSICAL PROPERTIES OF FRESH RED PEPPER

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## ABSTRACT

Geometrical characteristics of fresh red pepper(*Capsicum annuum* L.) were measured and indexed to define some important geometrical characteristics, and malformation of body and fruit stalk which are necessary for the design of the equipments for cutting, spreading and alignment of red pepper in developing a fruit stalk remover of fresh red pepper. The effects of bending of body and fruit stalk on the equipments of cutting, spreading and alignment were studied. The maximum lengths of some parts of fresh red pepper were found to be 180 mm, 125 mm, 144 mm, 67 mm and 76 mm for the body, the bent part of body, the fruit stalk, the bent part and the straight part of fruit stalk, respectively. The fresh red pepper with bending indices more than 0.4 and 0.3 for the body and the fruit stalk, respectively, was defined to be malformed based on the result of cutting rate using cutting unit; while the other ones to be normal in shape. Based on this, among the total fresh red peppers tested, 47%, 40% and 20% were found malformed for the body, the fruit stalk, and for both of the body and the fruit stalk. Malformed red peppers were poorer in spreading and alignment than normal ones, and the processed quantity was decreased with increased feed rate. The required time for the malformed peppers to pass on the alignment plate inclined at 30° increased rapidly at 8.3 Hz with increased feed rate. For the fresh red peppers with average moisture content of 85%,w.b., the maximum tensile strength between fruit stalk and body was 88.1 N; the maximum cutting resistances were 92.1 N and 94.9 N for the fruit stalk-calyx joint and body, respectively. Average coefficients of static friction were 0.99, 0.62, 0.59 and 0.3, respectively, for the surfaces of rubber, galvanized iron, acryl and plywood.

Key words : Fresh red pepper(*Capsicum annuum* L.), Fruit stalk remover, Shape factor, Bending index, Tensile strength, Cutting resistance, Coefficient of static friction.

## INTRODUCTION

Red pepper is important economic crop next to rice in Korea, as 4.5% of domestic agricultural

production and 30% of vegetables is red pepper. Large-scaled processing plants of red pepper powder are in operation around the chief producing places in Korea at present, using the fruit stalk remover for dried pepper. But, the physical characteristics of fresh red pepper(*Capsicum annum* L.) are quite different from dried red pepper. Consequently, it is quite necessary to develop a new fruit stalk remover made exclusively for fresh red pepper.

In this study, bending indexes of fruit stalk and body were defined based on the geometric shapes measured among the physical properties necessary for development of a fresh red pepper stalk remover, and effects of shape factor on the units of cutting, spreading and alignment were analyzed. Tensile strength and cutting resistance, and coefficients of static friction of fresh red pepper on some different surfaces were measured.

The objective of this study was to obtain basic data on some physical properties of fresh red pepper necessary in laying out a scheme in the design of efficient fruit stalk remover of fresh red pepper.

## MATERIALS AND METHODS

### 1. Materials

Variety of fresh red pepper tested was Nokgwang with the moisture content ranging from 80% to 85%,w.b., which was obtained from several sources.

### 2. Equipments and Methods

#### 1) Measurement of geometric shape

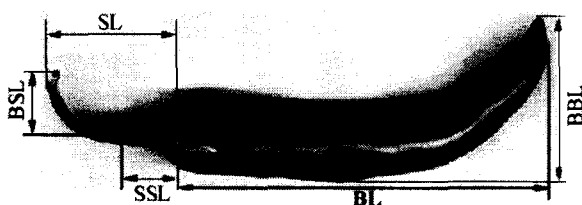


Fig. 1 Selected dimensions of fresh red pepper

To determine the index of shape factor of body and fruit stalk, lengths of some parts were arbitrarily defined, namely: body, bent body, (fruit) stalk, bent (fruit) stalk (Fig. 1 and Table 1).

Table 1. Definition of geometric characteristics of fresh red pepper.

| Nomenclature                      | Description  |
|-----------------------------------|--|
| Body length (BL)                  | Length from the end of calyx to the end of body                    |
| Bent body length (BBL)            | Length from the lowest part to the highest part of body            |
| Fruit stalk length (SL)           | Length from the end of calyx to the end of fruit stalk             |
| Bent fruit stalk length (BSL)     | Length from the center of calyx to the highest part of fruit stalk |
| Straight fruit stalk length (SSL) | Length from the end of calyx to the bent point of fruit stalk      |

A batch of 490 N of fresh red pepper was used to measure the dimensions using scale, vernier calipers and section paper. Indexes were calculated, namely: BBL/BL, BSL/SL and SSL/SL.

## 2) Cutting test

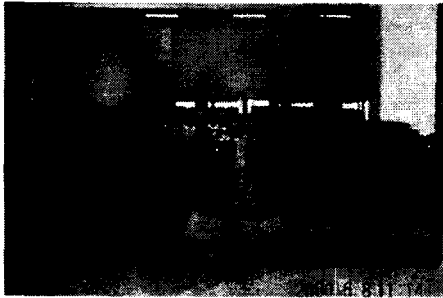


Fig. 2 Cutting equipment

Cutting unit consisted of cutting guide that caught fresh red pepper from conveyor belt, conveying brushes that pushed red pepper in the cutting guide to the rollers, and two cutting rollers of red pepper. Cutting experiment was performed to determine the index of shape factor of the fresh red pepper unfavorable to treat with the prototype cutting equipment using a batch of 490 N of pepper(Fig. 2). Indexes of shape factors were examined for the fresh red peppers which were ejected

by the conveying brush outwardly from the cutting guide while they were conveyed by the brush to the roller part, and for the ones which were not cut by the roller though they were conveyed to the roller part.

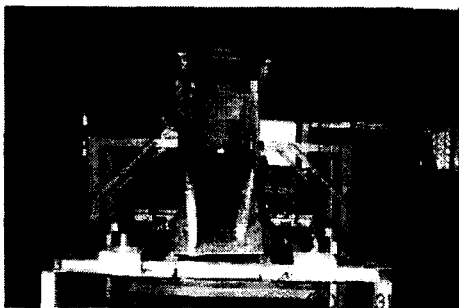


Fig. 3 Spreading equipment

## 3) Spreading test

Equipment for spreading of fresh red pepper consisted of vibrating spreading plate (700 mm × 235 mm) adjustable for inclination between 0° and 180° (Fig. 3). Normal and malformed fresh red peppers were selected based on the results from the cutting test and separately put onto the spreading plate and their passing times on the plate were compared. Carrying speed of conveyor, inclination angle of spreading plate

and its vibration frequency were controlled between 0.06 m/s to 0.11 m/s, 10° and 20°, and 6.7 Hz, 7.5 Hz, 8.3 Hz, respectively. 'Poor spreading' was defined when fresh red peppers were not spread on the plate or not conveyed because of their accumulation.

## 4) Alignment test

Equipment for alignment of fresh red pepper consisted of vibrating alignment plate(700 mm× 235 mm) with 2 lines of 48° - angled groove adjustable for inclination between 0° and 180° (Fig. 4). The

passing time of fresh red peppers, normal and malformed, from the alignment unit to the cutting unit were measured and compared. The carrying speed of fresh red pepper, the angle and the vibration frequency of alignment plate were controlled between 0.06 m/s and 0.1 m/s, 20° and 30°, and 6.7 Hz, 7.5 Hz, 8.3 Hz, respectively.



Fig. 4 Alignment equipment

'Poor alignment' was defined when fresh red peppers were accumulated or poorly conveyed.

### 5) Mechanical characteristics of fresh red pepper

A texture analyzer(TA-XT2i, Stable Micro Systems) was used to measure tensile strength and cutting resistance of fresh red pepper.

#### (1) Tensile strength

A chuck and a fixing device specially made were used to fix stalk and body of fresh red pepper. They were separated at the loading speed of 30 mm/min(ASAE S368.3). Two batches of 20 pieces of fresh red pepper with average moisture content of 84.9%, w.b., were measured.

#### (2) Cutting resistance

Cutting resistance of fruit stalk-calyx joint, and that of body were measured. Fresh red peppers were fixed using fixture block and two batches of 20 pieces of fresh red peppers with the average moisture content of 85.4%, w.b., were cut at the speed of 5 mm/min(ASAE S459). The width, angle of the wedge and the slit width for the cutting wedge were 3 mm, 80° and 3.3 mm, respectively.

#### (3) Coefficient of static friction

Red pepper was placed on an adjustable incline surface made of galvanized iron, rubber, plywood and acryl. The tangent of angle of the incline with the horizontal before the red pepper began to slip was taken as the coefficient of static friction. The value for the plywood was measured with the wood grain parallel to the motion of fresh red pepper. All the surfaces were cleaned using cotton cloth before each test run. The value was obtained from 25 replicates and the average moisture content of fresh red pepper was 85%(w.b.). The room temperature and relative humidity were 27°C and 85% inside the test room.

## RESULTS AND DISCUSSION

### 1. Measurement of geometric shape

Geometric shape of fresh red pepper was measured using 490 N sample of pepper. Average lengths of body, fruit stalk, bent part of body, bent part and straight part of stalk were 103.4 mm, 47.3 mm, 43.5 mm, 13.6 mm and 21.6 mm, respectively, showing large standard deviations. To define malformation, the ratio of BBL to BL and the one of BSL to SL were defined as the index of bent body and the one of bent fruit stalk, and found to be 0.47 and 0.32 in average.

Table 2. Geometric shape of fresh red pepper

| Item \ Size(mm) | BL    | SL    | BBL  | BSL  | SSL  | BBL/BL | BSL/SL |
|-----------------|-------|-------|------|------|------|--------|--------|
| Max.            | 180.0 | 144.0 | 125  | 67   | 76.0 | 3.33   | 3.20   |
| Min.            | 12.0  | 12.0  | 1    | 0.0  | 0.0  | 0.01   | 0.00   |
| Avg.            | 103.4 | 47.3  | 43.5 | 13.6 | 21.6 | 0.47   | 0.32   |
| S.D.            | 24.2  | 11.4  | 20.4 | 9.0  | 12.8 | 0.34   | 0.29   |

### 2. Cutting test to the determine the criterion index for malformed fresh red pepper

In table 3 is shown shape factors of fresh red peppers which were classified into 3 categories after peppers were passed through the cutting unit. The lengths of fruit stalk, straight part of fruit stalk and index of bent fruit stalk of fresh red peppers which were not cut were shorter by 6.4 mm and 4.6 mm, and larger by 0.16 than those of peppers which were cut. This explains that the length of fruit stalk and degree of bending of fresh red peppers that were put into cutting guide affect the cutting rate a lot. The degree of body bending did not affect much to the cutting of fruit stalk. The lengths of fruit stalk, straight part of fruit stalk, the index of bent fruit stalk and the one of bent body of fresh red peppers that were expelled out of cutting guide were shorter by 2.5 mm, 3.9 mm and larger by 0.15 and 0.18 than those of peppers that were cut.

Table 3. Shape factors of fresh red peppers classified into 3 categories

| Case \ Size (mm)  |      | BL    | SL   | BBL  | BSL  | SSL  | BBL/BL | BSL/SL |
|-------------------|------|-------|------|------|------|------|--------|--------|
| Cut fruit stalk   | Avg. | 108.9 | 50.2 | 38.5 | 10.5 | 24.8 | 0.40   | 0.22   |
|                   | S.D. | 21.8  | 3.7  | 5.9  | 2.5  | 3.8  | 0.18   | 0.07   |
| Uncut fruit stalk | Avg. | 108.4 | 43.8 | 42.6 | 14.9 | 19.9 | 0.42   | 0.38   |
|                   | S.D. | 16.8  | 2.5  | 5.2  | 2.5  | 2.2  | 0.07   | 0.05   |
| Expelled pepper   | Avg. | 98.8  | 47.7 | 52.0 | 15.7 | 20.6 | 0.58   | 0.37   |
|                   | S.D. | 18.0  | 3.0  | 6.0  | 3.3  | 1.6  | 0.14   | 0.07   |

As we have seen, the indexes of bent body and bent fruit stalk can be used as indexes to distinguish between malformed fresh red pepper and normal one; consequently, from observed data body and fruit stalk can be taken as malformed if the index of bent body and the one of the bent fruit stalk are more than 0.4 and 0.3, respectively. Based on this criteria, 47%, 40% and 20% of total fresh red peppers tested appeared malformed in body, fruit stalk, and in both of body and fruit stalk.

### **3. Effect of malformation factor on spreading unit**

Fresh red pepper was put onto the spreading unit and spreading state was observed and the required time to pass through the spreading plate was measured. In total of 9 test runs, poor spread was observed 6 times and 8 times in the cases of normal fresh red pepper and malformed one, respectively, showing poorer spread state in the case of malformed fresh red pepper. The required time to pass through the spreading unit was 3 to 4 seconds at 20° inclination of spreading plate, but the time increased to 5 to 7 seconds with increased feeding rate, i.e. showing more required time by 2 to 3 seconds.

### **4. Effect of malformation factor on alignment unit**

Fresh red pepper was put onto the alignment unit, and alignment state was observed, and the required time to pass through the alignment plate was measured. At 30° inclination angle of alignment plate and at the feeding rate of 0.06 m/s and 0.08 m/s, the required time for the malformed fresh red pepper was 7 to 8 seconds at 6.7 Hz, 11 to 14 seconds at 7.5 Hz, but 20 to 24 seconds at 8.3 Hz, i.e. showing more time by more than 10 seconds. At feeding rate of 0.1 m/s and frequency of 6.7 Hz, being the highest and the lowest, respectively, within the extent of this test, the required time to pass the alignment plate was about 20 seconds, i.e., being longer by 10 seconds.

## **5. Mechanical properties**

### **1) Tensile strength**

Tensile strength between fruit stalk and body was found to be 88.1 N, 50.7 N and 12.4 N for the maximum, the average and the standard deviation being high (Table 4).

### **2) Cutting resistance**

Cutting resistance of fruit stalk-calyx joint was found 92.1 N, 43.2 N, 15.8 N, respectively, for the maximum, the average and the standard deviation, respectively; while the one for body being

94.9 N, 60.5 N and 11.6 N, respectively (Table 4). The average resistance of body was higher by 2.8 N than the one of fruit stalk-calyx joint.

### 3) Coefficient of static friction

The average static friction coefficients on the surface of galvanized iron, plywood, rubber and acryl were 0.62, 0.3, 0.99 and 0.59, respectively, being the highest and the lowest on the surfaces of rubber and plywood, respectively.

Table 4. Tensile strength and cutting resistance of fresh red pepper

| Item | Tensile strength (N) | Cutting resistance (N) |      |
|------|----------------------|------------------------|------|
|      |                      | Stalk-Calyx joint      | Body |
| Max. | 88.1                 | 92.1                   | 94.9 |
| Min. | 32.2                 | 18.1                   | 40.9 |
| Avg. | 50.7                 | 43.2                   | 60.5 |
| S.D. | 12.4                 | 15.8                   | 11.6 |

Table 5. Static friction coefficient of fresh red pepper

| Surface<br>Item | Galvanized<br>Iron | Plywood | Rubber | Acryl |
|-----------------|--------------------|---------|--------|-------|
| Max.            | 0.78               | 0.40    | 1.19   | 0.75  |
| Min.            | 0.49               | 0.21    | 0.81   | 0.49  |
| Avg.            | 0.62               | 0.30    | 0.99   | 0.59  |
| S.D.            | 0.07               | 0.04    | 0.10   | 0.06  |

## CONCLUSIONS

The effect of physical properties of fresh red pepper on a developed fruit stalk remover was studied. The obtained results are as follows:

1. The maximum lengths of the body, the bent part of body, fruit stalk, the bent part and the straight part of fruit stalk for the fresh red pepper tested was found 180 mm, 125 mm, 144 mm, 67 mm and 76 mm, respectively.
2. The fresh red peppers with bending indexes more than 0.4 and 0.3 for body and fruit stalk, respectively, were defined to be malformed because they were not cut when put into the cutting unit. Based on this, among the total fresh red pepper tested, 47%, 40% and 20% were found malformed regarding the body, the fruit stalk, and for both of the body and the fruit stalk.
3. Malformed fresh red peppers showed poorer spreading state than normal ones at 10° incline, and

- much poorer at 20° incline with increased feed rate.
4. Malformed fresh red pepper showed very poor alignment with increased feed rate at 30° incline and 8.3 Hz.
  5. Maximum tensile strength between fruit stalk and body was 88.1 N. Maximum cutting resistances were 92.1 N and 94.9 N for the fruit stalk-calyx joint and the body, respectively.
  6. Average of static friction coefficients of fresh red pepper were 0.99, 0.62, 0.59 and 0.30 on the surface of rubber, galvanized iron, acryl and plywood, respectively.

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