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WATERMELON SURFACE ABRASION - A SENSORY METHOD

C. Puchalski[1], *G.H. Brusewitz*[2]

[1]Department of Agriculture Production Technology, University of Agriculture in Kraków, Ćwiklińskiej 2
35-959 Rzeszów, Poland
[2]Department of Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK 74078, USA

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Abstract. A sensory method to evaluate watermelon abrasion was developed on the basis of a 1 to 20 score by visual appearance and by feeling with the finger the surface of the scraped spot on the melon. Different abrasive surfaces produced failure associated with different layers of the watermelon surface. Linear relationships were found between the sensory score and absorbed energy per unit contact area, which were affected by the kind of abrasive surface.

Keywords: abrasion, friction, sensory, watermelon

INTRODUCTION

Abrasion is not only an important and useful description of a fruit's appearance but also an indication of water loss and the possible initiation of physiological changes [2,5]. Abrasion occurs during movement of one body against another leading to the removal of surface layers [4]. It is associated with the absorbed energy to remove a given volume of material below the point of tissue failure. This energy required for destruction of tissues may be the major factor to consider in evaluating abrasion and can serve as an accurate measure of abrasion. Sensory evaluation involves evoking, measuring, analyzing, and interpreting reactions to characteristics of food as they are perceived by the senses of sight, smell, taste, touch and hearing [9].

Sensory evaluation is used in conjunction with or instead of instrumental methods covering the entire range of food texture [11], but requires modification of the basic concepts for application to fruit quality. The ability of any method to evaluate quality depends on the terminology used, rating scales, procedures for evaluation, and frame of reference [1]. When the procedures are carefully specified and properly controlled, specific texture profile characteristics can be correlated with instrumental texture measurements to find the best correlation [10,12]. Such correlations are usually based on linear regressions. Since there is no information available about sensory evaluation related to fruit abrasion, it is necessary to develop a sensory method. The objectives of this study were to develop a sensory method to assess watermelon abrasion and correlate the results with a friction test.

MATERIALS AND METHODS

Two cultivars, 'Black Diamond' and 'Allsweet', were used because they represent the two different shapes of watermelon, i.e., round vs oblong. Twenty watermelons of each cultivar were harvested from the Oklahoma Vegetable Research Station at Bixby, OK, at their optimum maturity and checked by cutting open and looking at the color of the flesh after abrasion testing. The watermelons were hand picked, placed in padded cardboard boxes and transported 75 miles to campus for testing. The melons were allowed to equilibrate at 24°C and 65 % RH for 15 h before testing was begun.

Three abrasive surfaces were chosen having a range in roughness. The steel surface was the smoothest and hardest. Fabric belting material was more rough and considered 'medium' firmness. The rough side of a construction material, masonite, was used as a 'rough' material.

Abrasion testing was performed using a friction device (Fig. 1) connected to an Instron universal testing machine at a normal force of 100 N and sliding speed of 3.33 mm/s over a traveling distance of 0.8 m [6]. The force vs displacement relationship was used to determine failure threshold distance at the beginning of the abrasive process and absorbed energy during sliding as the area under the curve (Fig. 2) per unit contact area increase. The increase in contact areas was calculated as the difference between contact areas at the beginning and end of an abrasion test. After the friction abrasion test, the area on the melon was evaluated for size of the contact areas, amount of wax removal, and amount of skin removed. The area of contact between the melon and the abrasive surface was measured just before an abrasion test by inserting a pressure sensitive, reusable children's writing tablet between the two and applying pressure to form an imprint. The tablet was removed and the imprint of the contact area's boundary was traced onto thin paper. The size of the spots of wax and skin removed from the melon were hand traced and digitized for computer computation of area.

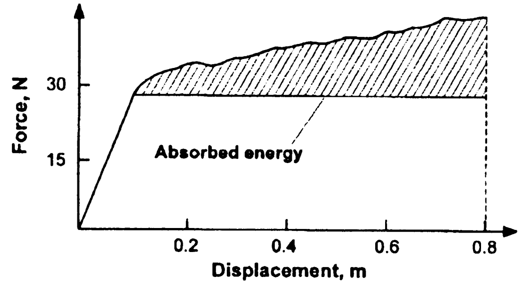

Fig. 2. Force - displacement chart from Instron.

The experimental design included two watermelon cultivars on six harvest dates with a

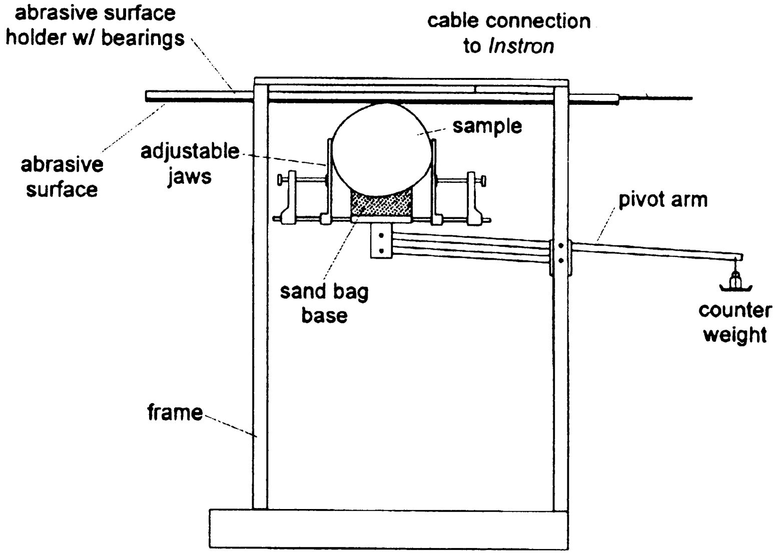

Fig. 1. A friction device.

masonite abrasive surface and three harvest dates for two other abrasive surfaces with three replicates of each. Data were analyzed using standard correlation and regression methods [3].

RESULTS AND DISCUSSION

Sensory scores

A sensory scoring system was developed from 250 abrasion tests on the basis of a 1-20 score recognizing different phases of surface failure (Table 1). The quantitative and qualitative changes of the surface involve the appearance of the wax, removing wax, removing first skin and then deeper layers of the sample. The morphology of watermelon surface was presented in the earlier work [6]. The assessment is obtained by visual appearance and by feeling the surface with the finger as performed on samples being in mechanical contact with rigid flat abrasive surface.

The changes in appearance of wax during abrasion was marked by smoothing of its surface and discoloration a few hours after the test. Discoloration could be produced by compression of the removed tops and smoothed wax asperities. For only slight appearance of some wax onto the abrasive surface is taken as a score of 1. Further failure of the sample was easily recognized by touching with the finger as the surface was pitted after the wax layer was removed. The total range in size of the removed wax spots from 19 to 332 was divided into the following, approximately equal in number, categories: small = 20-60 mm^2, medium = 60-120 mm^2, large = 120-160 mm^2, very large = more than 160 mm^2.

After reaching the skin resistance threshold [6], skin began to be removed, usually starting with a small point of about 5 mm^2 as marked with a score of 11 (Table 1).

The total range in area of removed skin from 6 to 618 was arbitrarily divided into the following categories: small pieces = less than 60 mm^2, medium pieces = 60-150 mm^2, large pieces = more than 150 mm^2.

Removed skin areas over 150 mm^2 reached layers deeper than skin.

After large pieces of skin were removed, the abrasive surface reached the outer mesocarp and caused further surface scratching which was marked with a score of 15 or 16. Marks on the abrasive surface tended to be

Table 1. Definition of sensory scores of watermelon abrasion

Score	Definition	Symbol*
1	Smooth wax surface or one with impressed lines	PSW
2	Slight discoloration of surface	SDW
3	Moderate discoloration of surface	MDW
4	Moderate discoloration with brown shades on surface	BDW
5	Extreme discoloration with strong brown color	EDW
6	Beginning of wax removal	BRW
7	Small area of wax removed as detected by finger	SRW
8	Medium area of wax removed as detected by finger	MRW
9	Large area of wax removed as detected by finger	LRW
10	Very large area of wax removed as detected by finger	VRW
11	Beginning of skin removal	BRS
12	Small pieces of skin removed	SRS
13	Medium size pieces of skin removed	MRS
14	Large pieces of skin removed	LRS
15	Large area of skin removed with a few scratches of outer mesocarp	FSM
16	Large area of skin removed with a lot of scratching of outer mesocarp	LSM
17	Beginning to remove tops of outer mesocarp	BRT
18	Large area of removed tops of outer mesocarp	LRT
19	Beginning of removing deeper layers of outer mesocarp	BRM
20	Large area of removed outer mesocarp	LRM

*first, second and third, respectively, indicates the size of abrasion, abrasion process and particular layer removed.

straight lines. Removing the top of the outer mesocarp led to smoothing of the surface which was detected by touching with the finger and assigned a score of 17-18. Still larger failure of the sample's surface associated with removal of the outer mesocarp was marked with a score of 19-20. The extensive degree of abrasion was observed as surface holes and changes in the surface of the outer mesocarp resulting in deep breaks in the sample surface and subsequently in rapid loss of water from the melon.

Correlations

Analysis of results were based on the increase in absorbed energy per unit contact area increase for different abrasive surfaces involving larger abrasion relating to higher sensory score values. Each different abrasive surface produced failures associated with different layers of the sample.

The masonite abrasive surface mainly caused skin removal and deeper layers at different levels as marked with scores of 11 to 20. To compare sensory evaluation with objective measurements, two parameters were introduced to determine large failures. The first parameter was the absorbed energy during sliding as obtained from the area under the force-displacement curve (Fig. 2) per unit contact area increase. This parameter indicates the energy required to first contact and then remove different layers of surface. The second parameter was a failure threshold distance [8] showing a linear relationship with r^2=0.99 between the beginning of the application of the abrasive process and the start of removing the skin. The relationship between those two parameters and sensory scores was linear with r^2 of 0.76 and 0.92 (Figs 3 and 4) and confirmed findings of Szczesniak [12]. Higher values of energy absorbed during sliding of the abrasive surface against the melon sample resulted in greater failure of the surface associated with its deeper layers (Fig. 3). However, a high failure threshold distance is associated with larger resistance of surface to abrasive as shown by a delay in the start of skin removal. As a consequence, sample failure was less associated with its surface layers (lower values of sensory score in Fig. 4). However, there was an increase in absorbed energy per unit contact area increase with failure threshold distance, as described by a power relationship with r^2 = 0.88 (Fig. 5). Small changes in failure threshold distance in the range of 20-40 mm produced large changes in absorbed energy.

The use of fabric belting as a abrasive surface sliding against the melon sample mainly caused only wax removal. The resulting scores ranged from 5 to 10. To compare sensory evaluation with objective measurements, the following two parameters were introduced for large failures; (1) absorbed energy per unit contact area increase and (2) the measured amount of removed wax area. The best relationship between those two parameters and sensory evaluation were linear, both having r^2 = 0.97 (Figs 6 and 7). Higher values of energy

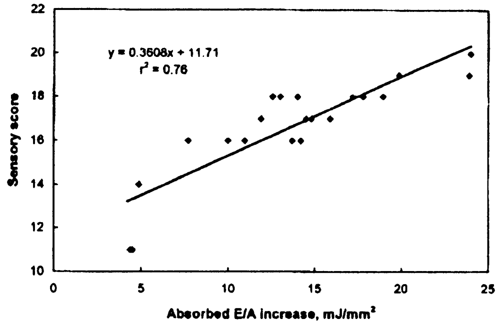

Fig. 3. Sensory score vs absorbed energy (E) per unit contact area (A) increase for both cultivars against masonite abrasive surface.

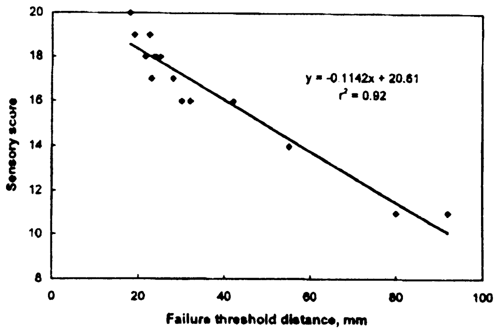

Fig. 4. Sensory score vs failure threshold distance for both cultivars against masonite.

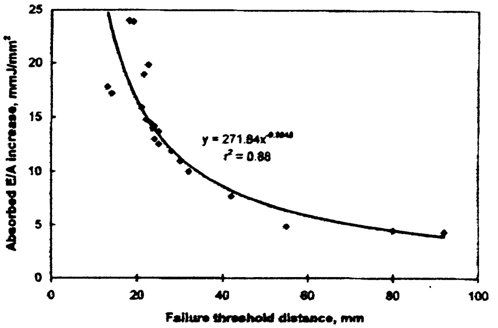

Fig. 5. Absorbed energy (E) per unit contact area (A) increase vs failure threshold distance for both cultivars against masonite abrasive surface.

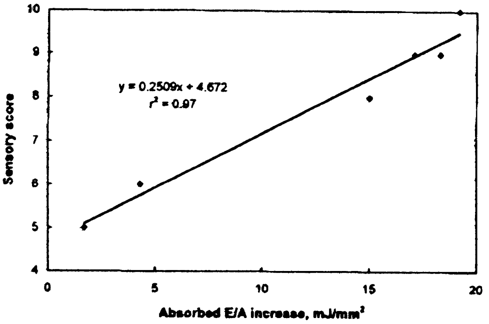

Fig. 6. Sensory score vs absorbed energy (E) per unit contact area (A) increase for both cultivars against fabric belting surface.

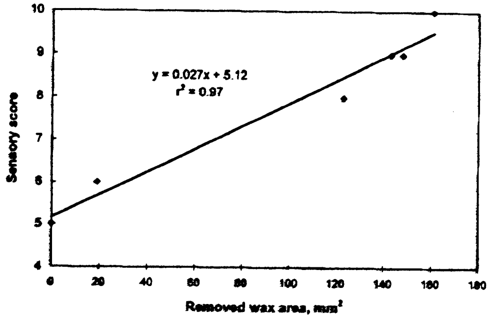

Fig. 7. Sensory score vs removed wax area for both cultivars against fabric belting surface.

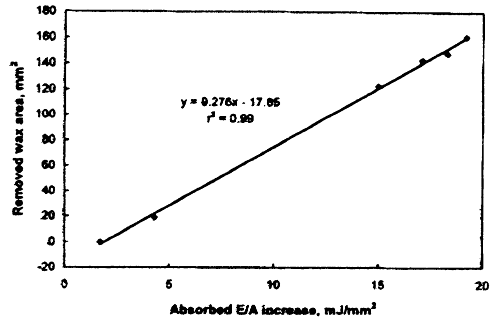

Fig. 8. Removed wax area vs absorbed energy (E) per unit contact area (A) increase for both cultivars against fabric belting surface.

absorbed during sliding of the abrasion surface against the melon sample caused more wax removal as indicated by high sensory scores.

A linear relationship having r^2=0.99 (Fig. 8) was found between the amount of wax area removed and the absorbed energy per unit contact area increase. With the fabric belting abrasive surface against a melon sample, the absorbed energy per unit contact area increased to more than 2 mJ/mm^2, which caused wax removal. This relationship could be used to predict the quantity of wax removed if the roughness characteristics of the abrasive surface is known.

The steel abrasive surface's sliding against the sample caused changes in appearance of the wax by smoothing and removing its asperities mainly by adhesion between the two surfaces. Between sensory score and absorbed energy per unit contact area increase there was a linear relationship with r^2 of 0.99 (Fig. 9). The absorbed energy in this case was larger than that found for the other abrasion surfaces, i.e., masonite and fabric belting. Absorbed energy per unit contact area generally increased, for the same sliding distance, depending on the particular abrasive surface producing different surface failure (Figs 3 and 9). The absorbed energy relating to the abrasive surface were: 2-19 mJ for fabric belting (removing wax), 5-24 mJ for masonite surface (removing skin and deeper layers) and 50-100 mJ

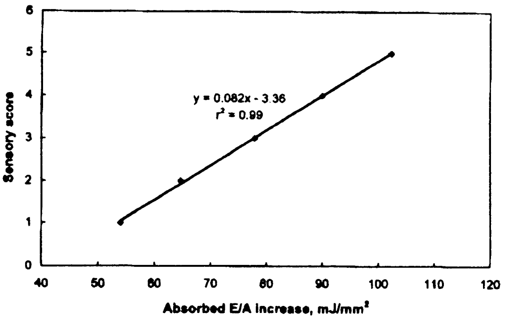

Fig. 9. Snesory score vs absorbed energy (E) per unit contact area (A) increase for 'Allsweet' against steel surface.

for steel abrasive surface (smoothing and discoloration of wax).

The higher amount of absorbed energy for the steel surface could be caused by more adhesion resulting from a physico-chemical process occurring while relative motion is made between steel and the melon's wax surface which was observed as a blue pigmentation on the melon and as larger cyclic changes in recorded friction force. The earlier study [7] found that average dynamic coefficient of friction for steel was higher than for fabric belting while the static coefficient was lower.

CONCLUSIONS

1. Sensory evaluation of abrasion was developed on the basis of a 1 to 20 score involving the appearance of the wax, the amount or removed wax and skin, and deeper layers of the watermelon. The score was obtained by visual ispection and by feeling the surface with the finger.

2. Different abrasive surfaces produced failure associated with different layers of the watermelon surface. The masonite surface mainly caused removal of skin and deeper layers, fabric belting caused wax removal, and the steel surface caused changes in appearance and smoothing of the wax.

3. The relationship between absorbed energy per unit contact area increase and sensory score was linear for masonite, fabric belting, and steel surfaces with r^2 of 0.76, 0.97, and 0.99, respectively.

4. A linear relationship was found between the wax removal area and absorbed energy per unit contact area increase with r^2 of 0.99.

5. The developed sensory method has the important advantages that it does not require costly instrumentation and can be performed on melon in the field.

6. Growers and handlers of watermelon could learn with minimal traning, how to do their own sensory abrasion testing and known it relates to a more sophisticated laboratory metodology.

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