EVALUATION OF EFFECTS OF HANDLING DEVICES ON SOME PHYSICAL AND MECHANICAL PROPERTIES OF FRESH TOMATOES.

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ABSTRACT

The effects of packaging and transport devices currently being used to handle fresh tomatoes between states were studied. Selected engineering properties of the fresh tomatoes were measured and assessed to ascertain the effects of the handling devices on the quality of the produce being delivered to the consumers. An experimental design (complete randomized) consisting of two types of vehicles and three packaging (basket) sizes were used in the study. Highlights of the results indicated that the vehicle types do not have any significant effects ($p < 0.05$) on the produce delivered to consumers. The packaging sizes, however, significantly ($p < 0.05$) affected the quality of tomatoes transported. The larger the sizes of the baskets, the better the quality of the contents at the destination. Several recommendations based on the findings were given in order to further improve the quality of the produce delivered to the consumers.

INTRODUCTION

Postharvest handling of fresh tomatoes especially the inter-state distribution in Nigeria deserves better attention if the product quality at the destination is to be ensured. Dry-season tomato(Roma variety) is grown mostly in the Northern parts of Nigeria under irrigation. The consumers,however, are scattered all over the country. Hence, the produce has to be handled through transportation and distribution to the consumers and this involves handling.

Like other horticultural crops, tomato has soft tissue, high moisture content varying from 70 - 90 percent (wet basis) and high rate of physiological activities such as respiration and transpiration which make it liable to rapid deterioration resulting in heavy losses during handling and storage (Aworh and Olorunda,1988; Oyeniran,1988; Singh and Singh,1992 and NSPRI,1991).

Losses as high as 50 percent are not uncommon from fresh fruits and vegetables between rural production and urban consumption in the tropics(Oyeniran,1988). A study in Nigeria also indicated that losses as high as 20 % in some cases occurred in fresh tomatoes, pepper and onions transported from the production areas in Northern Nigeria to some urban wholesale markets in the Southern parts of Nigeria (Olorunda and Aworh,1983). Identifying individual factors contributing to damage of these produce during transportation, it has been noted is at times difficult due to the varying nature of transport facilities (Erinle and Karikari,1988). Some of the likely factors identified include, physical properties of the produce, packaging materials transport devices and route characteristics (Oyeniran,1988; Villareal,1980; Olorunda and Aworh,1983).

It has been noted that boxes used in transporting tomatoes received greater vibrations during transportation than the produce (Singh and Singh,1992). The study also revealed that the firmness value of the tomatoes transported over a distance of 200 km decreased considerably when compared to untransported samples.

Kra and Bani (1988) observed that vibration and shaking of the truck led to compact packing of the produce in the baskets that further restricted ventilation. Findings indicated that above a threshold velocity of 5m/s, increase in bump height produced increase in average bruise volume in apples (Jones et al, 1991). The study revealed that lightly loaded trucks caused more damage to the produce than heavily loaded ones. The worst damage ,it was noted, occurred in the produce located behind the rear axle on the truck tray. Increase in food production, it has been observed is not the only goal in the food supply chain, but also how to get the food to the consumers in the state that it is desired (Olorunda and Aworh,1983). This definitely calls for proper handling.

Tomato distribution in Nigeria involves the use of local baskets woven from palm fronds as packaging materials. These baskets had been categorised into three sizes namely, small, medium and large sizes (Idah et al,1996). The types of vehicles used for the inter-state transportation of tomatoes were identified as Mercedes 911 lorry,Petrol tankers,Toyota (open) van and "Pick up" van (Idah et al, 1996).

To curtail the losses highlighted earlier requires designing appropriate handling devices. Further evolvement of such a design requires a proper knowledge of the physical and mechanical properties of the produce to be handled. As noted by Mohsenin (1970), the increasing economic importance of food materials (such as tomato) together with the complexity of modern technology for their production, handling, storage, processing, preservation, quality evaluation, distribution and marketing demands a better knowledge of the physical and mechanical properties of the materials.

The aim of this paper is to assess the effects of existing handling devices on the engineering (physical and mechanical) properties of the transported fresh tomatoes with focus on the inter-state movement of the produce so as to generate relevant data/information that can be used to conceptualise appropriate handling devices.

MATERIALS AND METHODS

Fresh tomatoes (Roma) were obtained from the study site at Ipata tomato wholesale market at Ilorin. During the study, fifteen(15) fruit samples were obtained from each of the basket sizes under each of the vehicle types. The vehicle types were the Mercedes 911 lorry and Petrol tanker, while the basket sizes were the small, medium and large sizes (Idah et al, 1996).

The sizes of the fruits were determined by measuring the three perpendicular axes H, H' and L herein referred to as major, minor and linear length respectively(Fig. 1), using vernier calliper (Mohsenin,1970). The mechanical properties of the produce were determined from a force-deformation curve plotted from a compression test.

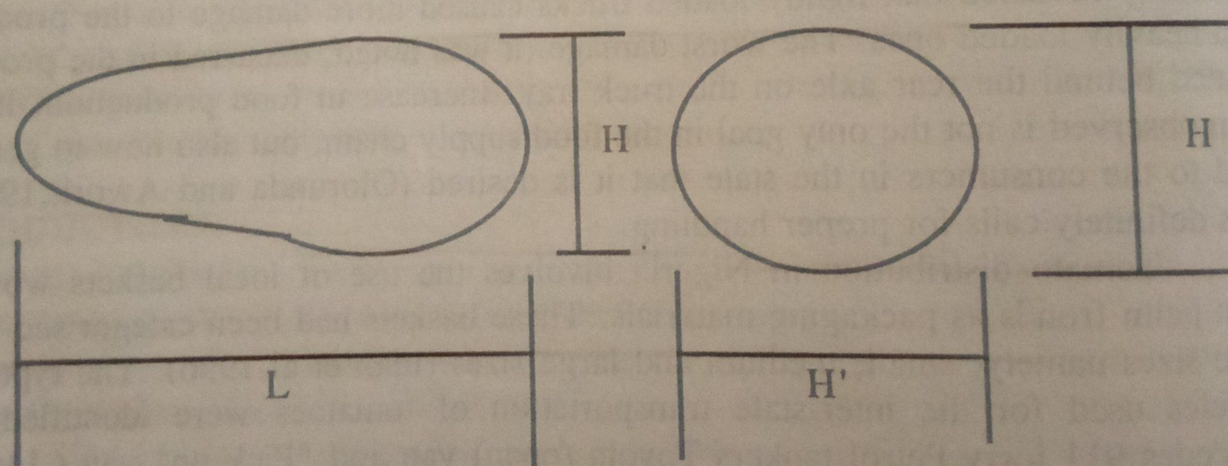

Figure 1. Dimensions of tomato fruit measured

Following the American society of Agricultural Engineer's standard S368.1 (ASAE, 1986), a triaxial compression testing equipment was adapted for the test in the absence of a universal instron testing machine with some set of modifications to give the desired results. The equipment is motor and gear driven and a drive speed of 1.5mm per minute was used for the test (Babatunde et al, 1988).

Deformation of fruits samples and the load causing the deformation were monitored on the dial gauge and stop watch. The load reading was monitored on the dial gauge attached to the load ring. Loading was discontinued after observing a continuous reduction in the load which signified that the tomato had ruptured.

From the force-deformation curve (Fig 2) and known formulae, the following Engineering properties were determined.

a) The fruit firmness value is defined as the slope of the linear force-deformation curve.

$$Q = \frac{F}{D}$$ (Olorunda and Tung,1985)

where, Q = fimness value, D = deformation, F = peak force (bio yield)

(b) The toughness value, T is defined as the total energy absorbed up to the rupture point as given by the area under the force-deformation curve.

$$T = 1/2FD$$ (Olorunda and Tung 1985)

where, the terms are as defined above

The fruit bioyield values were taken as the peak force (F) just prior to sudden decrease in force sustained by the fruit due to tissue rupture. Deformation was defined as distance (D) of the cross head traveled from the first contact with the tomato surface to the point of rupture (Fig. 2).

(c) The rupture stress was determined from

$$\delta = \frac{F}{A}$$

where, d = rupture stress (kN/m^2)

F = peak force

A = contact area between the compression tool and the convex bodies

$$A = \pi a^2$$

where a = radius of circle of contact given by

$$a^2 = \frac{D}{\frac{1}{R} + \frac{2}{d}} \qquad \text{(ASAE, 1986)}$$

where, D= elastic deformation

d= diameter of spherical indenter (compression tool)

R= average of the radii of convex bodies

(d) The modulus of deformability (E) is defined as

$$E = \frac{0.531F(1-\mu)}{D^{1/2}}\left[\frac{1}{R_1} + \frac{1}{R_1'} + \frac{4}{d}\right]^{1/2} \qquad \text{(ASAE, 1986)}$$

where, E = modulus of deformability (Pa)

F = bioyield force (i.e ½ peak force)

D = deformation (i.e ½ of the value)

D = diameter of spherical tool

m = Poisson's ratio

R_1, $R_1^!$ = radii of curvature of the contact. R_1, $R_1^!$ Were determined as follows

$$R_1 = \frac{H}{2}$$

$$R_1' = \frac{H^2 + \frac{L^2}{4}}{2H}$$

The statistical analysis of variance and Duncan multiple range test Ott (1977) were used to assess the effect of vehicle types and packaging sizes.

RESULTS AND DISCUSSION

The results of the measured physical and mechanical properties of the fresh tomatoes transported by the vehicle types are shown in Table 1. Mean values of the physical and mechanical properties measured under the two vehicles do not show any significant difference. In other words, the vehicle types do not seem to have any significant effects on the fresh tomatoes transported.

With regards to the packaging sizes, the result of the measured physical and mechanical properties under the three baskets size are shown in Table 2. The results showed that the mean values of major diameter, minor diameter, weight and volume of the fresh fruits packaged in different basket sizes were different. While the mean values of these parameters of tomatoes packaged in small and medium basket sizes were not significantly different ($p< 0.05$), those between small/medium and the large basket sizes were significantly different. The values of those packaged in large basket sizes are higher than those in small/medium basket sizes.

The mechanical properties of the produce assessed under the packaging sizes are shown in Table 2. The results of the firmness and toughness values of the samples packaged in small and medium basket sizes were significantly different. Tomatoes samples packaged in large baskets sizes were firmer than those packaged in small and medium basket sizes. The effect of vibration during transportation as related packaging material sizes could be used as a possible explanation.

Kra and Bani (1988) noted that vibration and shaking of the truck led to compact packing of produce in baskets that further restricted ventilation. Singh and Singh (1991) revealed that the packaging materials usually received more vibration than the produce inside them. Thus it is possible that the larger baskets by virtue of their sizes seem to absorb more vibration than the smaller ones. It thus seems that the produce in the smaller basket sizes are subjected to more compression and compaction which subsequently weaken the produce tissue. The results indicated that the larger basket sizes maintained better quality produce during handling and transportation compared to smaller ones.

As regards the rupture stress and modulus of deformability of the produce (Table2), the results showed that there were not significant difference ($p<0.05$) between mean values of these parameters for the samples packaged in medium and large basket sizes. However, the mean values of these parameters were significantly different ($p<0.05$) between the samples packaged in small basket sizes and those packaged in medium or large basket sizes. Rupture stresses of the samples packaged in large or medium basket sizes were higher than those packaged in small basket sizes. Similarly, the modulus of deformability of the samples packaged in large basket sizes were higher than those handled in small sizes. The results again showed that the larger basket sizes seem to protect and maintain better quality of the fresh tomato fruit compared to the smaller baskets during handling and transportation.

CONCLUSION AND RECOMMENDATIONS

The results of the study provided some useful information about the existing handling and transport devices in the inter-State fresh tomato transportation. While the existing handling and transport devices showed some remarkable performances in handling the fresh produce, there are however, areas (such as provision of lids to ease stacking and handling) that needed modifications for further improvement.

From the assessment of the handling devices using the Engineering properties of the produce as a measure of quality, the vehicle types used in transporting these produce seem not to have any significant effects on these quality parameters. If they do, they do so equally as indicated by the results. On the other hand packaging materials significantly affected these assessed parameters. The large basket sizes seem to perform better on preserving the quality of the fresh tomatoes during handling than the smaller sizes as far as the existing handling systems are concerned.

Hence, in the absence of any other alternative packaging containers, the large basket sizes of the three categories of the existing packaging baskets for fresh tomatoes in the inter-State handling should be encouraged. Provision of lid and handles (modification) on the baskets will ensure better handling and stacking inside the vehicle. It is suggested that quality assessment of the produce at the origin and destination should be carried out to ascertain the overall effect of transportation on the produce quality. This was not possible in this studies due logistic problem involved in moving the equipment involved to the field, however, precautions were taking at the loading points such that all the containers were loaded under the same conditions.

Table 1. Some measured Physical and Mechanical Parameters of fresh tomatoes transported by different vehicles.

	Mercedes 911		Petrol Tanker	
Measured Parameters	Average	Coeff. of Variation	Average	Coeff. of Variation
Major diameter(mm)	40.26a	0.14	41.17a	0.16
Minor diameter(mm)	38.36a	0.13	38.61a	0.17

Length (mm)	56.30a	0.13	54.50a	0.19
Weight (g)	46.29a	0.32	48.22a	0.38
Volume x 10^{-5}(m^3)	4.79a	0.31	4.88a	0.40
Firmness value(N/mm)	1.48a	0.30	1.67a	0.26
Toughness value(joules)	193.28a	0.58	181.96a	0.50
Rupture Stress(kN/m^2)	86.29a	0.29	80.64a	0.24
Modulus of deformability(Pa)	155.09a	0.29	141.07a	0.26

Note: Means with the same letter for the measured properties (on the row) are not significantly different at $p < 0.05$ using Duncan' Multiple range test.

Table 2. Some measured Pysical and Mechanical Parameters of fresh tomatoes packaged in different packaging basket sizes.

	Small size		Medium size		Large size	
Measured parameters	Average	CoV	Average	CoV	Average	CoV
Major diameter(mm)	39.14b	0.16	39.91b	0.11	43.10a	0.15
Minor diameter(mm)	36.72b	0.16	37.96b	0.13	40.77a	0.14
Length (mm)	55.05a	0.13	56.10a	0.14	55.13a	0.22
Weight(g)	42.65b	0.36	45.88b	0.32	55.23a	0.34
Volume x 10^{-5}(m^3)	4.12b	0.37	4.64b	0.48	5.53a	0.36
Firmness value(N/mm)	1.25b	0.31	1.43b	0.26	2.06a	0.29
Toughness value(joules)	165.46b	0.56	182.65b	0.52	228.23a	0.50
Rupture stress(kN/m^2)	73.32b	0.27	84.93a	0.25	92.15a	0.26
Modulus of deformabilty(Pa)	131.87b	0.25	153.41a	0.29	158.97a	0.25

Note: Means with the same letter for measured properties (on the row) are not significantly different at $P < 0.05$ using Duncan's multiple range test.
CoV = Coefficient of Variation

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