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TIGHT-FILL TOMATO PACKAGING STUDIES

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SUMMARY

Four seconds of vibration was found adequate for settling tomatoes in a tight-fill package. Vibration settling for longer than 6 sec bruised coloured tomatoes.

Tomatoes in tight-fill packages carried as well as in loose-fill packages. The reduction in fruit movement with the tight-fill packages was not important in reducing fruit bruising under the transport conditions tried.

The tight-fill package held 25% more fruit than the loose-fill package, and a good full appearance of the package was obtained.

I. INTRODUCTION

The Queensland tomato industry prior to 1968 was using two principal packing methods, viz. pattern packing and loose-fill packing, for marketing of tomatoes. Pattern packing is the accurate size grading of fruit and packing into containers by hand in layers in a definite pattern to give a specific count. Schoorl (1968*b*) reported on loose-fill packing investigations of tomatoes in comparison with pattern packing. In the loose-fill pack fruit is randomly poured into a container, which is filled to a specific weight regardless of the position of the fruit in the container. The loose-fill pack reduced packing time and obviated the necessity for the skilled packers required for pattern packing. However, 21·6% less fruit was packed in the container.

A new pack called tight-fill was described by Mitchell *et al.* (1968). This pack was reported to reduce transit injury of tomatoes, mechanization of fruit packing was possible and higher net weights were packed than by the loose-fill method. Tight-fill consists of filling the containers with sized fruit to a given weight, settling the fruit in the container by vibration, and closing the lid. The pack has been adapted to a range of fruits, namely pears and stone fruit, and when properly done there is little opportunity for fruit movement in transit.

Guillou (1963) and Mitchell (1968) have reported on the optimum vibration settling conditions for pears and plums. These were a vibration frequency of 800–1100 cycles per minute with a stroke of $\frac{1}{4}$–$\frac{5}{16}$ in., settling time of 5–10 sec and a pressure of 10 lb/sq ft. The settling sequence consists of a short period of free vibration, during which motion is imparted to all fruit within the container, followed by a short period of vibration with a light top pressure.

Injury of tomatoes has been studied by Miles (1969). Tomatoes were subjected to slow increase in pressure and fruit damage was caused by increased tension on the side walls. Mitchell *et al.* (1968) and Mohsenin (1970) reported on damage to fruit and vegetables by pressure, impact and vibration. Guillou, Sommer and Mitchell (1962) and Schoorl (1968*a*) reported on the evaluation of packages on their reaction to transport hazards.

II. MATERIALS AND METHODS

Experiments.—Three experiments were conducted as follows.

Experiment I, which was conducted during August 1968, was designed factorially to find out how the amount of fruit bruising would be affected by three stages of fruit maturity (green, slightly coloured, and fully coloured) and three times of vibration (3, 6 and 12 sec). Only fully coloured fruit were submitted to the 3 sec vibration treatment. Treatments were replicated five times.

Experiment II, which was conducted during June 1970, was designed to compare two packing methods (loose-fill and tight-fill in packages 18 in. x $11\frac{7}{8}$ in. x $6\frac{1}{2}$ in.) under two transport treatments (stationary control and rail transport from Brisbane to Sydney and return) with 10 replicates.

Experiment III, which was conducted during August 1970, compared three container packs (18 in. x $11\frac{7}{8}$ in. x $6\frac{1}{2}$ in. loose-fill, 18 in. x $8\frac{3}{4}$ in. x $7\frac{1}{8}$ in. tight-fill, and $16\frac{3}{8}$ in. x $10\frac{1}{4}$ in. x 7 in. tight-fill) under two transport treatments (stationary control and rail from Brisbane to Rockhampton and return) with four replicates.

Tomatoes.—The tomatoes for the experiments were obtained from the Rocklea packing house of the Committee of Direction of Fruit Marketing. The fruit was a commercial sample taken from the packing house after sorting and size grading.

Containers.—All the cartons used in the experiments were of telescopic design. In preliminary trials the 18 in. x $11\frac{7}{8}$ in. x $6\frac{1}{2}$ in. container designed to hold 24 lb loose-fill was found to hold 30 lb tight-fill and it was filled to these weights in the main investigations. The containers measuring 18 in. x $8\frac{3}{4}$ in. x $7\frac{1}{8}$ in. and $16\frac{3}{8}$ in. x $10\frac{1}{4}$ in. x 7 in. had cubic capacities suitable for 24 lb tight-fill. These capacities were chosen as they held the commercially accepted net weight for a selling unit of tomatoes. The $16\frac{3}{8}$ in. x $10\frac{1}{4}$ in. x 7 in. container was designed to keep cost down and to permit efficient stacking on a pallet 46 in. square.

Settling of pack.—A vibrator similar to the one described by Guillou, Sommer and Mitchell (1962) was used for vibration settling of tomatoes. The vibrator was constructed by mounting a table on soft springs, and a counterweight on a revolving shaft vibrated the table. The shaft was driven by a V-belt from a 2 h.p. variable speed D.C. motor. The vibration frequency was measured by a revolution counter. The vibration amplitude (stroke) was determined by holding a pencil against a card fastened to the side of the vibrating table and measuring the figure that was traced.

All tight-fill cartons were vibration settled by vibrating at a frequency of 1 000 cycles/min at ¼ in. stroke. Cartons were vibrated upside down so as to give a level full appearance of the package when opened the right way up.

Transport.—The transport treatments (Brisbane to Sydney and return, and Brisbane to Rockhampton and return) involved transport distances of 1 000 miles and 8–10 handling operations; these conditions could be considered normal in the handling of most Queensland tomatoes.

Tomato damage determination.—Tomatoes were checked for flesh deformation damage and cracking 1 day after the transported fruit had returned to Brisbane. Flesh damage was determined by assessing the amount of softening, discoloration and change of shape of the tomatoes. Damage areas greater than ¾ in. were recorded.

III. RESULTS AND DISCUSSION

(a) Vibration Settling

The increase in bruising after vibration settling is shown in Figure 1. It was calculated by subtracting the percentage bruising of the control non-vibrated fruit from that of the vibration settling treatment in experiment I.

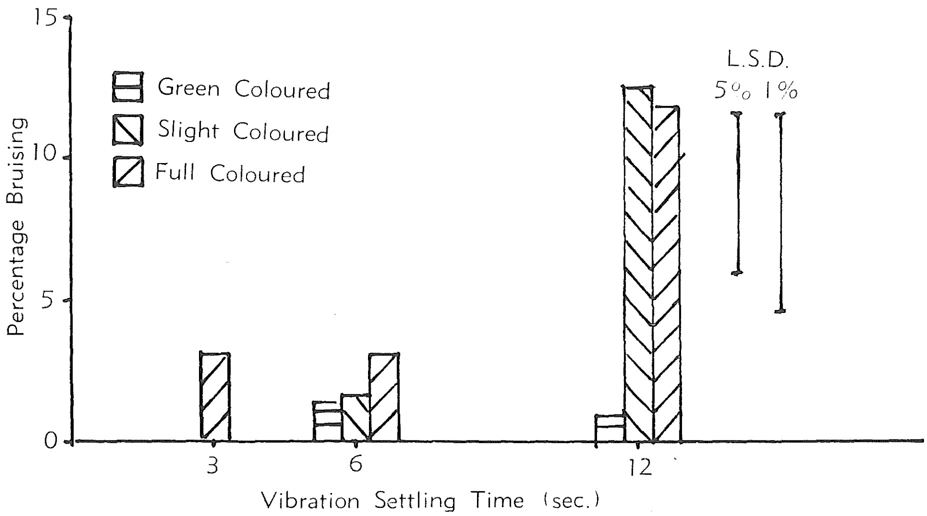

Fig. 1.—Incidence of bruising in vibration settled tomatoes.

Coloured fruit were more susceptible than green fruit to injury from vibration settling. The increased time of settling, from 6 to 12 sec, caused a significant increase in bruising in only the coloured fruit.

Fruit could be adequately settled with 4 sec of vibration.

(b) Effect of Transport

The effect of transport to Sydney and back to Brisbane, and to Rockhampton and back to Brisbane, on bruising of loose-fill and tight-fill tomatoes is shown in Tables 1–3.

TABLE 1

EFFECT OF TRANSPORT AND PACKING ON BRUISING OF TOMATOES

Mean percentage of severely bruised fruit

Treatment	Bruising (%)
No transport	7·69
Transport	16·19
Loose-fill	11·85
Tight-fill	12·03
Necessary differences for significance 5%	4·08
Necessary differences for significance 1%	5·47

TABLE 2

EFFECT ON BRUISING OF POSITION IN CONTAINER

Bruised fruit as percentages of total numbers of fruit in the layer

Position	Bruising (%)
Top	5·81
Middle	9·83
Bottom	20·18
Necessary differences for significance 5%	3·12
Necessary differences for significance 1%	1·15

TABLE 3

EFFECTS OF CONTAINER, PACKING AND TRANSPORT ON BRUISING

Equivalent mean percentage for bruising after inverse sine transformation

Pack	Transport	
	1 000 Miles	Nil
Loose-fill—18″ x $11\frac{7}{8}$″ x $6\frac{1}{2}$″ ..	18·68	0·18
Tight-fill—18″ x $11\frac{7}{8}$″ x $6\frac{1}{2}$″ ..	17·98	1·07
Tight-fill—$16\frac{3}{8}$″ x $10\frac{1}{4}$″ x 7″ ..	19·09	3·55

Transport ≫ Control.

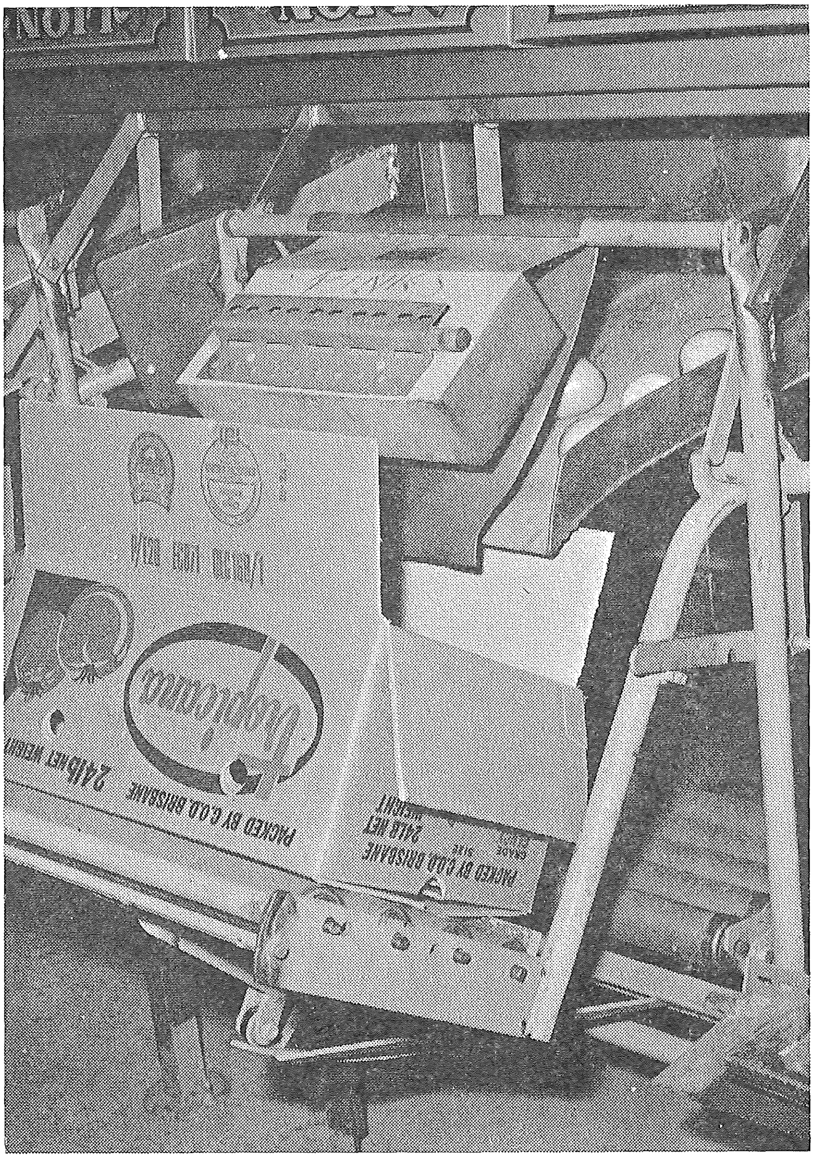

Fig. 2.—Semi-automatic mechanical weight fillers for weighing tomatoes in fibreboard cartons.

Fig. 3.—Vibrator used for settling tomatoes in fibreboard cartons.

Bruising of tomatoes in all packs was significantly increased by transport. The shape of the bruises on the tomatoes was relatively deep in relation to width. The bottom layers of the pack suffered more bruising than others.

The causes of bruising by transport may be static load, impact and vibration. The type of bruising may be used to indicate the cause of damage.

Mohsenin (1970) reported that bruises from static load were shallow, whereas bruises from impact were deeper and had a greater depth to diameter ratio than bruises from static load. Arrivo (1968) reported that most bruising occurred on the bottom layers of impacted apple boxes. O'Brien *et al.* reported that bruising from vibration occurred predominantly on the top layers of fruit in the package.

In the experiments reported here, the main cause of bruising during transport was considered to be impact occurring when boxes were handled in loading and unloading operations. This is because the bruises were deep and the bottom layers of the pack were more bruised.

No difference in bruising was apparent between loose-fill and tight-fill packs in any of the container treatments that were transported.

Mitchell (1968) reported that vibration settling prevented loosening of the pack and that fruit remained immobilized during transit. This tightness of pack was reported to reduce vibration and compression bruising. The results of these trials are not in accord with Mitchell's findings as they show no reduction in fruit injury by tightening the pack.

(c) Commercial Application

The results of these investigations have been in commercial application since 1970 at the Rocklea packing plant of the Committee of Direction of Fruit Marketing. The tomato packing plant uses mechanical fillers (Figure 2) and a vibrator (Figure 3) and a throughput of 4 000 tight-fill tomato packages per day is possible. Container cost is reduced because a tight-fill pack contains 25% more fruit by weight than a loose-fill pack. The appearance of the pack is improved because it seems to be better filled than the loose-fill.

IV. ACKNOWLEDGEMENT

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