# The influence of tablet weight on compaction pressure/tablet density relations

The compaction of different weights of lactose or Trudex (anhydrous dextrose obtained from starch) in the same diameter die, has been shown to result in tablets whose tensile strength is determined only by the compaction pressure (Newton, Rowley & others, 1971; Newton, Rowley & Fell, 1972). This implies that a similarity in structure exists within the different sizes of tablets. The relative density of the tablets of lactose and Trudex, prepared with 1·27 cm diameter flat faced punches as described previously (Newton & others, 1971, 1972), was calculated from the tablet dimensions (determined to ±0·005 mm), tablet weight (determined to ±0·0001 g) and material density (determined by a helium pyconometer). For each tablet weight, the relative density of the tablet was found to be related to the log of the mean compaction pressure used to form the tablets. The relations involved, calculated as described by Newton & others (1971) are given in Table 1. It was also found possible to obtain a linear relation between the log of the mean compaction pressure and the relative density of tablets, prepared from two different weights of Trudex with 1·27 cm diameter deep concave punches, as described by Newton & others (1972). The relative density of the convex tablets could be calculated because comparison of the magnified image of the convex tablets with that of a casting taken from the concave punches established that, irrespective of the tablet weight and applied pressure, the tablets retain the curvature of the punch from which they are formed. Hence changes in tablet thickness which occur with the application of pressure are associated with changes in the central cylindrical and not the convex region of the tablet. This allows the calculation of the tablet volume, apparent density and relative density, from the radius of curvature of the convex portion, the height of the convex section, the central diameter, the tablet thickness and weight. For each of the materials, these regression lines did not differ significantly when different quantities were compressed into tablets (see Table 1). This is somewhat surprising in view of the differences in density which can exist within tablets (Train, 1956). The thickness to diameter ratio for the flat-faced tablets ranges from 0·17 for the most compacted low weight tablet to 0·540 for the least compacted high weight tablet and hence covers the normal range of pharmaceutical tablets. The findings have certain theoretical implications.

For two weights of powders, $W_1$ and $W_2$, the relations state that the relative densities are equal, both at the initial conditions and after compaction at an equal mean compaction pressures. Hence we can write: $W_1/V_{i_1} = W_2/V_{i_2}$ and $W_1/V_{f_1} = W_2/V_{f_2}$

Table 1. *Linear regression equations relating log mean compaction pressure (M.C.P.) and the relative density [apparent tablet density/material density = R.D.] of 1·27 cm diameter flat faced lactose and Trudex tablets and 1·27 cm diameter deep convex Trudex tablets.*

| Type of tablet | Tablet Weight g | Number of tablets | Range of mean compaction pressure pressure MN m⁻² | | Linear regression equation relating mean compaction pressure and relative density of tablet | Correlation coefficient r |
|---|---|---|---|---|---|---|
| | | | Minimum | Maximum | | |
| Lactose Flat | 0·4 g | 48 | 38·8 | 316·2 | R.D. = 0·2078 Log M.C.P. + 0·4246 | 0·9878 |
| | 0·6 g | 48 | 15·6 | 321·5 | R.D. = 0·2021 Log M.C.P. + 0·4413 | 0·9987 |
| | 0·8 g | 83 | 21·6 | 320·7 | R.D. = 0·1985 Log M.C.P. + 0·4480 | 0·9914 |
| | 1·0 g | 70 | 24·0 | 307·1 | R.D. = 0·2118 Log M.C.P. + 0·4213 | 0·9866 |
| Trudex Flat | 0·6 g | 61 | 22·6 | 298·6 | R.D. = 0·2610 Log M.C.P. + 0·2954 | 0·9957 |
| | 0·8 g | 87 | 22·5 | 298·0 | R.D. = 0·2538 Log M.C.P. + 0·3118 | 0·9868 |
| | 1·0 g | 45 | 29·9 | 298·2 | R.D. = 0·2670 Log M.C.P. + 0·2810 | 0·9777 |
| Trudex Deep concave | 0·8 g | 70 | 34·4 | 220·6 | R.D. = 0·2642 Log M.C.P. + 0·3042 | 0·9891 |
| | 1·0 g | 58 | 54·8 | 200·0 | R.D. = 0·2739 Log M.C.P. + 0·2824 | 0·9849 |

where $V_1$ and $V_2$ are the volume of the compacts produced from $W_1$ and $W_2$ respectively and the subscripts i and f represent initial and final conditions. At the pressures used, no change in tablet diameter was detected, hence because the same diameter die was used to produce the tablets, changes in volume can be considered to be caused by changes in compact length $l$. Thus we can write:— $W_1/l_{i1} = W_2/l_{i2}$ (1) and $W_1/l_{f1} = W_2/l_{f2}$ (2). Combination of (1) and (2) yields $l_{i1}/l_{i2} = l_{f1}/l_{f2}$ (3). The equation (3) is obtained in spite of the different punch travel which exists for the different quantities of powder (Newton & Rowley, 1972). The relation expressed above can therefore only exist if: (*a*) the length of the compact at pressure is proportional to the quantity of the material compacted; and (*b*) the amount of elastic expansion on the release of pressure is proportional to the length of the compact at pressure.

These conditions can be expressed by $l_{p1}/l_{i1} = l_{p2}/l_{i2}$ (4) for condition (*a*) where $l_p$ is the length of the compact at pressure, and, the numerical subscript indicates the powder weight, and $l_{e1}/l_{p1} = l_{e2}/l_{p2}$ (5) for condition (*b*) when $l_e$ is the length of elastic expansion of the compact on the release of pressure and the numerical subscript indicates powder weight.

If these conditions hold, we can write:—

$$\frac{l_{i1}}{l_{i2}} = \frac{l_{p1}}{l_{p2}} = \frac{l_{e1}}{l_{e2}} = \frac{l_{p1} + l_{e1}}{l_{p2} + l_{e2}} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

The final length of the compact is $l_p + l_e$

Hence

$$\frac{l_{p1} + l_{e1}}{l_{p2} + l_{e2}} = \frac{l_{f1}}{l_{f2}} = \frac{l_{i1}}{l_{i2}} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

This suggests that the compaction system can be described by two moduli which are characteristic of the material. The first can be described as an apparent compression modulus D where $l_i\text{-}l_p/l_i = \sigma/D$ where $\sigma$ is the applied mean compaction pressure, and the second an apparent expansion modulus E, where $l_e/l_p = \sigma/E$.

In practical terms, for the two materials tested, over the mean compaction pressures (see Table 1), the findings predict that compaction by the same pressure, of different weights of the same material, in the same diameter die will result in a compact whose thickness is proportional to the quantity of material compacted. Conversely, if two compacts of the same diameter have thicknesses whose ratio is equal to that of their weights, they have been compacted to the same pressure.

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