DRUG DEVELOPMENT AND INDUSTRIAL PHARMACY, 15(1), 133-145 (1989)

LINEAR RELATIONSHIP BETWEEN TABLET PROPERTIES IN SYSTEMS COMPRESSED DIRECTLY UNDER FIXED COMPRESSION FORCE

Udeala and Aly (1) proposed a model showing a linear relationship between certain physical properties of vitamin B_1 tablets compressed under fixed pressure. It was found that the minimum concentration of a given vehicle or blend of vehicles required to obtain a compressible mix was not less than 79% w/w. Harder and less friable tablets were obtained for batches formulated with higher concentration of a given vehicle. The data derived from the study (1) and those of others (2) indicate similar trend. It was shown that the relationship between hardness, H and vehicle concentration, C may be given by (1)

$$\text{Log } H = \text{Log } H_o - 1/C \qquad \text{Eq. 1}$$

where H_o and K are absolute hardness of the compact ($\epsilon = 0$) and the slope of the linear curve, log H vs I/C. According to these investigators (1) K equals $1/P_f$ where P_f is the packing fraction of the vehicle used. These authors further stated that Eq. 1 was found valid and applicable to the data obtained by Sakr et al (2). Apparently, data obtained by different investigators (1-2) presented in Table 1, conform to the relationship expressed by Eq. 1. However, the mathematical approach by Udeala and Aly (1) is not convincing. Besides, the suggestion that K equals I/P_f is questionable. Udeala and Aly (1) had derived their expression from the empirical formula of Duckworth which is

$$\log H = \log H_o - K/2.303 \qquad \text{Eq. 2}$$

where H and H_o are the hardness of the compact of porosity ϵ and absolute hardness at $\epsilon = 0$ respectively. On the basis of this expression, Fig. 1 does indeed show that those tablets compressed with higher concentration of a given vehicle which are harder and also less porous. Thus, porosity would seem to be related to

Table 1: Effect of Varying Concentrations of Named Vehicles on Hardness and Friability of Different Directly Compressed Tablets

Vehicle Name	Conc.% w/w	Hardness* MNm^{-2}	Friability Loss % w/w
		Udeala & Aly (Vitamin B_1)	
Avicel	79.60	12.76	2.26
	85.29	16.92	1.19
	88.29	19.06	0.85
	90.46	21.26	0.474
AHL USP	79.60	3.089	16.31
	85.29	5. 63	3.86
	88.29	7.53	1.09
	90.46	9.14	0.57
		Sakr & Others	
Celutab[x]	16.30	0.53	6.13
	28.00	1.35	3.76
	36.80	1.95	3.00
	43.60	2.15	2.60
	49.00	2.25	2.09
Emcompress	19.60	4.18	4.14
	32.70	4.45	3.58
	42.00	4.48	2.89
	49.00	4.60	2.48

*Erweka units for batches obtained after Sakr et al

x Data obtained after Sakr et al, Pharmazie, 35, 164 (1980).

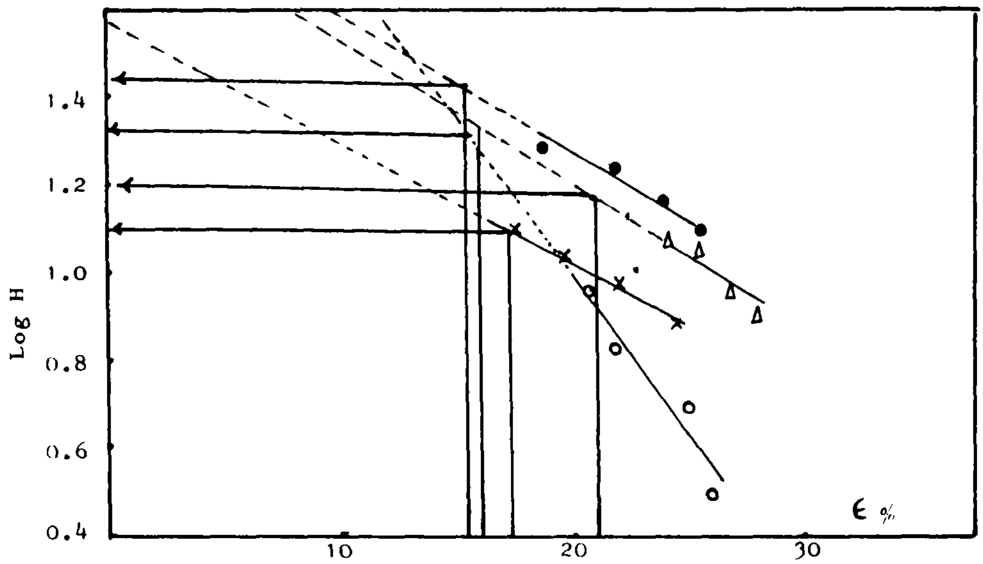

Fig. 1. Log Hardness log H, vs porosity ε % for Thiamine Hcl Tablets compressed with varying concentrations of ● Avicel, Δ Celutab X Emcompress and O Anhydrous lactose under constant compression force.

the vehicle concentration, C. This may be expressed as

$$\varepsilon = A + X/C \qquad \text{Eq. 3}$$

where A and X are constants. A plot of ε vs I/C using the data reported earlier (1) is shown in Fig. 2. The value A according to Fig. 2, would represent the porosity of a compact compressed with infinite concentration

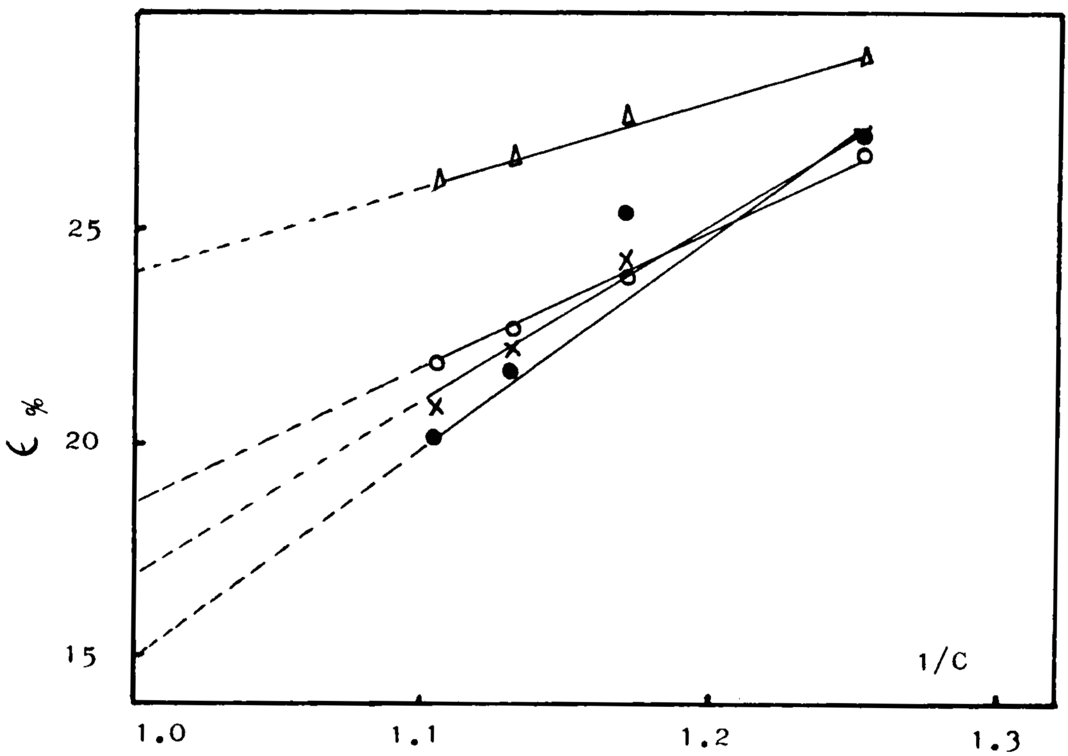

Fig. 2 Porosity ε %, as a Function of Reciprocal concentration 1/C for Thiamine Hcl Tablets Compressed Directly under fixed compression force

Key: See Fig. 1

of a given vehicle. This is an imaginary value since no compact can practically be compressed with infinite concentration of the vehicle under consideration. It is known that porosity is pressure dependent rather than vehicle concentration dependent (3). This may strictly apply if the vehicle concentration is fixed. Porosity may be concentration dependent where the concentration is being varied and compression force is constant. Also, the absolute hardness of the compact (at $\epsilon = 0$) is an extrapolated value (3) and is practically impossible to obtain. On the basis of these considerations it may be reasonable to consider A as the porosity of the compact compressed with 100% w/w of a given vehicle. A decrease in vehicle concentration would increase the porosity at a fixed compression pressure. Thus, Eq. 3 may be re-written as

$$\epsilon = \epsilon_{100} + X/C \qquad \text{Eq. 4}$$

Table 2 shows the least square fit of on I/C using the data presented in table 1. Expressing Eq. 2 and 4 in terms of porosity, yields.

$$\log H = \log H_o - \frac{K}{2.303}(\epsilon_{100} + X/C) \qquad \text{Eq. 5}$$

or

$$\log H = \log H_o - \frac{K\epsilon_{100}}{2.303} - \frac{KX}{2.303C} \qquad \text{Eq. 6}$$

Equation 2 shows that the term $(\log H_o - \frac{K\epsilon_{100}}{2.303})$ reduces to $\log H_o$ at 100% w/w vehicle content.

Thus,

$$\log H = \log H_{100} - \frac{KX}{2.303C} \qquad \text{Eq. 7}$$

Table 2: Least Square Fits of on 1/C for Directly Compressed Vitamin B_1 Tablets

Vehicle	A	100 (%)	x (Slope)	Corr. Coeff.
Avicel	- 0.41	13.90	0.55	1.078
AHL	- 0.040	17.03	0.211	0.9365
Celutab	-	-	-	-
Emcomp.	- 0.26	15.00	0.41	1.0979

The least square regression of log H on I/C for thiamine hydrochloride tablet batches tested is given in Table 3. It can be seen that the intercept does not equal log H_o. The slope is neither equal to K/2.303 nor the reciprocal value of P_f of the vehicle used as suggested earlier (1). The intercept should give the value of log H_{100}. The value of H_{100} calculated from Figs. 1 and 2 is indentical with that obtained from a plot of log H vs I/C. (Fig. 3).

The relationship between friability, F of thiamine hydrochloride tablets and vehicle concen-

Table 3: Least Square Fits of log H on 1/C and log F on 1/C for Thiamine Hcl Tablets Compressed Directly with Named Vehicles

Vehicle	Log H on 1/C				Log F on 1/C			
	Log H	Log H_{100}	Slope	Corr. Coeff.	Log F	Log F_{100}	K_f	Corr. Coeff.
Avicel	3.03	1.49	1.538	0.936	-6.99	-2.69	4.3	0.976
AHL	4.877	1.36	3.52	1.020	-	-	-	-
Celutab	-	-	-	-	-6.29	-2.72	3.57	1.0197
Emcompress	1.94	1.14	0.80	0.925	-3.49	-2.06	1.42	0.85

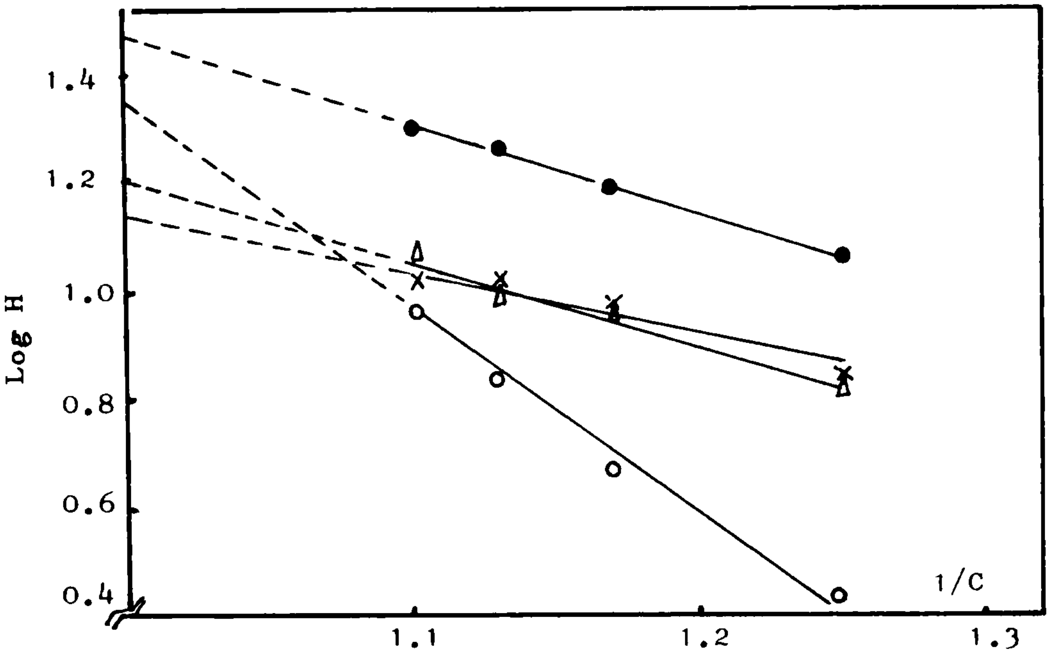

Fig. 3. Log H vs 1/C Plot for Thiamine Hcl Tablets compressed Directly with Different Direct Compression vehicles under constant compression force.

Key: See Fig. 1

tration, C reported by Udeala and Aly (1) should be corrected to satisfy the expression.

$$\log F = A + K_f/C \qquad \text{Eq. 8}$$

The equation derived initially (1) was

$$\log F = \log F^o - K_f.C \qquad \text{Eq. 9}$$

where F^o was given by the investigators (1) as the friability of the compact compressed with

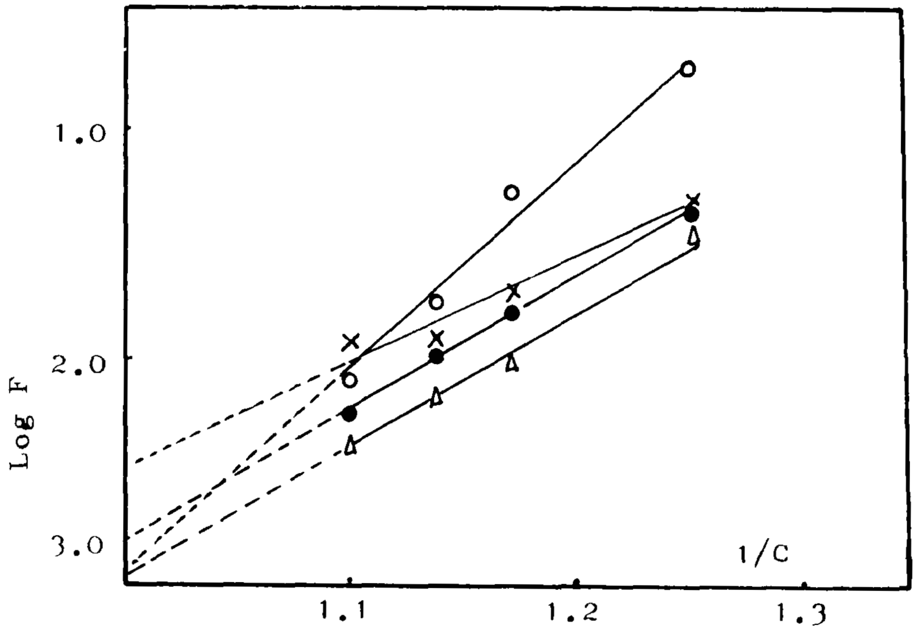

Fig. 4 Log F (Friability) vs 1/C plot for Thiamine HCl Tablets compressed under fixed compressed force with Different vehicles

Key: See Fig. 1

a limiting concentration of a given vehicle. It was argued that below this concentration, drugs of poor compression characteristics could not be compressed. The flow inherent in Eq. 8 and 9 as given earlier is that the value A and F^o respectively were not specific for the concentration. In other wards Eqs 8 and 9 respectively yielded values for compacts compressed from infinite and

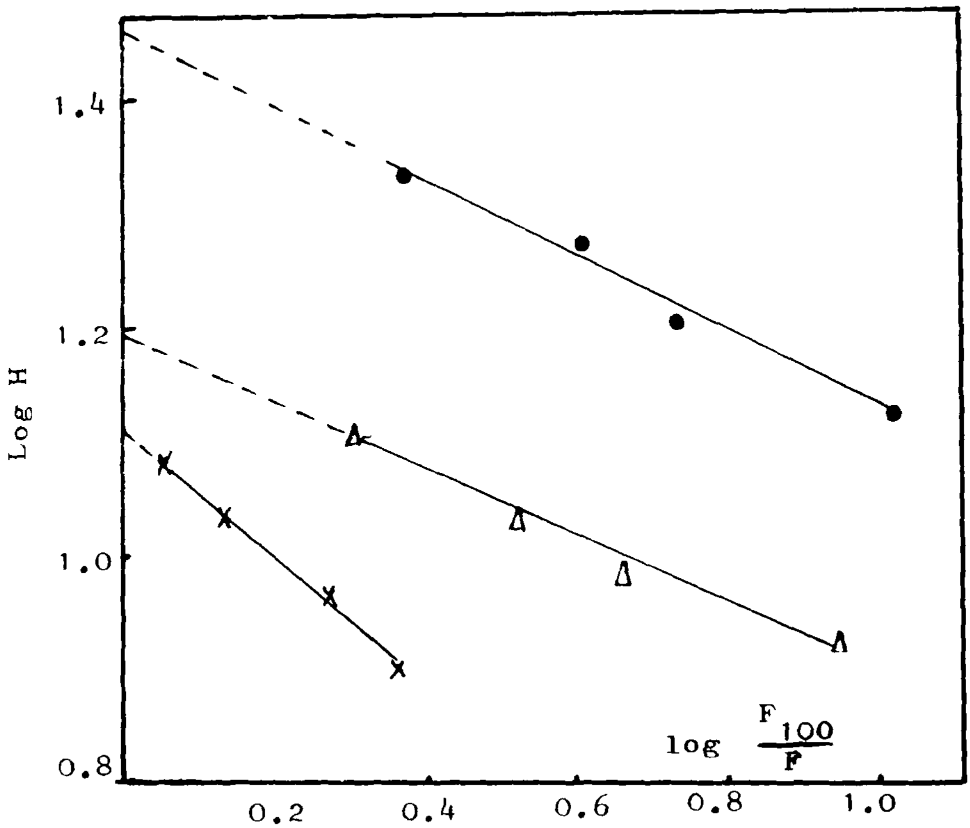

Fig. 5 Log H vs log $\frac{F_{100}}{F}$ for Thiamine Hydrochloride Tablets compressed with varying concentration of Avicel Celutab and Emcompress

zero concentrations of a given vehicle. Therefore it is reasonable and of practical application to assume that the values of the intercept stand for the friability of the compact compressed with highest concentration of the given vehicle i.e 100% w/w. In this case Eq. 8 only is valid.

Table 4: Least Square Fits of Log H on Log $\frac{F_{100}}{F}$ for Thiamine Hcl Tablets Compressed with Named Vehicle

Vehicle	Log H_{100}	Slope	Corr. Coeff.
Avicel	1.48	1.857	0.962
Emcompress	1.17	0.8	0.974

Thus

$$\log F = \log F_{100} + K_f/C \qquad \text{Eq. 10}$$

A plot of log F vs 1/C is shown in Fig. 4 and the least square fits of log F on 1/C is given in Table 3. Eqs. 7 and 10 can be solved for the common parameter 1/C and one may write

$$\text{Log } H = \log H_{100} - \frac{KX}{2.303\, K_f} \log \frac{F_{100}}{F} \qquad \text{Eq. 11}$$

setting $\frac{KX}{2.303\, K_f} = K^*$ thus

$$\log H = \log H_{100} - K^* \log \frac{F_{100}}{F}$$

A plot of log H vs log F_{100}/F is shown in Fig. 5

from the data given in Table 4 it seen that no deviation obtained for the value of H_{100}.

O.K. Udeala & S.A.S. Aly
University of Nigeria, Nsukka

REFERENCES

1. **O.K. Udeala and S.A.S Aly** ; This Journal in press.

2. A.M. Sakr, A.A. Kassem, A.E. Abu-Taleb, S.H. Khidr and S.I. Saleh Egypt J. Pharm. Sci., 17, 335 (1976).

3. J. Okada, Y. Mastuda and Y. Wada, J.Pharm. Sco, Japn. 88, 647 (1968).