International Journal of Pharmaceutics, 21 (1984) 307–315
Elsevier

IJP 00732

Granular magnesium stearate as a lubricant in tablet formulations

Mats E. Johansson

Research and Development Laboratories, Pharmaceutics, Solid Systems, Astra Läkemedel AB, S-151 85 Södertälje (Sweden)

(Received February 20th, 1984)
(Modified version received May 31st, 1984)
(Accepted June 6th, 1984)

Summary

Magnesium stearate in granular form was compared with powdered magnesium stearate as lubricant in 3 directly compressible tablet formulas and one prepared by wet-massing. The lubricating effect was evaluated as the maximum ejection force (EJF/A) and the adhesion to the punch faces. The tablet porperties were evaluated in terms of tensile strength, friability and disintegration time.

Tablets with granular lubricant showed values of EJF/A comparable with those of tablets with powdered lubricant at high concentrations (2–5%). Granular lubricant gave tablets with better physical properties at high concentrations than powdered lubricant. Powdered magnesium stearate was better than granular in preventing adhesion to the punch faces at low concentrations.

Introduction

The most widely used lubricant in the pharmaceutical industry is probably magnesium stearate. Magnesium stearate exhibits its lubricating properties by forming a film of low shear strength between the die wall and the compact, thus reducing the friction (Lachman et al., 1976). It also exhibits anti-adhesive properties by preventing tablets from sticking to the die wall and punch faces. Besides these advantageous properties, the lubricant forms a hydrophobic film around the granules which can negatively affect the tablet properties such as crushing strength, disintegration time, friability and dissolution (Shotton and Lewis, 1964; Sheikh-Salem and Fell, 1981; Bolhuis et al., 1975; Levy and Gumtow, 1963). These effects are

known to increase with prolonged mixing, and in practice one tries to keep the lubricant mixing time as short as possible (Ragnarsson et al., 1979).

It has been shown that the die wall film of magnesium stearate is resistant to wearing off and the lubricating effect remains for several compactions when an unlubricated granulation is added to a lubricated die (Hölzer and Sjögren, 1981).

The lubricant film around the granules is formed at the final mixing, while the film at the die wall is formed at the compaction. It has been proposed that an ideal lubricant should have an ability to hold layers together during mixing and make them available for shearing at the ejection of the tablet (Buehler, 1978). One possibility to obtain a lubricant with the above-mentioned properties might be to granulate magnesium stearate. Each granule should be an agglomerate of fine primary particles and be strong enough to withstand the forces at the lubricant mixing. Due to the shearing action at the die surface the primary particles may spread out at the die wall and if the occurrence of magnesium stearate granules is frequent enough the lubricant film might persist long enough to give adequate lubrication. Granulated magnesium stearate has been used by Shotton and Lewis (1964). However, they only measured the crushing strength of the tablets and found only minor effects on crushing strength by using granulated magnesium stearate. The lubricating effect and effect of disintegration time of magnesium stearate was not measured.

The purpose of this study was to investigate if it is possible to reduce the negative effects on tablet properties by using magnesium stearate in a granular form and still retain acceptable lubrication properties.

Materials and Methods

Materials

Magnesium stearate (Unilever, Emery, The Netherlands), acetylsalicylic acid (ASA 7028, Monsanto Chem., U.K.), microcrystalline cellulose (AVICEL PH 101, FMC, U.S.A.), corn starch (Sta-Rx 1500 Staley Mfg., U.S.A.), paracetamol DC (Graesser Salicylates, U.K.), sodium chloride USP (NaCl, KNZ, The Netherlands), lactose (DMV Vegel, The Netherlands) and polyvidone (Kollidon K 25, BASF, F.R.G.) were all of commercial grade.

Granulation of magnesium stearate

Magnesium stearate was slugged on a single punch machine at approximately 250 MPa. The slugs were screened through 1 mm screen. Fines < 71 μm were removed in an air jet sieve. Particle size is given in Table 1. As reference, untreated magnesium stearate of the same batch was used (specific surface area by permeametry 3.1 m^2/g, L.O.D. (105°C) 3.5%). SEM pictures of both granular and powdered magnesium stearate are shown in Fig. 1.

Powder mixing

Four different tablet masses were tested. Three masses were direct compressible systems: (1) acetylsalicylic acid 79%, microcrystalline cellulose 16% and corn starch

5%; (2) paracetamol DC 83%, microcrystalline cellulose 9% and corn starch 8%; and (3) sodium chloride 100%.

The components in each mixture were mixed for 10 min in a 3 litre glass double-cone mixer (60 rpm). The fourth granulation was a conventional wet granulation. Lactose 88% and microcrystalline cellulose 10% were granulated in a planetary mixer with a 10% solution of polyvidone in purified water (a total of 2% polyvidone on dry basis). The wet mass was dried in a hot air oven at 50°C for 16 h. The dry mass was milled in a Frewitt oscillating granulator with 1.25 mm screen. Particle sizes are given in Table 1.

Magnesium stearate in either granular or powdered form was added in one of the following concentrations: 0.1%, 0.25%, 0.5%, 0.75%, 1.0%, 2.0% or 5.0% w/w. The lubricant was admixed for 2 min in a 3 litre glass double-cone mixer (60 rpm). Powdered magnesium stearate was screened through 0.5 mm screen before being added.

Compaction

Tablets were pressed in a single punch press (Korsch EKO) with piezoelectric load washers (Kistler mod. 9031). The signals from the load washers were amplified in two charge amplifiers (Kistler model 5001) and recorded on a UV-oscillograph (Southern Instruments model 1300) fitted with 1000 Hz mirror galvanometers (Southern Instruments model SMI/M). To facilitate the recording of the ejection force the lower punch signal was amplified 40 times on a separate amplifier (Astra Läkemedel workshop).

Tablets of 200 ± 2 mg were pressed at 30 rpm using 8 mm flat-faced cylindrical punches. Only tablets compacted at 200 ± 10 MPa were further analyzed. The machine was run for 5 min at the stipulated settings before tablets were sampled for analysis. Between each new tablet mass the die was cleaned with acetone.

As a measure of the lubricating effect the maximum ejection force was recorded (EJF). The EJF was compensated for variations in contact area between the die wall and the compact by dividing the EJF with the contact area (EJF/A) (Hölzer and Sjögren 1977). The tablet height was measured after ejection with a calipergauge to 0.01 of a millimeter. The results are given as mean of 10 tablets.

The adhesion to the punch faces was estimated visually as the approximate percentage coverage of the upper punch after the machine had been running for 5 min.

Tablet properties

All tablet properties were evaluated 24 h after compaction. The diametrical crushing strength was measured on a motorized instrument (Heberlein); the results were recalculated to tensile strength in accordance with Fell and Newton (1968)

$$T = \frac{2 \cdot P}{\pi \cdot D \cdot t} \tag{1}$$

where T = tensile strength (MPa); P = diametrical crushing strength (N); D = tablet diameter (m); t = tablet thickness (m).

TABLE 1

PARTICLE SIZE OF TABLET MASSES AND MAGNESIUM STEARATE GRANULATION

Material	Median diameter (μm)	Aritm. S.D.	Geom. S.D.	Method
Sodium chloride	345	255	-	dry sieving
Lactose granulation	420	-	2.62	dry sieving
Paracetamol DC	120	65	-	air jet sieve
Acetylsalicylic acid	220	128	-	air jet sieve
Magnesium stearate granulation	225	-	1.8	dry sieving

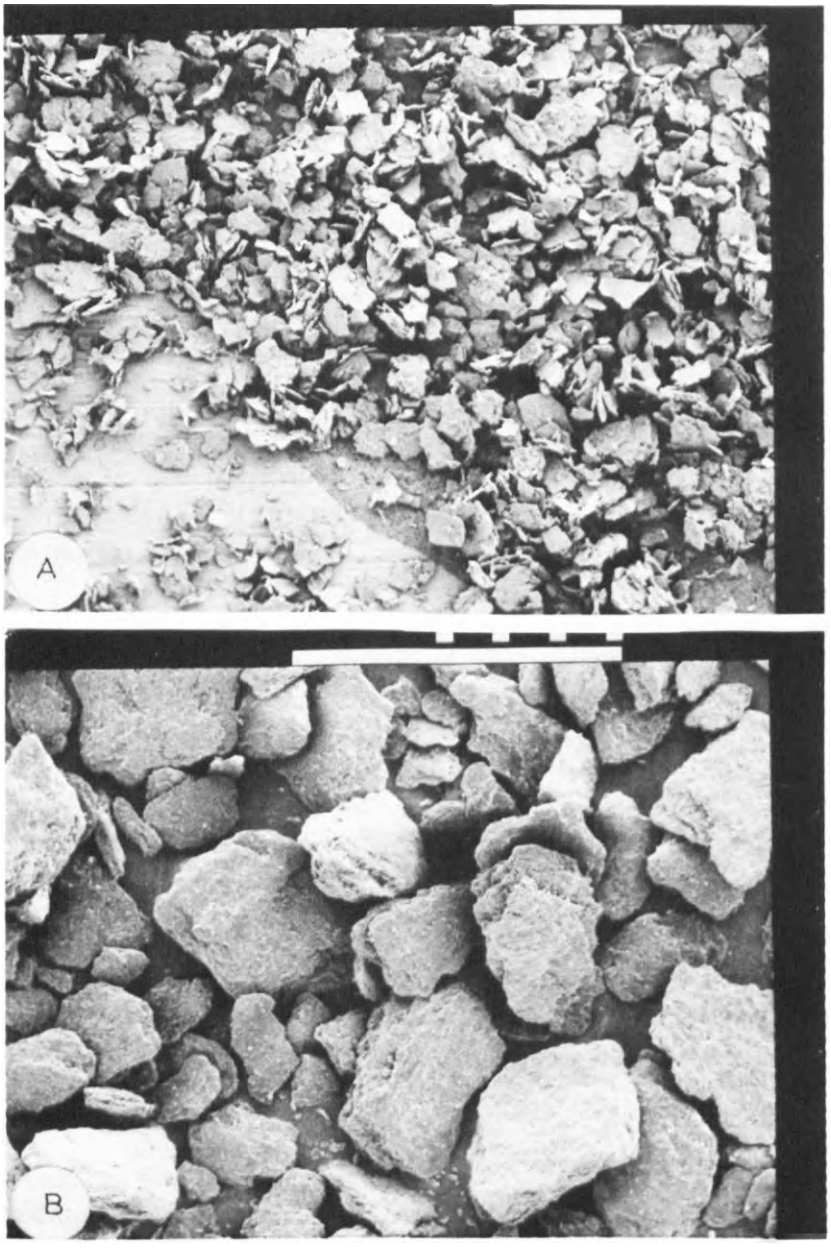

Fig. 1. SEM microphotographs of: (A) powdered magnesium stearate; white bar represents 100 μm. (B) granular magnesium stearate, white bar represents 1 mm.

The results are given as mean of 10 tablets. The disintegration time was measured in water with the BP 73 apparatus without discs, the results are given as median of 6 tablets. Friability was measured with the Roche apparatus at 100 rev.

Results and Discussion

Lubricating effects

In Fig. 2 the EJF/A versus lubricant concentration are given for all 4 materials.

For all 4 tablet masses there was a similar tendency towards higher EJF/A values for granular magnesium stearate at low concentrations, but there was a convergence of the two different curves when the concentration was increased. At about 1–2% there was practically no difference in EJF/A between the two forms of lubricant. The difference in lubrication at the low concentrations might be that the number of magnesium stearate granules in contact with the die wall is too small to retain a lubricant film. At higher concentrations more points become lubricated and equally good lubrication is obtained with granular and powdered magnesium stearate.

Anti-adhesive effects

In Table 2 the estimated values of the adhesion to the punch faces are given.

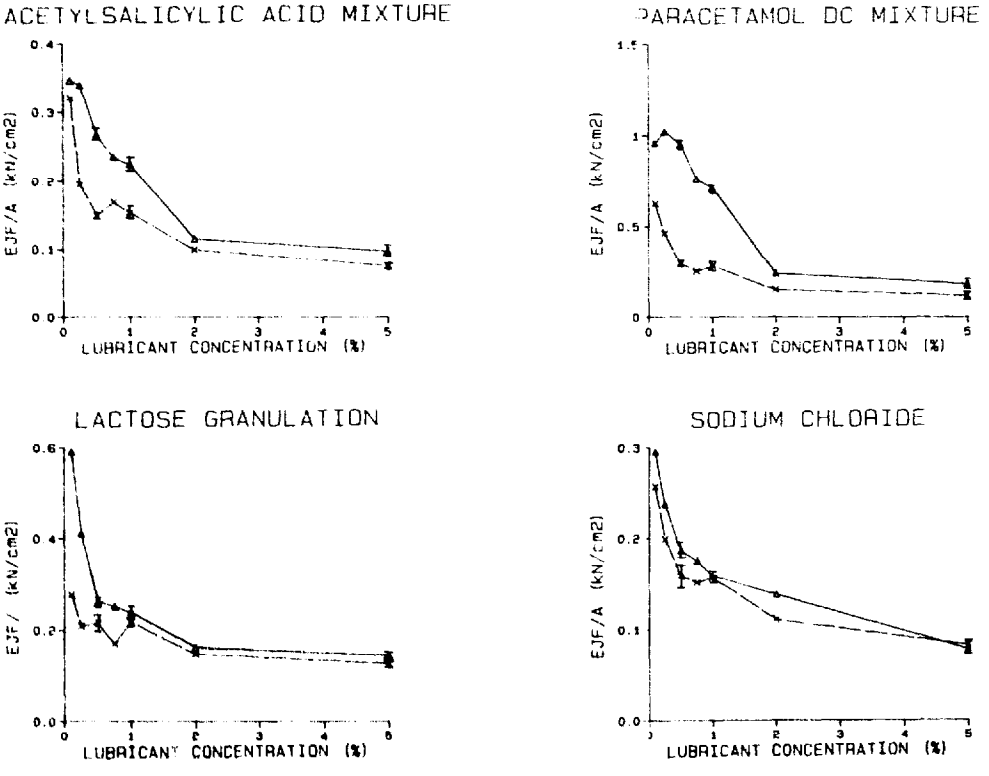

Fig. 2. EJF/A versus lubricant concentration for acetylsalicylic acid mixture, paracetamol DC mixture, lactose granulation and sodium chloride. Vertical bars represent 99% confidence limits. △, granular magnesium stearate; ×, powdered magnesium stearate.

TABLE 2

ADHESION ON THE PUNCH FACES MEASURED AS % COVERAGE OF THE UPPER PUNCH FACE

Conc. (%)	Lactose (% coverage)		Acetylsalicylic acid (% coverage)		Paracetamol (% coverage)	
	gran.	powd.	gran.	powd.	gran.	powd.
0.10	100	10	100	60	90	80
0.25	100	0	80	20	80	5
0.50	100	0	80	5	80	0
0.75	80	0	60	5	80	0
1.00	50	0	50	5	80	0
2.00	0	0	10	5	50	0
5.00	0	0	5	0	0	0

The anti-adhesive properties showed a similar pattern with increasing lubricant concentrations as the ejection force with a convergence of the values at high concentrations. However, the discrepancy between the two lubricants at low concentrations were much more pronounced on the anti-adhesive properties.

Tablet properties

The results from the tensile strength measurements are given in Fig. 3, from friability measurements in Fig. 4 and from the disintegration test in Fig. 5.

For ASA and lactose, granular magnesium stearate gave higher values of the tensile strength over the whole concentration range. However, at concentrations of 2% and more the difference between the lubricants was very small for ASA tablets. For paracetamol DC there was hardly any difference except at 2 and 5% where granular magnesium stearate gave higher values. It was not possible to measure tensile strength of sodium chloride tablets.

ASA tablets and lactose tablets both showed lower friability with granular magnesium stearate over the whole concentration range while paracetamol DC showed similar friability up to a concentration of 2%. At the 5% level there was an increase in friability with powdered magnesium stearate due to capping of about 15% of the tablets. This was not seen with tablets containing granular magnesium stearate. It was not possible to measure friability of sodium chloride tablets.

All masses showed a similar pattern of the disintegration time with little effect at low concentrations for both forms of lubricants and a dramatic increase in disintegration time for powdered magnesium stearate at concentrations exceeding 1%.

In summarizing all the tablet properties it is apparent that many of the adverse effects of magnesium stearate, especially those appearing at high concentrations, can be eliminated or reduced by using granular magnesium stearate. At the same time granular magnesium stearate gives almost as good lubrication properties at high concentrations as powdered magnesium stearate.

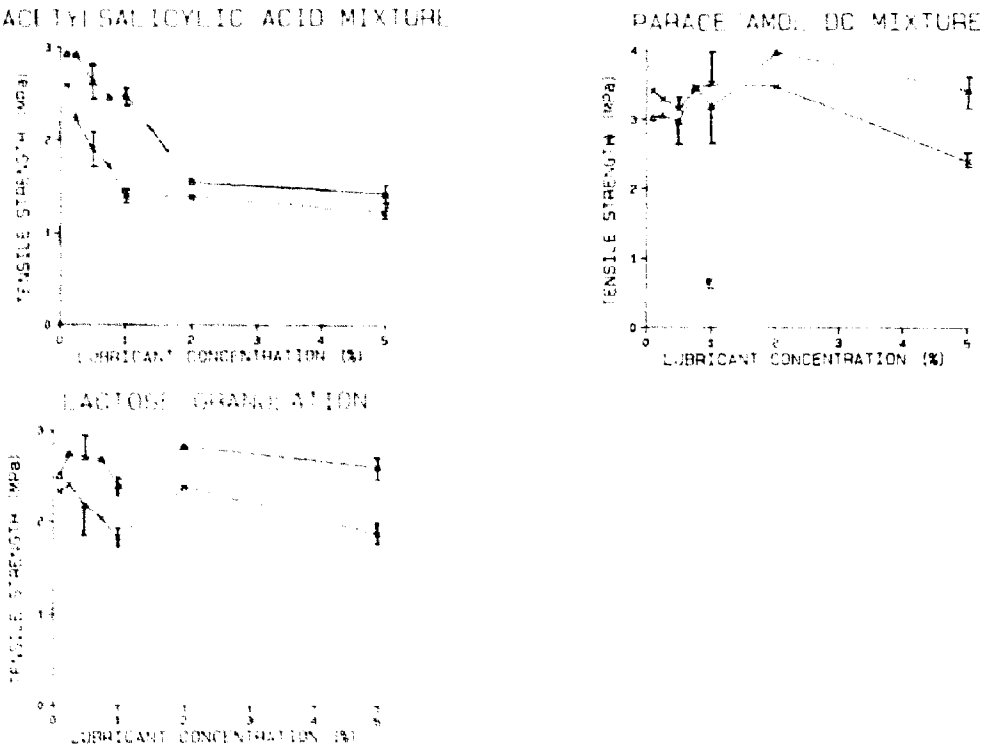

Fig. 3. Tensile strength versus lubricant concentration for acetylsalicylic acid mixture, paracetamol DC mixture and lactose granulation. Vertical bars represent 99% confidence limits. Symbols as Fig. 2.

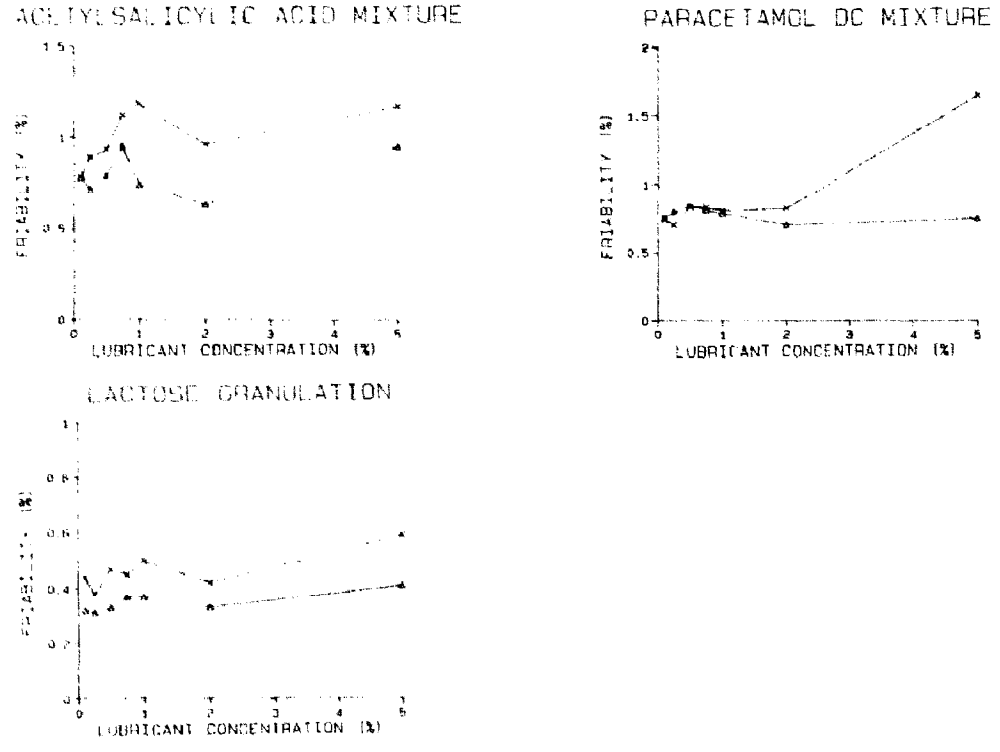

Fig. 4. Friability versus lubricant concentration for acetylsalicylic acid mixture, paracetamol DC mixture, lactose granulation and sodium chloride. Symbols as Fig. 2.

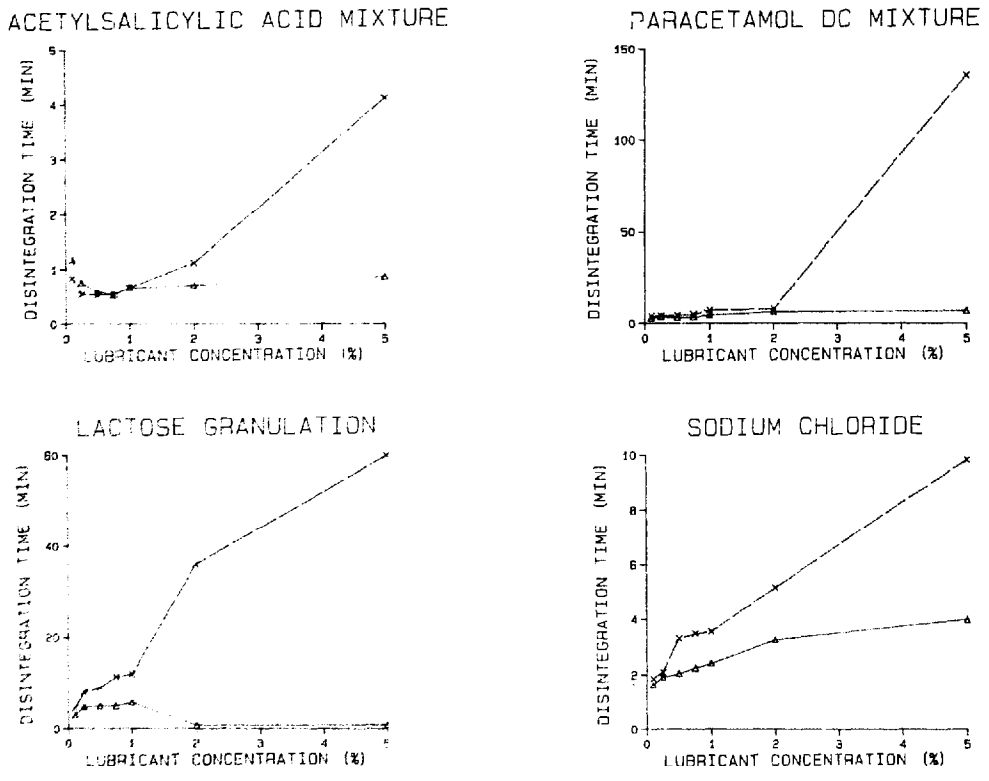

Fig. 5. Disintegration time versus lubricant concentration for acetylsalicylic acid mixture, paracetamol DC mixture, lactose granulation and sodium chloride. Symbols as Fig. 2.

Conclusion

It is possible to obtain equally good lubrication of tablets when using high concentrations of granular magnesium stearate or powdered magnesium stearate. At the same time granular magnesium stearate does not give as negative effects on the tablet properties, e.g. tensile strength, friability and disintegration time as powdered magnesium stearate. Granular magnesium stearate does not seem to be as good as powdered magnesium stearate in preventing adhesion to the punch faces when present in low concentrations.

References

Bolhuis, G.K., Lerk C.F., Zijlstra, H.T. and de Boer, A.H., Film formation by magnesium stearate during mixing and its effect on tabletting. Pharm. Weekbl., 110 (1975) 317–325.

Buehler, J.D., An investigation of some aspects of the lubrication of tablet granulations. Philadelphia College of Pharmacy and Science, Ph.D. thesis, 1978.

Fell, J.T. and Newton, J.M., The tensile strength of tablets. J. Pharm. Pharmacol., 20 (1968) 657–658.

Hölzer, A.W. and Sjögren, J., Comparison of methods for evaluation of friction during tabletting. Drug. Dev. Ind. Pharm., 3 (1977) 23–37.

Hölzer, A.W. and Sjögren, J., Friction coefficients of tablet masses. Int. J. Pharm., 7 (1981) 269–277.

Lachman, L., Lieberman, H.A. and Kanig, J.L., The theory and practice of industrial pharmacy, 2nd Edn. Lea and Febiger, Philadelphia, 1976, p. 306.

Levy, G. and Gumtow, R.H., Effect of certain tablet formulation factors on dissolution rate of the active ingredient III tablet lubricants. J. Pharm. Sci., 52 (1963) 1139–1144.

Ragnarsson, G., Hölzer, A.W. and Sjögren, J., The influence of mixing time and colloidal silica on the lubricating properties of magnesium stearate. Int. J. Pharm., 3 (1979) 127–131.

Sheikh-Salem, M. and Fell, J.T., The influence of magnesium stearate on time dependent strength changes in tablets. Drug Dev. Ind. Pharm., 7 (1981) 669–674.

Shotton, E. and Lewis, C.S., Some observations on the effect of lubrication on the crushing strength of tablets. J. Pharm. Pharmacol., 16 (Suppl.) (1964) 111T–120T.