ISSN: 0128-7680
Pertanika J. Sci. & Technol. **16 (1)**: 15 - 22 (2008)


# Understanding the Tabletting Behaviour of *Ficus deltoidea* Herb

**Yus Aniza Yusof*, Rohaiza Abdullah, Chin Nyuk Ling and Russly Abd. Rahman**
*Department of Process and Food Engineering, Faculty of Engineering,*
*Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia*
**E-mail: niza@eng.upm.edu.my*

## ABSTRACT

This paper presents a study on tabletting of *Ficus deltoidea*, a herb known as "Emas Cotek" in Malaysia and traditionally used for treating gout, hypertension and diabetes as well as to improve blood circulation and to reduce cholesterol and toxins levels in the body. Research has shown that this herb contains active compounds such as flavonoid, tetripenoids, tannins and phenols. For centuries, it was consumed at home through infusion and recently the herb was marketed in the form of tea sachet, capsules and tablets. The tablet is a universal form of delivery in modern medicine due to its ability to provide uniform product composition, particle size and density distributions, and to eliminate dust formation; and most importantly, it has a longer shelf life compared to the other forms of delivery. It is achieved by pressing a blend of ingredients into a tablet. In this study, a 13-mm-diameter cylindrical uniaxial die was used for tabletting. Pressures ranging from 7.5 to 75 MPa were applied to the herb powder. The effect of binder was investigated using Avicel, with compositions ranging from 10 to 60 % of the blend. The strength of the tabletted herb was then tested using an indirect tensile strength test, called diametrical compression test. The results were presented in the form of pressure-volume relationship and tensile strength. The experimental data was then compared to that of the prediction using a first order model. The results indicated that this simple approach can be used to understand the tabletting behaviour of the herb.

**Keywords:** ***Ficus deltoidea*, pressure-volume, tabletting, tensile strength**

## INTRODUCTION

*Ficus deltoidea* or well known as "emas cotek" is a plant that is becoming popular amongst modern Malaysian community. This herb is usually cultivated as a houseplant or as an ornamental shrub and it quite unique as there are two types; the male and female. For the male species, the leaves are small and light weight, with one red spot at the back of the leaves, while for female species the leaves are bigger, round and thicker with a few black spots at the back of the leaves.

The chemical contents analysis carried out by researchers in Universiti Malaya and MARDI showed that *Ficus deltoidea* contains flavonoids, tannins, triterpenoids, and phenols compounds. Traditionally, *Ficus deltoidea* was used for treating gout, hypertension and diabetes as well as to improve blood circulation, to reduce cholesterol and toxins levels in the body and to strengthen the uterus after childbirth (Ismail, 2006).

For centuries, it was consumed at home through infusion and recently the herb has been marketed in the form of tea sachet, capsules and tablets. The tablets are generally in high demand due to several advantages such as convenience during consumption, and sweeteners or coatings can be used to mask any unpleasant taste of *Ficus deltoidea*. Tablets are defined as solid mixtures of active substances and binders, usually in powder form,

* Corresponding Author

and compressed into solid. The binders represent the materials that provide the necessary bonding in order to hold the powders together to form granules under compaction. A compactor is a device that performs compaction and in this study, the uniaxial die compaction was used for tabletting of grounded *Ficus deltoidea* leaves.

The main objectives of this study were to investigate the compactibility and compressibility of *Ficus deltoidea* powder and the effect of addition of binder such as Avicel, or also known as microcrystalline cellulose upon tabletting. Compactibility is the ability of two or more substances combined with each other to form a homogeneous composition of useful plastic properties, with negligible reactivity between materials in contact. Compressibility is defined as the ability of a powder to decrease in volume under pressure.

## VALIDATION OF THE EXPERIMENTAL DATA

Pressure-volume relationship from the uniaxial die compaction is used for the analysis of the interactions between the particles and the particles as well as the particles and the wall, and the study of the microstructure of compact. There are many equations to describe the powder compaction processes (Heckel, 1961; Cooper and Eaton, 1962; Kawakita and Lüdde, 1970/71). The Kawakita and Lüdde (1970/71) equation is probably the most widely used model in both powder metallurgy and pharmaceutical industries particularly for soft medical powders, and was adopted for this study. Kawakita and Lüdde (1970/71) equation is shown below.

$$\frac{\sigma_a}{C} = \frac{1}{ab} + \frac{\sigma_a}{a} \tag{1}$$

where $s_a$ is the pressure applied, $C$ is the degree of volume reduction (defined as $C = (V_o - V)/V_o$, with $V_o$ is the powder volume before pressure is applied, and $V$ is the powder volume after pressure is applied), and $a$ and $b$ are the constants characteristics of the powder. The constant value $a$ represents the initial porosity in the case of piston compression. The value of the constant $b$ is related to the resisting force, or the cohesiveness, of powdery particles in the case of tapping and vibrating.

## MATERIALS AND METHODS

### *Materials*

*Ficus deltoidea* powder (Ya'acob Berkat Enterprise, Melaka) and microcrystalline cellulose, trade name Avicel PH-101 (Sigma – Aldrich Chemil GmbH, Ireland) were used in this study. The particle size of the powders was estimated based on the Scanning Electron Microscopy (SEM) images. SEM was used to capture images of *Ficus deltoidea* and Avicel powders at 500 magnifications as shown in *Fig. 1*. The material properties before the uniaxial die compaction process are shown in Table 1. The moisture content of the powders was measured using a digital moisture analyzer (OHAUS MB45, USA) at 104ºC. The bulk and tapped density were measured and described elsewhere (Abdullah, 2007).

The Carr's compression Index (Carr, 1965) and Hausner ratio (Hausner, 1967) obtained indicated that *Ficus deltoidea* powder has poor flowa compared to Avicel powder which has good flow characteristics, which may be used to infer their compressibility characteristic later.

(a) (b)

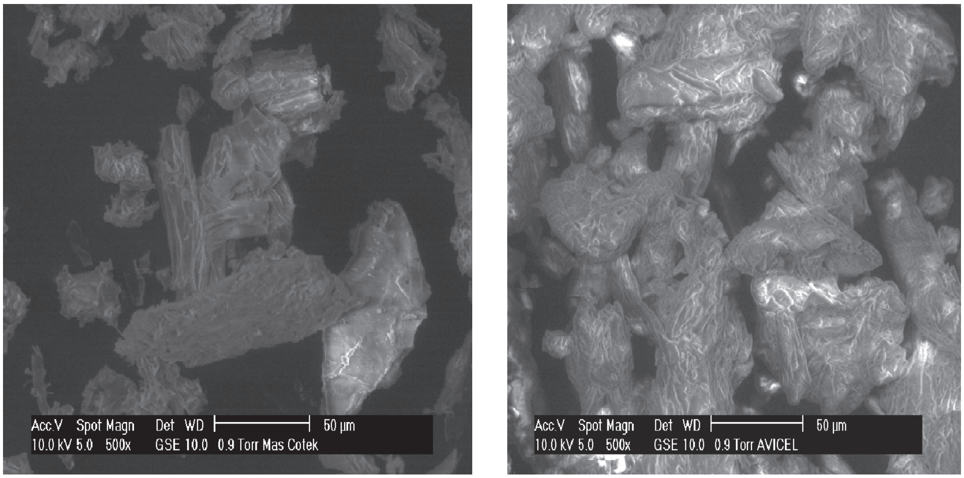


*Fig. 1: SEM images for (a)* Ficus deltoidea *and (b) Avicel powders at 500x magnifications*

TABLE 1
Material properties of *Ficus deltoidea* and Avicel powders

| Material Properties | *Ficus deltoidea* | Avicel |
|---|---|---|
| Estimated Particle Size (μm) | 100-150 | 80 |
| Moisture Content (%) | 11.34 | 4.45 |
| Bulk Density (kg/m$^3$) | 250 | 340 |
| Tapped Density (kg/m$^3$) | 333 | 423 |
| Carr Index (%) (Carr, 1965) | 25 | 19.6 |
| Hausner Ratio (Hausner, 1967) | 1.30 | 1.24 |
| Flowability | Poor flowability | Good flowability |

*Uniaxial Die Compaction*

The *Ficus deltoidea* tablets were prepared using a 13-mm-diameter cylindrical uniaxial die (Runnig Sdn. Bhd, Selangor). *Ficus deltoidea* powder (0.5 ± 0.01g) was poured into the stainless steel die using a plastic funnel to facilitate the flow of the powder. Then, the die was tapped for about 20 times to form a homogenous density distribution within the powder. Upon loading, a universal testing machine (Instron 5566, USA) was used for tabletting, with pressures ranging from 7.5 to 75 MPa and at a constant crosshead speed of 5 mm/min.

The data were recorded by a computer connected to the machine in the form of force-displacement curves. Upon unloading and ejection, the thicknesses of the tablets were measured using a digital vernier caliper and the volumes of the tabletted powder were obtained.

*Tensile Strength Test*

Tensile strength was determined by a diametrical compression test also known in the pharmaceutical industry as ''hardness'' test. In this test, the tablets were placed between two flat plates as shown in *Fig. 2*. The tests were conducted at a crosshead speed of 5 mm/min until an ideal fracture occurred (Newton *et al.*, 1971).

*Fig. 2: A tensile strength test for a tablet*

*Effect of Binder*

Mixtures of *Ficus deltoidea* and Avicel powders were prepared at 0.5 and 1.0 g of feed powders with the percentages of Avicel binder being 10, 20, 30, 40, and 60 %. Pure *Ficus deltoidea* and pure Avicel powders were also tabletted separately. These samples were compacted at various loads using the Instron machine.

## RESULTS AND DISCUSSION

*Pressure – Volume Relationship*

*Fig. 3* shows the pressure – volume relationship of 0.5 g of feed powder containing pure *Ficus deltoidea* and Avicel powders. Generally, as the pressure increases, the volume decreases, or in other words the density increases as the pressure increases. This could be explained based on the fact that the tabletting process may be divided into two main processes; rearrangement and deformation processes of the powders. Upon loading (at low pressure) the particles rearrange and slid to fill in the void spaces in the powder bed, creating higher inter-particle friction. As the pressure increases, further powder rearrangement and deformation occurs, thus forming a closer packing structure such that the compactibility of the powder increases. Intermolecular forces, such as van der

Waals forces were postulated to exist at this stage (Nyström *et al.*, 1993). During the final stage of tabletting process, the powder starts to deform permanently. The compressibility of the powder decreases in which tablet volume reduces slightly as the pressure increases. This may be due to the formation of large bonding points (junctions of contact), hence increasing the inter-particle contact area. Consequently, stronger bonds form between the particles that may have prevented further volume reductions. The trend of the findings in *Fig. 3* is similar to those of Yusof (2005) for compaction of maize with Avicel powders, and Abdullah (2007) for tabletting of 1.0 g of *Ficus deltoidea. Fig. 3* shows that the compressibility of Avicel powder is better compared to *Ficus deltoidea* powder as indicated by a large amount of volume reduction. Thus, the density of the Avicel tablet is higher than the *Ficus deltoidea* tablet. This agrees well with Avicel characteristics, commonly known as a universal binder.

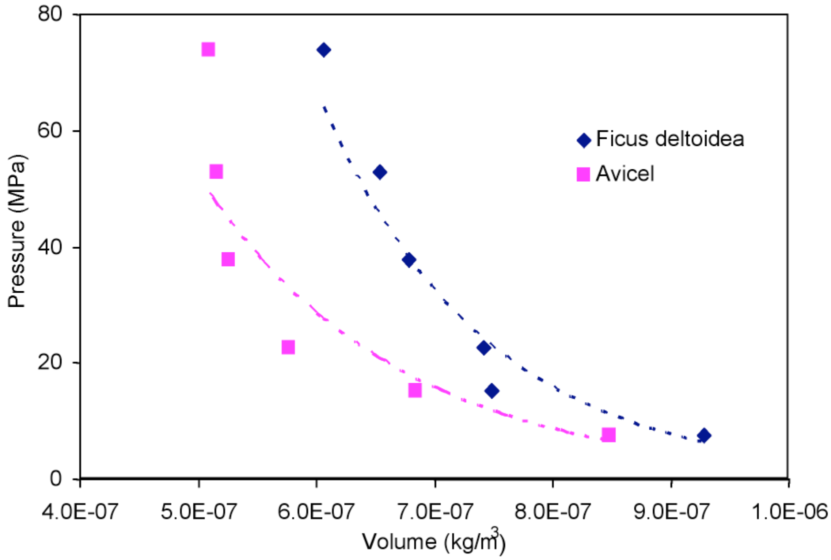


*Fig. 3: Pressure vs volume for 0.5g of feed powder. The lines are the trend lines*

*Validation of the Experimental Data*

The experimental data obtained were verified using a classical model of Kawakita (Kawakita and Lüdde, 1970/71). Constant *a* in the Kawakita relationship is considered to represent the initial porosity and constant *b* is related to the resisting force, or the cohesiveness of the powders (Kawakita and Lüdde, 1970/71). Table 2 shows *a* and *b* values for 0.5 and 1.0 g mixtures of *Ficus deltoidea* and Avicel powders with the compositions of Avicel powders ranging from 0 to 100%. There are some inconsistencies in the values of the constants as the compositions of Avicel increases and this is due to the segregation problem, which occurred in the feed powder mixture, which is unavoidable in a solid powder mixture (Yusof, 2005). Nevertheless, these values are comparable to the values for paracetamol powder with *a* and *b* values are 0.48 and 1.11 respectively (Mohammed, 2004). The *a* and *b* values for other herbal powders such as *Eurycoma longifolia jack* are 0.81 and 0.55 (Ahmad, 2007) and for *Morinda citrifolia* are 0.60 and 0.19 (Md Nor, 2007).

TABLE 2
The constant *a* and *b* from Kawakita's plot

| Weight | 0.5 g | | | 1.0 g | | |
|---|---|---|---|---|---|---|
| Composition of Avicel (%) | *a* | *b* | $R^2$ | *a* | *b* | $R^2$ |
| 0 | 0.64 | 0.22 | 0.9989 | 0.79 | 0.08 | 0.9681 |
| 10 | 0.75 | 0.20 | 0.9971 | 0.74 | 0.14 | 0.9937 |
| 20 | 0.73 | 0.17 | 0.9968 | 0.75 | 0.13 | 0.9956 |
| 30 | 0.71 | 0.24 | 0.9993 | 0.72 | 0.17 | 0.9981 |
| 40 | 0.72 | 0.24 | 0.9993 | 0.70 | 0.19 | 0.9990 |
| 60 | 0.81 | 0.48 | 0.9996 | 0.69 | 0.20 | 0.9995 |
| 100 | 0.77 | 0.43 | 0.9996 | 0.75 | 0.12 | 0.9995 |

*Tensile Strength*

*Fig. 4* shows the tensile strength as a function of load applied to 0.5 g of the mixture of *Ficus deltoidea* and Avicel powders. Avicel was used as a binder at various compositions, ranging from 0 to 100 % Avicel. Obviously, the tensile strength of pure Avicel is the strongest among the other samples. This finding agrees well with those of Ahmad (2007) and Md Nor (2007) for tabletting of *Eurycoma longifolia jack* and *Morinda citrofolia* herbs, respectively. Similar finding was found for tabletting of 1.0 g of the mixtures of *Ficus deltoidea* and Avicel powders (Abdullah, 2007).

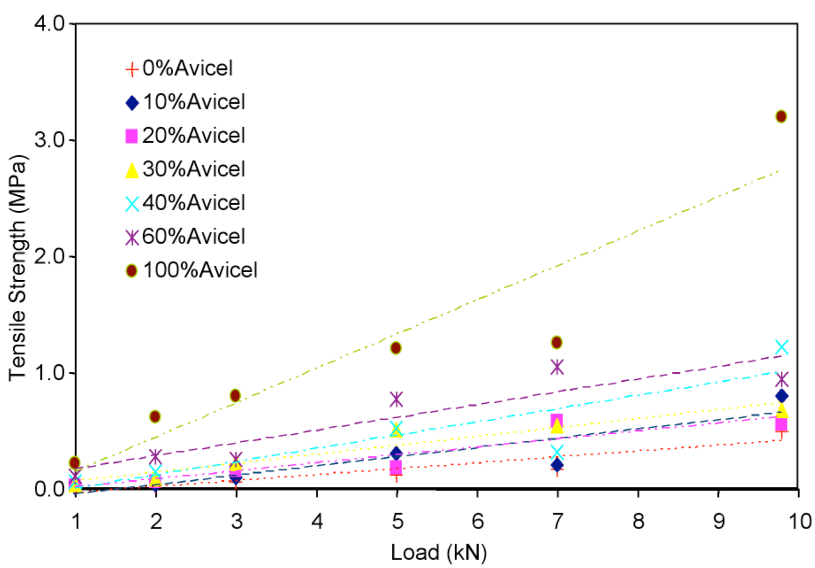


*Fig. 4: Tensile strength vs load for 0.5 g of feed powder. The lines are the trend lines*

## CONCLUSIONS

The *Ficus deltoidea* powder was investigated upon tabletting. It was found that as the pressure to produce the tablet increases, the volume decreases, and the density increases. Therefore, higher pressure can produce a more tough and coherent tablet. The effect of binder was studied by the tensile strength versus load relationship. It was found that the tensile strength of pure Avicel (100% Avicel) was the strongest when compared with that of the mixed *Ficus deitoldea*- Avicel powders. The experimental results obtained for the tabletting study were also verified with an established model and they were found comparable to those in the literature. In conclusion, this study may be used to understand the tabletting characteristic of *Ficus deltoidea* herb.

## ACKNOWLEDGEMENTS

The authors wish to thank the Universiti Putra Malaysia for the financial support through the young lecturers scheme (PLB), funding no. 5315831.

## REFERENCES

Abdullah, R. (2007). Uniaxial die compaction of *Ficus deltoidea* (Thesis, Universiti Putra Malaysia, 2007).

Ahmad, S. (2007). Mechanical granulation by tabletting of *Eurycoma longifolia jack* (Thesis, Universiti Putra Malaysia, 2007).

Carr, R.L. (1965). Evaluating flow properties of powders. *Chemical Engineering, 72,* 163-167.

Cooper, Jr. A.R. and Eaton, L.E. (1962). Compaction behaviour of several ceramic powders. *Journal of the American Ceramic Society, 45,* 97-101.

Hausner, H.H. (1967). Friction conditions in a mass of metal powder. *International Journal of Powder Metallurgy, 3, 4,* 7-13.

Heckel, R.W. (1961). An analysis of powder compaction phenomena. *Transaction of Metallurgy. Society. AIME, 221,* 671-675.

Kawakita, K. and Lüdde, K.H. (1970/71). Some consideration on powder compaction equations. *Powder Technology, 4,* 61-68.

Ismail, M.K. (2006, April 7). Mas Cotek herba berkhasiat pencabar Tongkat Ali. *Utusan Malaysia,* http://www.frim.gov.my/fin/file/ACFA93.jpg.(date cited:7 Jun 2007)

Md Nor, C.R. (2007). Uniaxial die compaction of *Morinda citrifolia.* (Thesis, Universiti Putra Malaysia, 2007).

Mohammed, H. (2004). Contact mechanical aspects of pharmaceutical compaction (PhD Thesis, Imperial College London, London, 2004).

Newton, J.M., Rowley, G., Fell, J.T., Peacock, D.G. and Ridgeway, K. (1971). Computer analysis of the relation between tablet strength and compaction pressure. *Journal of Pharmacy and Pharmacology, 23,* 195-S201.

Nyström, C., Alderborn, G., Duberg, M. and Karehill, P.G. (1993). Bonding surface area and bonding mechanisms-two important factors for the understanding of powder compactability. *Drug Development and Industrial Pharmacy, 17 & 18,* 2143-2196.

YUSOF, Y. A., SMITH, A. C. and BRISCOE, B. J. (2005). Roll compaction of maize powder. *Chemical Engineering Science, 60(14),* 3919-3931.

YUSOF, Y. A. (2005). Rolling-mill granulation of powders (PhD thesis, United Kingdom Imperial College London, London, 2005).