Acta Pharmaceutica Sciencia
51: 271- 280 (2009)

Seed mucilage of *Blepharis edulis* Pers. as a disintegrant in tablet: extraction, formulation and evaluation

Dhiren P. Shah*[1], Girish K. Jani[2]

[1]Department of Pharmaceutics, C K Pithawalla Institute of Pharmaceutical Science and Research, Via Magdalla Port, Nr. Malvan Mandir, Dumas Road, Gavior Gam, Surat -395 007, Gujarat, India.
[2]Principal, S S R College of Pharmacy, Sayli-Silvassa Road, Silvassa, U T of Dadra and Haveli.

Abstract

The present study was undertaken to extract mucilage from the seeds of *Blepharis edulis* Pers. and explored its use as a tablet disintegrant. Various physico-chemical properties like flow property and swelling ratio etc., of mucilage were evaluated. Concentration of disintegrant on disintegration time, crushing strength and friability were carried out on Diclofenac sodium tablet. Dried mucilage has good flow properties and superior swelling. It was found that as the concentration of disintegrant increases there was a decrease in disintegration time. It was concluded that dried mucilage can work as disintegrant in conventional tablets and could be alternate to starch.

Key words: *Blepharis edulis* Pers, diclofenac sodium, mucilage, disintegrant, CSFR/DT.

Introduction

Excipients are the additives used to convert active pharmaceutical ingredients into pharmaceutical dosage form suitable for administration to patients. New and improved excipients continue to be developed to meet the needs of conventional drug delivery system and to meet the needs of advanced tablet manufacturing. Plant products serve as an alternative to synthetic products because of local accessibility, environment friendly nature, and lower price as compared to synthetic excipient. Various natural materials have been explored as disintegrant, due to easy of availability, plenty in nature and non-toxic. Today, we have a number of plant-based pharmaceutical excipients. Various natural materials have been explored as disintegrating agents like plantago ovata husk powder, *Ocimum basillicum* Linn and *Ocimum americanum* Linn (Srinivas et al. 2003, Patel et al. 2007), sorghum and plantain starches (Gbenga 2003), cassia tora and cassia nodosa (Gupta 2000).

Since a tablet is not useful until its active component is made available for absorption, the disintegrant is arguably the most important excipient in a tablet. A greater importance is given to the disintegration and dissolution characteristics of tablets since bioavailability may be related with these factors. In a compressed tablet disintegrant is that excipient which facilitates the break up of the tablet in a liquid environment into fine particles prior to dissolution of the active drug and its absorption from the gastro-intestinal tract.

In a compressed tablet disintegrant is that excipient which facilitates the break up of the tablet

***Corresponding author:** dhirenpshah1@gmail.com

in a liquid environment into fine particles prior to dissolution of the active drug and its absorption from the gastro-intestinal tract. Several mechanisms have been proposed to rationalize the action of disintegrants. These include porosity and capillary action, rate of water uptake into the tablet, swelling of disintegrant particles, gas release, melting and enzymatic action, and heat of wetting and lysis of physico-chemical bonds. These enhanced dissolution and bioavailability of a drug are always invariably preceded by rapid disintegration of solid dosage form. However, during disintegration process a number of these mechanisms could occur simultaneously (Shangraw et al. 1980). During the last two decades, pharmaceutical researchers have tried different adjuvant to improve product performance related to disintegration.

Blepharis edulis Pers., (family-Acanthaeae) are used in traditional system of medicine as diuretic, resolvent, aphrodisiac, expectorant and deobstruent. The plant is used in rheumatism and impotency. Common names are Uttingana (Sanskrit), Ucchata (Bengali), utingum & chopunivel (Gujarati), Utangan (Hindi), Uttangan (Punjabi), Uttanjana (Tamilnadu), Utingana (Orissa), uttangan (Telugu) and Utangan (Urdu). A seed contains glycosides, tannins and mucilage. The plant is used as fodder for sheep and goats and is given to cattle to increase milk production. (Birit 2001, Kirtikar 1999, Anonymous 2002, Jograj 1936 and 1940, Chopra et al. 1969).

Diclofenac sodium is a potent nonsteroidal anti-inflammatory drug, which has anti-inflammatory, analgesic and antipyretic properties. It is used for the treatment of degenerative joint diseases such as rheumatoid arthritis, osteoarthritis, and ankylosing spondilitis. Diclofenac sodium is rapidly dissolved in intestinal fluid and reaches its maximum blood concentration (C_{max}) within 30 min. In healthy human volunteers, mean plasma clearance of diclofenac sodium was 16 h/l and mean elimination half-life of the terminal phase was 1.2–1.8 h (Fowler et al. 1983, Hardman 2006, Willis et al. 1981).

The plant selected for present work was based on its availability and presence of mucilage in it. Literature review revealed that less work has been carried out on formulation front from the plant *Blepharis edulis* Pers. Seed mucilage of *Blepharis edulis* Pers has not been explored as pharmaceutical excipient. The objective of present study was to extract mucilage from *Blepharis edulis* pers seeds and explore its use as a disintegrant in tablet. Various physico-chemical properties like flow property, compressibility and swelling index etc., were evaluated and compared with starch. Initially, lactose and dibasic calcium phosphate tablets containing mucilage were prepared and evaluated for crushing strength, friability and disintegration time. Diclofenac sodium tablets were prepared containing mucilage and starch. To assess the efficacy of mucilage, different concentration of mucilage were used and tablets prepared with different types of filler like dibasic calcium phosphate and lactose. Various quality control tests like disintegration time, crushing strength and friability were performed for the prepared tablets.

Materials and Methods

Materials

Diclofenac sodium (DS) was received as generous gift from Torrent Pharmaceutical Ltd., Ahmedabad, Gujarat, India. The seeds of *Blepharis edulis* Pers were procured from South Gujarat region. Dibasic

calcium phosphate (DCP) IP, Lactose IP, Poly-vinyl pyrollidone (PVP) IP, Starch, Talc IP and Magnesium stearate IP were used as received. All other solvents and chemicals were of AR grade. Deionized double distilled water was used through out the study.

Methods

Extraction of mucilage

The seed of *Blepharis edulis* Pers was washed with water to remove dirt and debris, dry it. Then they were powdered and soaked in water for 5–6 h, boiled for 30 min, kept aside for 1 h for complete release of mucilage into water. The material was squeezed from eight-fold muslin cloth bag to remove the marc from the solution. Then, three times volume of acetone was added to filtrate, to precipitate the mucilage. The mucilage was separated, dried in oven at temperature less than 50° C, collected dried powdered passed through sieve no. 80 and stored for further use in desiccators (Kulkarni et al. 2002, Baveja et al. 1988).

Particle Size

Average particle size of mucilage and starch was measured by optical microscopy.

Angle of repose

Method utilized in measuring the angle of repose was fixed funnel and free standing method, calculation was made and the mean angle of repose calculated.

Bulk and tapped density

Bulk and tapped densities of mucilage and starch were determined. The powder was placed inside the measuring cylinder of a tapped density apparatus and the bulk volume was recorded and subjected to 200 taps and the tapped volume was recorded. The bulk and tapped densities were computed.

Carr's index and hausner ratio

Carr's Index and hausner ratio of mucilage and starch was carried out and calculated by the formula given in Aulton 2002 (Aulton 2002).

Swelling Ratio

The study was carried out in 100ml stopper graduated cylinder. The initial bulk volume of 1g dried mucilage was noted and then water added in sufficient quantity to yield 100 ml uniform dispersion. The sediment volume of the swollen mass was noted after 24 h storage at room temp. The swelling ratio was calculated by taking the ratio of the swollen volume to the initial bulk volume. The mean of two determinations was calculated (Bowen 1984).

Hydration capacity

The hydration capacity (water retention capacity) was determined. 1 g of powder was placed in a centrifuge tube and covered with 10 ml of water. The tube was shaken intermittently over a 2 h period and left to stand for 30 min. This was then centrifuged for 10 min. at 30000 rpm. The supernatant was decanted and the weight of the powder after water uptake and centrifugation, x was determined.

$$HydrationCapacity = \frac{x}{y} \qquad (1)$$

Where x is weight of moist powder after centrifugation and y is weight of dry powder. The values of hydration capacity listed were the means of two determinations.

Preparation of Lactose and DCP tablet

Lactose was passed through a sieve 60 #; it was then granulated using 10% wt/vol solution of PVP in alcohol. Mucilage was added intra-granular. The wet coherent mass was passed through sieve 22 #. The wet granules were dried at 60°C in a tray dryer. Fines were removed by sifting the granules on a sieve 60 #. The powder blend was then lubricated with talc. Lubrication was done in a glass jar for 2 min (Lachman et al. 1987). Granules of DCP were prepared, similarly. Lactose (Batches A1 and A2) and DCP (Batches B1 and B2) tablets were prepared with and without disintegrant, respectively. Tablets were prepared on a rotary tablet press using flat-faced punches and die (Model Rimek-II, Karnavati Engg., Ahmedabad, India). The turret was rotated at a fixed speed of 30 rpm. Target weight of each tablets were 100mg. The tablets were evaluated for disintegration time (DT), crushing strength and friability. Formulations are shown in Table 1.

Table 1. Formulation of lactose and DCP tablets with and without dried mucilage.

Ingredients (mg)	Batch			
	AB1	AB2	BB1	BB2
Lactose	85	80	-	-
DCP	-	-	85	80
PVP	10	10	10	10
Dried Mucilage	-	5	-	5
Talc	5	5	5	5
Total	100	100	100	100

Preparation and characterization of DS tablet

DS, and DCP or lactose was passed through sieve no. 60 #; it was then granulated using 10% PVP in ethanol as a binder. The wet coherent mass was passed through a sieve 22# and then dried at 50°C in a hot air oven. Mucilage was added intra + extra-granular in ratio of 1:1. Talc was lubricated in glass jar for 2 min. Tablet formulations are shown in Table 2.

Table 2. Formulation of DS tablet containing dried mucilage.

Ingredients (mg)	Batch Code							
	AD1	AD2	AD3	AD4	BL1	BL2	BL3	BL4
DS	50	50	50	50	50	50	50	50
DCP	116	110	100	90	--	--	--	--
Lactose	--	--	--	--	116	110	100	90
PVP	20	20	20	20	20	20	20	20
Mucilage (intra-granular)	2	5	10	15	2	5	10	15
Mucilage (extra-granular)	2	5	10	15	2	5	10	15
Talc	10	10	10	10	10	10	10	10
Total	200	200	200	200	200	200	200	200

Tablets containing DCP (Batch AD1 to AD4) or lactose (Batch BL1 to BL4) were prepared and mode of addition of was intra + extra-granular in ratio of 1:1. The blend was compressed on Rotary Tablet Machine (Minipress II, Karnavati Eng., Ahmedabad, India). Similarly, DS, starch, DCP or lactose containing tablets were prepared (Batches SD1 to SD4 and SL1 to SL4 – intra + extra-granular in ratio of 1:1 starch). Target weight of tablet was 200 mg. Tablets were stored in well-closed glass jars.

Uniformity of weight

The weights of 20 tablets were weighed individually using an electronic balance and the average weight was calculated.

Disintegration time

Disintegration times (DT) of six tablets per batch were individually determined containing distilled water at 37±0.5° C. The mean disintegration times were calculated.

Crushing strength and Friability test

Crushing strength of tablets was determined using a Monsanto hardness tester. The mean crushing strength of ten tablets was calculated. Friability was determined using a Roche friabilator. Twenty tablets per batch were weighed and caused to cascade in the drum of the friabilator, which rotated at 25 rpm for 4 min. The tablets were de-dusted and reweighed. The loss in weight expressed as a percentage of the original weight of the ten tablets was calculated as the friability of the tablets.

Stability study

To study the effect of storage on crushing strength and disintegration time, stability study of optimized formulation (Batch AD3) was carried out at 40^0c in a humidity oven having 75% RH. Samples were withdrawn after three-month interval and evaluated for change in crushing strength and DT.

Results and Discussion

Table 1 shows results of physico-chemical properties of dried mucilage extracted from *Blepharis edulis* Pers. Average particle size of dried mucilage was found to be 175µm. The moisture content indicates the amount of moisture present in the material available to interact with other material and it was found to be 5%. The flow properties and compressibility of the dried mucilage and starch include bulk and tapped density, carr's index, hausner ratio and angle repose were assessed. A comparison of all parameters of dried mucilage was compared with starch. The angle of repose of a powder provides an insight into the magnitude of the cohesiveness of the powder, and hence its flowability. Moderately cohesive powders have angles of repose between 40 and 60 when measured by any of the standard methods. Dried mucilage has an angle of repose of 23 while starch has an angle of repose of 56. It could be inferred that dried mucilage powder being less cohesive and has superior flow property. The hausner's ratio previews the degree of densification, which could occur during tabletting. Higher hausner's ratio, greater the propensity of powder to densify. Dried mucilage powder densified more than starch; this could also be an indication of its superior flowability. Dried mucilage shows good compressibility as compared to starch. It could be conclude that dried mucilage has excellent flow property and compressibility as compared to starch.

The common feature of all theories of disintegration is that penetration of water (or liquid medium) into the tablet must precede disintegration. The swelling ratio and water retention (hydration capacity) capacity of the dried mucilage powder were over 16 and 3 times higher than those of starch, respectively. These results may suggest that dried mucilage powder may be a superior disintegrant to starch. The swelling ratio of mucilage was carried out in distilled water, simulated gastric fluid (0.1 N HCl) and in phosphate buffer (pH 6.8). It was found to be 19, 18 and 19, respectively. There was a no significant effect of dissolution media on swelling

index. It was concluded that the swelling of mucilage is pH independent and mucilage may be considered as non-ionic.

Table 3. Physico-chemical characteristics of dried mucilage and starch.

Parameters	Dried mucilage ± S.D. (n = 2)	Starch ± S.D. (n = 2)
Bulk Density (g /mL)	00.40 ± 0.050	00.55 ± 0.045
Tapped Density (g /mL)	00.50 ± 0.055	00.66 ± 0.047
Carr's Index (%)	20.00 ± 0.850	16.67 ± 0.985
Hausner's Ratio	01.25 ± 0.045	01.20 ± 0.035
Angle of Repose (Φ)	23.00 ± 1.250	56.00 ± 1.526
Moisture Content (%)	05.00 ± 0.582	11.00 ± 0.955
Swelling Ratio	19.00 ± 1.575	01.20 ± 0.250
Hydration Capacity	03.00 ± 0.325	01.00 ± 0.256

To investigate the versatility of the dried mucilage, lactose and DCP tablets were prepared and evaluated for DT, crushing strength and % friability. Data are shown in Table 4. It was observed that there was an acceptable crushing strength and friability for lactose and DCP tablets. It was also observed that incorporation of dried mucilage in lactose tablets, there was a marginal increased in crushing strength and decreased in friability, while DCP tablets remain unchanged. The probable reasons could be facilitated flow and densification of the granule in die. DCP shows higher fragmentation propensity as compared with lactose. This could be one of the reasons for higher crushing strength of DCP tablets compared with lactose tablets. It was noted that lactose tablets showed relatively faster disintegration (Batch AB1) as compared to DCP tablets (Batch BB1). The possible reason for faster disintegration may be attributed to increased water uptake by lactose tablets. A comparison of batch AB1 and AB2 was made, it was observed that in the presence of dried mucilage there was a decreased in DT, this may be due to effect of presence of dried mucilage. Similar results are observed when comparison was made between batch BB1 and BB2. The results reveal that tablets contain DCP and dried mucilage - batch BB2 showed substantial decrease in DT as compared to batch BB1 containing no disintegrant. A comparison of batch AB2 and BB2 shows that faster DT observed with batch BB2; this may be due to presence of dried mucilage and DCP. The slightly lower DT of DCP tablets with dried mucilage compared with lactose tablets with dried mucilage may be attributed to higher crushing strength and poor aqueous solubility. Lactose is a water-soluble excipient, and hence it works as an auxiliary disintegrant (Gohel et al. 2007). The purpose of the present study was to evaluate disintegrant property of dried mucilage. Hence, DCP and lactose both were selected for further studies.

Table 4. Results of lactose and DCP tablet with and without dried mucilage.

Batch Code	Crushing strength ± S.D. (kg/cm^2) (n=5)	Friability ± S.D. (%)(n=20)	DT ± S.D. (min) (n=6)
AB1	4.5 ± 0.100	0.65 ± 0.024	17.20 ± 1.170
AB2	5.5 ± 0.215	0.61 ± 0.021	04.06 ± 0.550
BB1	5.5 ± 0.115	0.55 ± 0.025	>100.00
BB2	6.0 ± 0.325	0.51 ± 0.025	03.54 ± 0.450

Formulations of DS with different quantity of dried mucilage and its different mode of addition were prepared, as shown in Table 2. The order of addition of disintegrant was internal + external (Batch AD1 to AD4 and BL1 to BL4) in ratio of 1:1. In these experiments, a

comparison of dried mucilage and starch was carried out at various concentration levels and effect of different filler (hydrophobic - DCP and hydrophilic - lactose filler) were studied, respectively, on parameters like DT, crushing strength and friability.

It was found that at every disintegrant concentration, tablets containing dried mucilage powder disintegrated faster than tablets containing starch. This may be due to more swelling capacity of dried mucilage powder, which absorbed more water and swelled to a greater extent than starch. There was considerably lesser time was observed in all batches with dried mucilage as compared to starch.

In this study different fillers were (hydrophobic – DCP and hydrophilic – lactose) used, it was found that tablets containing DCP (Batch AD1 to AD4) take lesser time to disintegrate as compare to tablets containing lactose (Batch BL1 to BL4), data shown in Table 5.

Table 5. Results of different parameters for tablets containing different filler & various percentage of disintegrant when intra+extragranular addition in ratio of 1:1.

Batches	Amount of DA* (%)	DT (min) (n=6)		Crushing Strength (kg/cm^2) (n=5)		Friability (%) (n=20)		CSFR/DT	
		DM	Starch	DM	Starch	DM	Starch	DM	Starch
AD1/ SD1	2	07.75 (0.055)	11.42 (0.120)	05.70 (0.100)	05.40 (0.153)	00.57 (0.006)	00.80 (0.040)	01.29	00.59
AD2/ SD2	5	03.58 (0.100)	10.33 (0.185)	05.20 (0.153)	05.20 (0.100)	00.61 (0.010)	00.82 (0.015)	02.38	00.61
AD3/ SD3	10	02.65 (0.095)	04.75 (0.100)	05.00 (0.153)	04.70 (0.058)	00.62 (0.015)	00.85 (0.015)	03.04	01.16
AD4/ SD4	15	02.47 (0.115)	04.42 (0.100)	04.50 (0.126)	04.50 (0.058)	00.68 (0.006)	00.85 (0.015)	02.68	01.20
BL1/ SL1	2	08.02 (0.075)	12.08 (0.165)	05.40 (0.058)	05.20 (0.058)	00.55 (0.006)	00.82 (0.015)	01.22	00.52
BL2/ SL2	5	04.00 (0.195)	11.58 (0.160)	05.00 (0.058)	05.00 (0.100)	00.58 (0.010)	00.82 (0.020)	02.16	00.53
BL3/ BL3	10	02.83 (0.160)	05.33 (0.125)	04.50 (0.153)	04.80 (0.100)	00.60 (0.006)	00.85 (0.015)	02.65	01.06
BL4/ SL4	15	02.63 (0.150)	05.08 (0.125)	04.00 (0.115)	04.50 (0.058)	00.65 (0.020)	00.88 (0.015)	02.34	01.01

A comparison of DT was made with lactose - hydrophilic filler and DCP - hydrophobic filler with different concentration of dried mucilage. It was found that lactose containing tablets required more time to disintegrate than DCP tablet. The solubility of filler in a tablet formulation affects both the rate and mechanism of tablet disintegration; the more soluble is the filler, the longer DT of the tablet. DCP is insoluble in water; therefore, the matrix can be easily and quickly broken up with no increase in void space, allowing the disintegrant to absorb water fast into the tablet, thus speeding up the disintegration process. Dried mucilage draw more water to saturate the increased void space, in order to exert the necessary pressure to break the granules, thus increases the DT. Since, lactose is soluble in nature or water soluble, it dissolves and increases the void space of the tablet, so it become more difficult for the disintegrating agent to push against the insoluble remaining matrix. Another reason for above results may be, DCP promoted water uptake by dried mucilage particles, whereas, lactose competes for water.

It is probable that lactose may have formed a diffusion barrier layer of saturated lactose solution around the tablet. This diffusion layer may impede the availability of water to the dried mucilage particles, slowing the rate of water uptake by the tablet. There is an absence of diffusion barrier to the dried mucilage particles since DCP is insoluble in water. The desired DT for lactose containing tablets can be obtained by optimizing the proportion of disintegrating agent is needed to overcome the negative effect (Chebli 1998). Similar results were observed with batches SD1 to SD4 and SL1 to SL4.

It was concluded that intra + extra-granular disintegrants in ratio of 1:1, a externally added disintegrant was initially exposed to the disintegrating fluid, which led to the absorption of large quantities of water and subsequent generation of higher swelling force. This force activates the active mechanism of disintegration at a faster rate. It was irrespective of different type of filler (Ferrari et al. 1996).

The results of crushing strength and friability showed, as the concentration of disintegrant increased there was decreased in crushing strength and increased friability. It was also found that comparatively harder tablets were formed with DCP (hydrophobic filler) as compared to lactose (hydrophilic filler) because DCP shows higher fragmentation propensity as compared to lactose. It was observed that, when the concentration of disintegrating agent was at 10% and 15% level, there was a marginal difference in DT. So, compromise between the amount of disintegrating agent and DT was done and it was concluded that at 10% level of dried mucilage was considered as optimized.

Final selection of optimized batch was carried out with help of CSFR/DT ratio. The CSFR/DT (crushing strength-friability / disintegration time) ratio has been suggested as a better index of measuring tablet quality than the crushing strength-friability ratio (CSFR) because in addition to measuring tablet strength (crushing) and weakness (friability), it simultaneously evaluates all negative effects of these parameters on DT (Upadrashta et al. 1992). In general, higher values of the CSFR/DT ratio indicate a better balance between binding and disintegration properties. It was observed that there was an increase in the CSFT/DT ratio with increasing dried mucilage concentration. At 10% level of dried mucilage, CSFT/DT ratio was increased while at 15% level there was a marginal decreased. It was also found that tablets containing lactose has lesser values for CSFR/DT ratio as compared to DCP. Data are shown in Table 5. From all results, Batch AD3 was concluded as optimized batch, where the level of disintegrant was 10% and hydrophobic filler DCP was used (Gohel et al. 2007).

All the tablets passed the uniformity of weight test.

To study the effect of storage condition on DT and crushing strength, tablets of optimized batch (batch AD3) was kept at 40^0C and 75% RH for three months. It was found that the crushing strength of tablets was decreased (from 5.0 to 4.62 kg/cm^2) and DT of tablets was increased (from 148 to 160 seconds). There was an insignificant difference in crushing strength and DT before and after stability study. Further dried mucilage can be explored as sustained release agent and gelling agent.

Conclusion

In present study, mucilage was extracted from dried seeds of *Blepharis edulis* Pers. Physico-chemical properties like flow property, compressibility, swelling ratio and hydration capacity was found to be superior than starch. It was concluded that as the concentration of dried mucilage increased, there was a decreased in DT. These results were similar with different type of filler like DCP and lactose containing tablet. Final selection of optimized batch was carried out with the help of CSFT/DT ratio. It can be concluded that dried mucilage could be alternative to starch in conventional tablet.

References

Anonymous. (2002). National Institute of Science and Communication. The Wealth of India, CSIR, New Delhi, India, pp. 162-163.

Aulton, M. E. (2002). Pharmaceutics– the science of dosage form design, Churchill Livingstone, USA, pp. 216 - 235.

Baveja, S. K., Rangarao, K. V. and Arora, J. (1988). Examination of natural gums and mucilages as sustaining materials in tablet dosage forms. *Ind. J. Pharm. Sci.* 50: 89-92.

Birit, M. and Laddha, K. S. (2001). Studies on *Blepharis edulis* seeds. *Indian Drugs* 38: 541-543.

Bowen, F. E. and Vadino, W. A. (1984). A Simple method for differentiating starches. *Drug Dev. Ind. Pharm.* 10: 505-511.

Chebli, C. and Cartilier, L. (1998). Cross-linked cellulose as a tablet excipient: A binding/disintegrating agent. *Int. J. Pharm.* 171: 101-110.

Chopra, R. N., Chopra, I. C. and Verma, B. S. (1969). Supplement to Glossary of Indian Medicinal Plants, CSIR, New Delhi, India.

Ferrari, F., Bertoni, M., Bonferoni, M. C., Rossi, S., Caramella, C. and Nystrom, C. (1996). Investigation on bonding and disintegration properties of pharmaceutical materials. *Int. J. Pharm.* 136: 71-79.

Fowler, P. D., Shadforth, M. F., Crook, P. R. and John, V. A. (1983). Plasma and synovial fluid concentration of diclofenac sodium and its major hydroxylated metabolites during long- term treatment of rheumatoid arthritis. *Eur. J. Clin. Pharmacol.* 25: 389–394.

Gbenga, A. and Oludele, A. I. (2003). Effects of starches on the mechanical properties of paracetamol tablet formulations II. Sorghum and plantain starches as disintegrants. *Acta Pharm. Sci.*-53: 313-320.

Gohel, M. C., Parikh, R. K., Brahmbhatt, B. K. and Shah A. R. (2007). Preparation and assessment of novel coprocessed superdisintegrant consisting of crospovidone and sodium starch glycolate: A Technical Note, *AAPS Pharm. Sci. Tech.* 8: E1-E7.

Gohel, M. C., Parikh, R. K., Brahmbhatt, B. K. and Shah, A. R. (2007). Improving the tablet characteristics and dissolution profile by using co-processed superdisintegrant: A Technical Note. *AAPS Pharm. Sci. Tech.* 8: E1-E6.

Gupta, G. D. and Gaud, R. S. (2000). Formulation and evaluation of nimesulide dispersible tablets using natural disintegrants. *Indian J. Pharm. Sci.* 62: 339-342.

Hardman, J. G. and Limbrid, L. E. (2006). Goodman's and Gilman's, The Pharmacological Basis of Therapeutics, McGraw Hill, New York, pp. 697-698.

Jograj, B. (1936 and 1940). Constituents of seeds of *Blepharis edulis* Pers. *J. Indian Chem. Soc.* 13: 109 and 17: 259.

Kirtikar, K. R. and Basu, B. D. (1999). Indian Medicinal Plants, International Book Distributors, India, pp. 1872-1873.

Kulkarni, G. T., Gowthamarajan, K., Brahmajirao, G. and Suresh, B. (2002). Evaluation of binding properties of selected natural mucilages. *J. Sci. Ind. Res.* 61: 529-532.

Lachman, L., Liebermann, H. A. and Kanig, J. L. (1987). The Theory and Practice of Industrial Pharmacy, Varghese Publishing House, India, pp. 293-344.

Patel, D. M., Prajapati, D. G. and Patel, N. M. (2007). Seed mucilage from *Ocimum americanum* Linn. As a disintegrant in tablets: Separation and evaluation. *Indian J. Pharm. Sci.* 69: 431-435.

Shangraw, R., Mitrejev, A. and Shah, M. (1980). A new era of tablet disintegrants. *Pharm. Technol.* 4: 49-57.

Srinivas, K., Prakash, K., Kiran, H. R., Prasad, P. M. and Rao, M. E. B. (2003). Study of O*cimum basilicum* and *Plantago ovata* as disintegrants in the formulation of dispersible tablets. *Indian J. Pharm. Sci.* 65: 180-183.

Upadrashta, S. M., Katikaneni, P. R. and Nuessle, N. O. (1992). Chitosan as a tablet binder. *Drug Dev. Ind. Pharm.* 18: 1701-1708.

Willis, J. V., Kendall, M. J. and Jack, D. B. (1981). The influence of food on the absorption of diclofenac after single and multiple oral doses. *Eur. J. Clin. Pharmacol.* 19: 33–37.

Received: 25.01.2009
Accepted: 15.05.2009