PROPERTIES OF DELONIX REGIA SEED GUM AS A NOVEL TABLET BINDER

GBADEGESIN E. ADETOGUN and GBENGA ALEBIOWU*

Department of Pharmaceutics, Faculty of Pharmacy, Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract: The mechanical and disintegration properties of paracetamol tablets formulated using Delonix regia seed gum (DRSG) as a binder have been studied in this work. Acacia BP (ACG) and tragacanth BP (TRG) were used as official gum standards. The mechanical properties, i.e. tensile strength (TS) and brittle fracture index (BFI), showed that with an increase in concentration of the gum binder, the tensile strength increased while the BFI was reduced. The crushing strength – friability/disintegration time ratio used to analyze the disintegration properties gave a rank order: tablets containing DRS G > tablets containing ACG > tablets containing TRG at 1%, w/w binder concentration while for higher binder concentrations, the rank order is: tablets containing ACG > tablets containing TRG > tablets containing DRS G. The results suggest that while Delonix regia seed gum may be useful as a binder, its use at a low concentration will improve the balance between the binding and disintegration properties of tablets when a faster disintegration is desired, while its use at a high concentration could serve the desire for a modified or sustained release tablet formulation.

Keywords: Delonix regia seed gum, gum binder, tensile strength, brittle fracture index, crushing strength – friability/disintegration time ratio

Binders are employed in pharmaceutical tablet formulation to provide adequate mechanical properties by promoting the bonding properties existing between the different components of a powder mix in a formulation (1). Various natural, semi-synthetic and/or synthetic substances like starches, cellulose and gums have been employed in pharmaceutical tablet formulation as binders (2). Gums are an example of hydrophilic substances employed in pharmaceutical solid dosage formulation mainly as binders.

In this work delonix gum (DRSG) obtained from the seed of Delonix regia (Bojer ex Hook) Raf., family: Fabaceae, was evaluated for its activity as a binder in a paracetamol tablet formulation in comparison with two standard gum binders: acacia BP and tragacanth BP using the mechanical properties of tensile strength and brittle fracture index, and the crushing strength – friability/disintegration time ratio. Paracetamol powder was chosen due to its poor compression properties which therefore, requires a binding agent in order to form good quality tablets.

The tensile strength (T) and brittle fracture index (BFI) are two mechanical properties which have been used in assessing the usefulness of new binders in a formulation (3, 4).

The crushing strength – friability/disintegration time ratio (CSFR/DT) of a tablet formulation is an index of measuring tablet quality which measures tablet strength (crushing strength) and weakness (friability), and simultaneously evaluates any negative effects of these parameters on disintegration time, DT (5). This index is also used to assess the usefulness of binders in a formulation.

EXPERIMENTAL

Materials

The materials used were: corn starch BP (BDH Chemicals Ltd., Poole, U.K.), lactose (AB Knight and Co., London, U.K.), paracetamol powder BP (supplied by Gawo Pharmaceuticals Ltd., Lagos, Nigeria), tragacanth powder B.P. (Kimpton Brothers Ltd., London, U.K.), acacia gum (Hopkin and Williams Ltd., Chadwell Heath, Essex, England), Delonix regia seed gum extracted from the seed of unripe but matured pods of Delonix regia (Bojer ex Hook) Raf., family Fabaceae, as described (6) in our

* Corresponding author: e-mail: galebiowu@oauife.edu.ng ; galebiowu@rediffmail.com, mobile: +23480-573-45610.
Methods

Determination of swelling capacity of the gums

The method described by Bowen and Vadino (7) was used. Two grams of each powdered gum was poured gently into a 100 mL measuring cylinder and the bulk volume (\(V_0\)) measured. Distilled water was added to disperse the gum (at room temperature), and subsequently, made up to the 100 mL mark. The dispersion was allowed to stand for 24 h when the volume (\(V_1\)) of the swollen gum was read. The swelling capacity was calculated as \(\frac{V_1}{V_0}\). Determinations were done in triplicate.

Preparation of granules

Batches (300 g) of a basic paracetamol – lactose formulation (84.75 : 15.25 %, w/w) were dry-mixed for 5 min in a planetary mixer (Hobart model N50 planetary mixer, Hobart, Canada). The mixture was moistened with sufficient quantity of distilled water or appropriate amounts of gum mucilage to produce granules containing various concentrations of gum. Massing continued for 5 min, the wet masses were granulated manually by passing them through a 16-mesh sieve (1000 \(\mu\)m), dried in a hot air oven for 18 h at 50 OC, and resieved through a 16-mesh sieve (1000 \(\mu\)m). The granules were stored in air-tight containers before use. The granular density of each batch was determined by the pycnometer method with acetone as the displacement fluid. This same procedure was repeated for batches containing tragacanth and aca- cia gum binders.

Preparation of tablets

Tablets (590 mg) were prepared from the granules by compressing them using a 12.5 mm die and flat faced punches for 30 s with predetermined loads on a model C, hydraulic hand press (Carver Inc., Menomonee Falls, USA). Tablets with a hole (1.5 mm diameter) at their center were made using an upper punch with a hole and a lower punch with a pin (4). After ejection, the tablets were stored in a desiccator for 24 h to allow for elastic recovery and hardening in order to prevent false low yield values. The tablets’ weights and dimensions were determined to within ± 1 mg and 0.01 mm, respectively, and their relative densities (\(D\)) were calculated using the equation:

\[
D = \frac{m}{V_1 \rho_s}
\]

where \(V_1\) is the volume (cm\(^3\)) of the tablet volume (including the hole when present) and \(\rho_s\) is the particle density of the solid material.

Friability test

This was determined using an Erweka friabilator (Erweka Apparatebau, Offenbach/Main, Germany). Ten weighed tablets were placed inside the drum and allowed to tumble for 4 min at a speed of 25 rpm, the tablets were then weighed and the loss in weight was expressed as a percentage of the initial weight. Determinations were done in triplicate.

Crushing strength

The load required to break the tablet (crushing strength) at room temperature into two equal halves was determined by the application of a diametrical force using the Monsanto hardness tester (Monsanto Chemical, USA). Tablets with signs of lamination or capping were not used. The results were expressed as the mean of three determinations.

Disintegration test

Tablet disintegration time (\(DT\)) was determined in distilled water at 37 ± 0.5°C in a BP Manesty (Manesty Machines, U.K.) disintegration test unit. Six tablets were tested at each relative density and the results were expressed as the mean of three determinations.
Properties of delonix regia seed gum as a novel... 435

Figure 1. Plot of Log tensile strength versus relative density for paracetamol tablets containing 2% w/w of DRSG (●), TRG (▲) or ACG (◆). Tablets without a hole (——), tablets with a hole (---).

Figure 2. Effect of relative density on crushing strength of paracetamol tablets containing 2% w/w of Delonix regia seed gum (●), acacia gum (∗∗), and tragacanth gum (▲).

Figure 3. Effect of relative density on friability of paracetamol tablets containing 2% w/w of Delonix regia seed gum (●), acacia gum (∗∗), and tragacanth gum (▲).

Figure 4. Effect of relative density on disintegration time of paracetamol tablets containing 2% w/w of Delonix regia seed gum (●), acacia gum (∗∗), and tragacanth gum (▲).
Statistical analysis

Statistical analysis was done to compare the effects of Delonix regia seed gum and those of the official gums (acacia and tragacanth) employed as standards in this study using the $t$-test. At 95% confidence interval, the p value lower than or equal to 0.05 was considered the limit of significance.

RESULTS AND DISCUSSION

The results of the tensile strength tests on the paracetamol tablets were found to fit the general equation:

$$\log T \text{ (or } T_0) = AD + B \quad \text{Eq. 4.}$$

with a correlation coefficient = 0.956. A and B are the constants that depend on the type and concentration of the gum binder present in the formulation and on whether the tablet has a hole in it or not, and $D$ is the relative density of the tablets. Representative plots for tablets made from formulations containing 2% w/w of the binder are presented in Fig. 1.

The tensile strength of a tablet with a hole was less than that of the same tablet without a hole at all the relative densities considered, the hole acting as a stress concentrator (3). The plot of the effect of gum binder type on the $T$ shows that tablets prepared with DRSG had higher $T$ than those containing TRG or ACG in that order. This observation is in agreement with previous reports (2, 4, 9), and could be due to the fact that the inclusion of DRSG in a tablet formulation would produce a higher amount of total plastic deformation during compression as shown in an earlier report (6), this in effect would result into the formation of stronger tablets.

Table 1. Swelling index values of the gums

<table>
<thead>
<tr>
<th>Gum</th>
<th>Delonix regia seed gum</th>
<th>Tragacanth gum</th>
<th>Acacia gumseed gum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swelling index (± SEM)</td>
<td>17.840 ± 0.601</td>
<td>13.630 ± 0.687</td>
<td>Soluble</td>
</tr>
</tbody>
</table>

*the mean ± SEM, n = 3

Table 2. Tensile strength and brittle fracture index for paracetamol tablet formulations containing different concentration of ACG, TRG, or DRSG at 0.90 relative density

<table>
<thead>
<tr>
<th>Gum Binder</th>
<th>Conc. (% $\gamma_v$)</th>
<th>$T$ (MNm$^{-2}$)*</th>
<th>$T_0$ (MNm$^{-2}$)*</th>
<th>BFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.0</td>
<td>0.792 ± 0.087</td>
<td>0.285 ± 0.034</td>
<td>0.891</td>
</tr>
<tr>
<td>ACG</td>
<td>1.0</td>
<td>1.748 ± 0.133</td>
<td>0.854 ± 0.060</td>
<td>0.524</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>2.148 ± 0.075</td>
<td>1.106 ± 0.090</td>
<td>0.471</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>2.788 ± 0.079</td>
<td>1.534 ± 0.066</td>
<td>0.408</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>3.050 ± 0.034</td>
<td>1.990 ± 0.003</td>
<td>0.267</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>3.110 ± 0.100</td>
<td>2.204 ± 0.137</td>
<td>0.206</td>
</tr>
<tr>
<td>TRG</td>
<td>1.0</td>
<td>1.964 ± 0.059</td>
<td>0.874 ± 0.068</td>
<td>0.623</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>2.686 ± 0.040</td>
<td>1.208 ± 0.035</td>
<td>0.612</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>2.968 ± 0.062</td>
<td>1.637 ± 0.006</td>
<td>0.407</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>3.063 ± 0.207</td>
<td>1.940 ± 0.065</td>
<td>0.289</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>3.403 ± 0.181</td>
<td>2.302 ± 0.064</td>
<td>0.239</td>
</tr>
<tr>
<td>DRSG</td>
<td>1.0</td>
<td>1.459 ± 0.074</td>
<td>0.681 ± 0.035</td>
<td>0.571</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>2.890 ± 0.157</td>
<td>1.464 ± 0.108</td>
<td>0.487</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>3.071 ± 0.079</td>
<td>1.791 ± 0.006</td>
<td>0.357</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>3.239 ± 0.070</td>
<td>2.121 ± 0.001</td>
<td>0.263</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>3.330 ± 0.191</td>
<td>2.292 ± 0.001</td>
<td>0.226</td>
</tr>
</tbody>
</table>

*the mean ± SEM, n = 3. $T$ – tensile strength of tablets without a hole. $T_0$ – tensile strength of tablets with a hole. BFI – brittle fracture index.
Properties of delonix regia seed gum as a novel... 437

formation of the formulation and consequently to the formation of more solid bonds with an increase in tablet strength and resistance to fracture (2, 9). Many reasons have been adduced to this effect such as the melting of the asperities and of the binding agents due to the generation of heat during compression. These asperities would solidify on cooling to form strong solid bonds between the particles. The degree of bonding would therefore depend on the amount of the binding agent present (10). Also, being soft and plasto-elastic, binders undergo plastic and elastic deformation under high compression pressure and are forced into the interparticulate spaces. This increases the area of contact between particles due to further densification and formation of more solid bonds (4, 11).

The $BFI$ values at a relative density of 0.90 (Table 1) indicate that as the concentration of binder increases, the $BFI$ values decrease. This implies that with the increase in concentration of gum binder, there is an increased reduction in the propensity to cap or laminate by the tablets. This could be due to the presence of binder at interparticulate junctions which would facilitate plastic deformation for the relief of localized stresses (4, 11).

The crushing strength values for paracetamol tablets containing different concentrations of gum binder (ACG, TRG or DRSG) at a relative density of 0.90 is presented in Table 3. The result shows a general increase in the crushing strength value as the concentration of the gum binder in the tablet increases. This could be due to the fact that there exists more particle – particle contact points, particularly with the particles of the gum, which help to create more solid bonds hence, higher crushing strength values were obtained. It was also observed that as the relative density increased, the crushing strength of the tablets increased (Fig. 2). This could be due to the decrease in intra-granular and inter-granular voids (porosity) and a subsequent increase in the number of contact points, which would lead to an increase in the degree of bonding between the particles (11, 12). It is well known that friability tends to decrease with an increase in the crushing strength and relative density of tablets, as shown in Table 3 and Fig. 3, and could be due to the reasons for an increase in crushing strength.

The effect of the concentration of gum binder (ACG, TRG or DRSG) on the disintegration time ($DT$) of the tablet is shown in Table 3 for relative density of 0.90. An increase in concentration led to an increase in the disintegration time. Also, increasing the relative density of the tablets led to an increase in the disintegration time (Fig. 4). Similar observations have already been reported (5). The increase in $DT$ with increasing gum binder concentration could be due to the formation of a thick film of gum mucilage as the tablet comes into contact with the disintegrating fluid. This film would be converted into a mucilaginous viscous barrier. Also,

Table 3. Effect of gum binder on the crushing strength, disintegration time (DT), friability and crushing strength – friability/disintegration time ratio (CSFR/DT) of paracetamol tablets at 0.90 relative density

<table>
<thead>
<tr>
<th>Gum</th>
<th>Conc. (% w/w)</th>
<th>Crushing strength (N)*</th>
<th>Friability (%)*</th>
<th>DT (min)*</th>
<th>CSFR/DT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.0</td>
<td>39.028 ± 0.749</td>
<td>7.666 ± 0.139</td>
<td>0.524 ± 0.045</td>
<td>9.716</td>
</tr>
<tr>
<td>ACG</td>
<td>1.0</td>
<td>67.948 ± 1.021</td>
<td>4.302 ± 0.006</td>
<td>2.044 ± 0.006</td>
<td>2.076 ± 0.290</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>83.539 ± 0.567</td>
<td>1.856 ± 0.007</td>
<td>33.730 ± 2.090</td>
<td>1.284</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>83.954 ± 0.566</td>
<td>1.483 ± 0.008</td>
<td>45.815 ± 10.535</td>
<td>1.292</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>87.759 ± 0.283</td>
<td>1.435 ± 0.005</td>
<td>47.287 ± 12.454</td>
<td>1.333</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>90.430 ± 0.749</td>
<td>1.435 ± 0.005</td>
<td>47.287 ± 12.454</td>
<td>1.333</td>
</tr>
<tr>
<td>TRG</td>
<td>1.0</td>
<td>72.771 ± 0.491</td>
<td>2.717 ± 0.006</td>
<td>8.978 ± 3.659</td>
<td>2.984</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>79.080 ± 0.283</td>
<td>2.128 ± 0.005</td>
<td>66.247 ± 7.291</td>
<td>0.561</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>89.399 ± 0.491</td>
<td>1.859 ± 0.009</td>
<td>83.308 ± 4.147</td>
<td>0.577</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>111.362 ± 1.723</td>
<td>1.260 ± 0.002</td>
<td>96.305 ± 4.821</td>
<td>0.918</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>128.192 ± 1.499</td>
<td>1.146 ± 0.004</td>
<td>98.678 ± 9.560</td>
<td>1.134</td>
</tr>
<tr>
<td>DRSG</td>
<td>1.0</td>
<td>70.028 ± 0.567</td>
<td>3.937 ± 0.013</td>
<td>1.031 ± 0.021</td>
<td>17.263</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>81.298 ± 1.234</td>
<td>4.350 ± 0.004</td>
<td>58.229 ± 1.983</td>
<td>0.321</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>96.436 ± 0.566</td>
<td>2.455 ± 0.007</td>
<td>84.552 ± 0.986</td>
<td>0.465</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>107.449 ± 0.566</td>
<td>1.531 ± 0.004</td>
<td>90.896 ± 1.319</td>
<td>0.772</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>116.146 ± 1.499</td>
<td>1.458 ± 0.003</td>
<td>97.029 ± 5.084</td>
<td>0.821</td>
</tr>
</tbody>
</table>

* the mean ± SEM, n = 3.
the decrease in porosity as the relative density of the tablet increases due to the promotion of interparticulate bond by the gum binder, coupled with the mucilaginous barrier formed by the swelling gum could slow down water penetration by capillary flow of the disintegrating fluid into the tablets. Consequently, swelling and development of the active mechanism of disintegration would be reduced (12, 13).

Generally, except for tablets containing the gum binder (ACG, TRG or DRSG) at a concentration of 1% w/w, other tablets containing 2% w/w and higher concentrations of the gum gave disintegration times that were higher than the official limit of less than 15 min. for uncoated tablets. The observed sharp increases in the disintegration time of the tablet as the concentration of the gum binder increased from 1% w/w is a result of an increase in bond formation with an increase in binder concentration (10). The high DT values recorded at the higher gum binder concentrations and the swelling capacity result (Table 1) suggest the probable usefulness of DRSG in the formulation of a sustained/modified release tablet dosage form.

The CSFR/DT increased with an increase in gum concentration (Table 3) except for those tablets containing tragacanth for which no trend was observed. However, tablets containing 1% w/w of the gum – binder (ACG, TRG or DRSG) had the highest CSFR/DT value. The rank order of CSFR/DT values for the tablets containing 1% w/w was: tablets containing DRSG > tablets containing ACG > tablets containing TRG, thus implying that DRSG will improve the balance between binding and disintegration of the tablets more than those of ACG and TRG. The low DT and high CSFR/DT values obtained at 1% w/w concentration of the gum binder could be due to the high concentration of the diluent, lactose, whose concentration in the formulation decreases as the concentration of gum binder increases. Lactose is soluble in water, its presence in the tablet formulation would facilitate water penetration into tablet capillaries as it gets dissolved in the medium and therefore, promoting faster disintegration by annihilation of the hydrogen bonding existing between particles (10).

**CONCLUSION**

The results obtained in this work indicate that the use of DRSG in paracetamol tablet formulation would serve the purpose of a binder because the results of the mechanical property compares favorably well with those of tablets containing ACG or DRSG. The study also shows that the use of the gums (acacia, tragacanth or DRSG) at a lower concentration of 1% w/w gave better quality tablets in terms of the balance between the binding and disintegration properties of the tablets as shown by the CSFR/DT values obtained. Finally, the result obtained from this study suggests that DRSG would serve as a suitable alternative binder to the two official gums used as standard.

**REFERENCES**


*Received: 16.12.2008*