Carbohydrate Polymers 83 (2011) 506–511

Contents lists available at ScienceDirect

Carbohydrate Polymers

journal homepage: www.elsevier.com/locate/carbpol

Preliminary study of *Anacardium occidentale* gum as binder in formulation of paracetamol tablets

K. Gowthamarajan[b,*], G. Kanaka Phani Kumar[b], Narayan Babulal Gaikwad[a], B. Suresh[b]

[a] Department of Pharmaceutics, School of Pharmaceutical Sciences, Karpagam University, Coimbatore, Tamilnadu, India
[b] Department of Pharmaceutics, JSS college of Pharmacy, Ooty 643001, Tamilnadu, India

ARTICLE INFO

Article history:
Received 11 March 2010
Received in revised form 30 July 2010
Accepted 9 August 2010
Available online 17 August 2010

Keywords:
Anacardium occidentale
Gum
Binding efficacy
Paracetamol

ABSTRACT

An attempt was made to investigate the binding efficacy of cashew nut tree gum in tablet formulation in comparison with standard binders such as acacia and polyvinyl pyrrolidone (PVP K-30). The paracetamol granules were prepared with different concentration of the gum as binder by wet granulation method. The granules were evaluated and found to be satisfactory for preparing compressed tablets. The tablets were prepared from the granules by hydraulic hand press and evaluated for volume of tablet, apparent density, porosity, relative density (or) packing fraction, percentage elastic recovery, tablet physical stability, content uniformity, weight variation, hardness, friability, disintegration time, *in vitro* dissolution studies and surface analysis by SEM. Formulations containing the minimum concentration of 2.5% cashew nut tree gum as binding agent show short disintegration and fast dissolution including good physico-mechanical properties. The result suggests that cashew nut tree gum can be used as an alternative binder with 2.5% concentration to produce a tablet of better mechanical strength and dissolution profile of particular drug substance.

1. Introduction

Pharmaceutical tablets must have the mechanical strength to withstand the rigors involved in manufacture, packaging, transportation, dispensing and in the hand of the user. They must also release the drug content in the gastrointestinal tract for absorption. Binding agents are used in tablet formulations to impart the structural strength in order to improve the compressibility and flow of the formulation. Wet granulation is the most popular method for incorporating binder solution. Not only is wet granulation used extensively in the pharmaceutical industry to produce granules of fine powder but also to insure thorough mixing of different ingredients. A number of binding agents are available for tablet formulations. However, different binding agents can be useful in achieving various tablet mechanical strength and drug release properties for different pharmaceutical purposes. Thus, the development of new excipients for potential use as binders continues to be of interest and a number of plant gums have been used as binding agents in tablet formulation. They have been found useful in producing tablets with different mechanical strength and drug release properties for different pharmaceutical purposes. The fact that these gums are non-toxic and widely available has made them of continuing interest (Banker & Anderson, 1986).

Cashew nut tree gum is obtained from the incised trunk of the tree *Anacardium occidentale* (Family: *Anacardeaceae*). The gum is a complex polysaccharide comprising galactose, arabinose, rhamnose, glucose, glucurine acid and other sugar residues. It is used primarily in industrial application for binding books, as adhesives for envelopes, labels, stamps and posters. It is also used as an additive in the manufacture of chewing gum because of its thickening power. It is used as a jelling agent in canned food and jellies for fruits jam (Azeez, 2005; de Paula & Rodrigues, 1995; de Paula, Heatley, & Budd, 1998). Literature survey reveals that cashew nut tree gum had been studied as binder (Onunkwo & Okoye, 1997; Okoye, Onyekweli, Ohwoavworhua, & Kunle, 2009). Gelling property of cashew gum in aceclofenac gel also had been studied (Kumar, Patil, Patil, & Paschapur, 2009). This study investigated the efficacy of cashew nut tree gum as a binding agent for paracetamol tablets to determine their physical properties, mechanical strength and release profiles. Here, acacia and polyvinyl pyrrolidone (PVP K-30) were used as standard binders. Paracetamol, a drug with known capping and lamination problems that normally requires a binder and disintegrant to form satisfactory tablets, was used as the model substrate.

* Corresponding author. Tel.: +91 9443089812; fax: +91 4232442937.
E-mail addresses: gowthamsan@rediffmail.com, gowthamsang@gmail.com (K. Gowthamarajan).

0144-8617/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.carbpol.2010.08.010

Table 1
Formulation of different batches of paracetamol tablets using cashew gum, PVP K-30[a], acacia as binders.

	Batch code											
	F1[b]	F2[b]	F3[b]	F4[b]	F5[c]	F6[c]	F7[c]	F8[c]	F9[d]	F10[d]	F11[d]	F12[d]
Drug	250	250	250	250	250	250	250	250	250	250	250	250
Cashew gum	12.5	25	37.5	50	–	–	–	–	–	–	–	–
PVP K-30	–	–	–	–	12.5	25	37.5	50	–	–	–	–
Acacia	–	–	–	–	–	–	–	–	12.5	25	37.5	50
Corn starch	100	100	100	100	100	100	100	100	100	100	100	100
Lactose	122.5	110	97.5	85	122.5	110	97.5	85	122.5	110	97.5	85
Magnesium stearate	10	10	10	10	10	10	10	10	10	10	10	10
Talc	5	5	5	5	5	5	5	5	5	5	5	5
Total (mg/tablet)	500	500	500	500	500	500	500	500	500	500	500	500

[a] PVP K-30 indicates polyvinyl pyrrolidone.
[b] Formulation batches F1, F2, F3 and F4 contains Cashew gum with 2.5, 5, 7.5 and 10% binder, respectively.
[c] Formulation batches F5, F6, F7 and F8 contains PVP K-30 with 2.5, 5, 7.5 and 10% binder, respectively.
[d] Formulation batches F9, F10, F11 and F12 contains acacia with 2.5, 5, 7.5 and 10% binder, respectively.

2. Materials and methods

2.1. Materials

Crude cashew nut tree gum was collected from various places of Andhra Pradesh (India). Paracetamol was obtained from Tablets India Ltd. (Chennai, India). Cornstarch, lactose monohydrate, polyvinyl pyrrolidone (PVP K-30), acacia were supplied by SD Fine Chemicals (Chennai, India). All chemicals used in the study were of analytical grade.

2.2. Isolation of water-soluble fraction of cashew nut tree gum

The collected crude cashew nut tree gum (100 g) was ground by using mortar and pestle. The ground gum was dissolved in water (300 ml). The solution was filtered through several folds of muslin cloth and the filtrate was collected. To the filtrate, alcohol (90%, v/v) was added in 1:1 ratio and precipitate was obtained. The precipitate was filtered and dried in a hot air oven at 45 °C. 100 g of powder obtained was dissolved in 100 ml of water, filtered through several folds of muslin cloth. Then the filtrate was centrifuged at 3000 rpm for 10 min and the supernatant fluid was collected, evaporated and dried to obtain solid mass, which was ground. This mass was passed through sieve no. 80 and stored in an airtight container for further studies.

2.3. Characterization of gum

The gum was characterized for surface analysis, pH, surface tension and viscosity. The surface analysis was determined by scanning electron microscope (SEM, Hitachi S-2400, Japan). The gum was evaporated with carbon and then sputtered with gold to make the sample electrically connected. Carbon was layered to a thickness of approximately 10 nm and gold was layered to approximately 25 nm. The pH of the gum solution (1%, w/v) was determined using digital pH meter (pH system 361, Systronics, Mumbai). The surface tension of the gum solution (0.1%, w/v solution) was determined by drop count method, using stalagmometer. The viscosity of the gum (2%, w/v) was determined using RVDV II+ viscometer (Brookfield Engineering India, Mumbai). Prior to the study, the sample was filled in the sample adapter and allowed to stand for 24 h undisturbed for complete relaxation of the sample (Verma & Balkishen, 2002). Viscosity was determined using spindle S28, at 50 rpm using a constant temperature bath maintained at 20 °C.

2.4. Preparation and evaluation of granules

The different batches F1–F12 (100 g) of paracetamol granules were prepared using different concentration of gum, acacia, and PVP K-30 by wet granulation technique using the formula as shown in Table 1. Here, acacia and PVP K-30 were used as standard binders for comparison. The desired quantities of paracetamol, lactose and cornstarch were dry mixed for 5 min using mortar and pestle, then moistened with appropriate amount of binder solution, which was prepared with different concentration of gum and with the selected standard binders massed separately with sufficient amount of water. Massing was continued for 5 min and the wet mass was granulated by passing it manually through a mesh 16 sieve and dried in a hot air oven for 3–4 h at 50 °C. Dried granules were sieved through a mesh 16/22 sieve and granules were collected which were passed through 22 sieve for further studies. The granules were evaluated for surface analysis (SEM), bulk density, true density, apparent density, particle size distribution, porosity, Carr's index and Hausner ratio. The surface character was analyzed by scanning electron microscope as the procedure mentioned in characterization of gum. The bulk density of the sample was calculated by mass of powder/bulk volume of powder. A given quantity of the sample was transferred to a measuring cylinder and was tapped mechanically, using a bulk density apparatus (Electrolab, Mumbai, India) until a constant volume was obtained, which was referred as bulk volume (V_b). True density of the sample was determined by using the liquid displacement method and acetone was used as the liquid for displacement. The particle size distribution was determined by sieve analysis (Martin, Bustamante, & Cheen, 2002). The percentage porosity of the granules was calculated by ((bulk density − true density)/bulk density) × 100. Carr's index was calculated by ((initial volume − tapped volume)/tapped volume) × 100 (Car, 1965). The Hausner ratio was determined by bulk tapped density/bulk loose density (Hausner, 1967). All experiments were made in triplicate.

2.5. Evaluation of binding efficacy of gum

Tablets (500 mg) were prepared from the prepared granules by compressing them for 1 min with predetermined load (10 Ton) using a hydraulic hand press (KBr press, Tsi Tchno, Mumbai). Before each compression, the die (13.1 mm) and the flat-faced punches were lubricated with a 1% (w/v) dispersion of magnesium stearate in chloroform. After ejection, the tablets were stored over silica gel for 24 h to allow for hardening and elastic recovery. The prepared tablets were evaluated for volume of tablet, apparent density,

Table 2
Evaluation of paracetamol granules.

Parameters	Cashew nut tree gum[a]				PVP K-30[b]				Acacia[c]			
% of binder (batch)	2.5% (F1)	5% (F2)	7.5% (F3)	10% (F4)	2.5% (F5)	5% (F6)	7.5% (F7)	10% (F8)	2.5% (F9)	5% (F10)	7.5% (F11)	10% (F12)
Bulk density (g/ml)	0.440 (0.011)	0.454 (0.021)	0.395 (0.009)	0.440 (0.011)	0.370 (0.000)	0.344 (0.000)	0.390 (0.017)	0.420 (0.017)	0.416 (0.000)	0.454 (0.000)	0.484 (0.013)	0.416 (0.000)
True density (g/cm^3)	0.154 (0.023)	0.155 (0.089)	0.136 (0.018)	0.152 (0.029)	0.112 (0.000)	0.096 (0.078)	0.129 (0.089)	0.104 (0.068)	0.133 (0.018)	0.133 (0.023)	0.129 (0.098)	0.15 (0.06)
Porosity (%)	65.0 (0.011)	65.8 (0.023)	65.5 (0.07)	65.4 (0.089)	69.7 (0.019)	72.0 (0.021)	66.9 (0.023)	75.2 (0.017)	68.0 (0.038)	70.7 (0.052)	73.3 (0.023)	63.9 (0.048)
Particle size distribution (mm)	0.4592 (0.002)	0.4785 (0.0003)	0.4395 (0.0003)	0.4495 (0.0003)	0.4953 (0.0001)	0.5204 (0.0002)	0.4418 (0.0003)	0.4833 (0.0003)	0.4746 (0.0005)	0.4355 (0.0003)	0.4521 (0.0003)	0.4260 (0.0002)
Apparent density (g/ml)	0.394 (0.018)	0.379 (0.020)	0.357 (0.019)	0.389 (0.021)	0.319 (0.000)	0.315 (0.000)	0.337 (0.028)	0.370 (0.021)	0.365 (0.000)	0.411 (0.000)	0.428 (0.018)	0.348 (0.000)
Haunser ratio	1.16 (0.018)	1.19 (0.020)	1.10 (0.019)	1.13 (0.021)	1.15 (0.000)	1.09 (0.000)	1.15 (0.028)	1.13 (0.021)	1.13 (0.000)	1.10 (0.000)	1.13 (0.018)	1.19 (0.000)
Carr's index (%)	10.6 (0.018)	16.5 (0.018)	9.62 (0.09)	11.55% (0.023)	13.78 (0.032)	8.43 (0.052)	13.5 (0.053)	11.90 (0.017)	12.2 (0.121)	9.47 (0.093)	11.5 (0.02)	16.34 (0.018)

Values in parentheses represent SD, $n = 3$.
[a] Formulation batches F1, F2, F3 and F4 contains cashew gum with 2.5, 5, 7.5 and 10% binder, respectively.
[b] Formulation batches F5, F6, F7 and F8 contains PVP K-30 with 2.5, 5, 7.5 and 10% binder, respectively.
[c] Formulation batches F9, F10, F11 and F12 contains acacia with 2.5, 5, 7.5 and 10% binder, respectively.

porosity, packing fraction or relative density, percentage elastic recovery, tablet physical stability, content uniformity, weight variation, hardness, friability, disintegration time, *in vitro* dissolution studies and surface analysis by SEM. Apparent density was calculated by mass/volume of tablet. Tablet weight and dimensions were taken. The relative density or packing fraction (P_f) was calculated using weight of tablet/volume of tablet × density of granules (Odeku & Itiola, 2003). Percent porosity was calculated according to the following formula:

$$\text{Percent porosity} = \frac{(V_b - V_t)}{V_b \times 100}$$

where V_b is the apparent tablet volume calculated from tablet dimensions and V_t is the true volume calculated from the true density of the material. The difference $V_b - V_t$ represents the void volume. The percentage elastic recovery was assessed using equation:

$$\text{ER} = \left(\frac{h - h_c}{h_c}\right) \times 100$$

where h is the thickness of tablet after 24 h and h_c is thickness of tablet after ejection (Jain, 1999). Tablet physical stability of tablet was calculated by using hardness/disintegration × friability ratio (Adebayo & Itiola, 2003). The hardness of the tablets was determined using a Monsanto hardness tester (Cadmach, Ahmedabad, India). The percentage of friability, disintegration, content uniformity and dissolution were performed by following the official method given in USP (United Sates Pharmacopeia-24, 2000). The percentage of friability of the tablets was determined using Roche tablet friabilator (Indian Equipment Corporation, Mumbai, India) operated at 25 rpm for 4 min (Akihiko, Onishi, Yamamoto, & Machida, 2006). Disintegration time was determined in distilled water at 37 ± 1 °C using disintegration apparatus (Veego Equipments, Mumbai, India). The rate of dissolution of paracetamol from the tablets was studied in a rotary paddle USP (XXIII) apparatus II (Electrolab, Mumbai, India) operated at 50 rpm. The dissolution medium was 900 ml phosphate buffer at pH 5.8 at 37 ± 0.5 °C. At specified time intervals, 5 ml samples were withdrawn and immediately replaced with 5 ml samples of fresh buffer solution maintained at the same temperature. The amount of paracetamol in each sample was analyzed spectrophotometrically with UV-160A recording spectrophotometer (Shimadzu India, Chennai, India) at 243 nm. All parameters were made in triplicate.

3. Result and discussion

The gum was purified using water as solvent and alcohol 90% (v/v) as non-solvent. The yield was 70% (w/w). Water-soluble portion was separated from purified gum. The water-soluble gum was used as binder for developing paracetamol oral uncoated solid dosage form. The water-soluble gum was characterized for surface characters by SEM, pH, viscosity, surface tension to assess the gum as excipient (binder) for developing paracetamol tablets. The scanning electron microscopy microphotograph showed that the gum was smooth and crystalline in nature as shown in Fig. 1. The pH of the gum solution (1%, w/v) was 4.31, this falls within natural pH of *Acacia senegal* with a range of 3.8–4.9 (Azeez, 2005), which indicates that the gum was suitable for solid oral dosage form. Viscosity and surface tension of the gum were 4.2 Ns/m^2 and 13.1870 dyne/cm, respectively. The lower viscosity and surface tension of gum probably enabled better penetration and spreading over paracetamol powder during wet massing, thereby producing more porous granules, evidenced by SEM microphotograph as shown in Fig. 2. The characterized gum was selected as an excipient for preparing tablets to find out the binding efficacy associated with paracetamol. The gum was selected from natural sources as binder

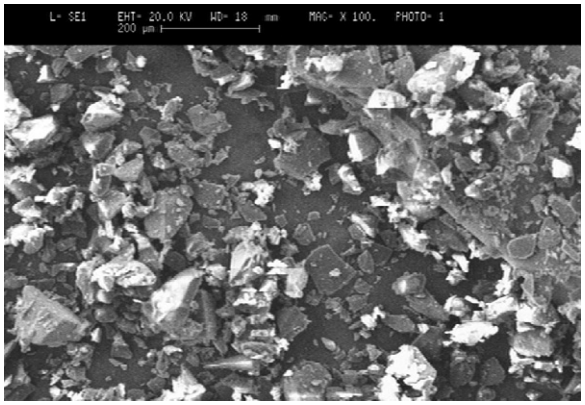

Fig. 1. Microphotograph depicting SEM cashew nut tree gum.

due to its distinguished characters such as low cost, abundant availability, ease of isolation, stickiness, surface tension and viscosity. The binding efficacy of the gum was compared with standard binders such as, acacia and PVP K-30 using different concentrations such as 2.5, 5, 7.5, and 10% (w/w). The twelve batches F1–F12, each batch of 100 g of granules were prepared using the formula as shown in Table 1 by wet granulation method. The prepared granules were evaluated for surface analysis by SEM microphotograph, bulk density, true density, porosity, Carr's index and Hausner ratio. The results for granules evaluation are shown in Table 2. The surface character of the prepared granules with 2.5% of gum (F1) was observed by SEM microphotograph as shown in Fig. 2, which indicates that the granules have irregular shape and are highly porous in nature. There was no significant difference in their bulk densities, true densities, apparent densities and porosity in all the prepared granules. Particle size distribution of granules was within size range of 0.4355–0.5204 mm. The average particle size of granules was 0.4629 mm. As per values indicated in Table 2 granules showed more intimate packing, better die filling during compression, which was further evidenced by Carr's index and Hausner ratio. According to literature data (Banker & Anderson, 1986), excellent flow properties had seen for granules with a Carr's index between 5 and 15% and a Hausner ratio below 1.25. All the formulations had a Carr's index between 8.43 and 16.4% while their Hausner ratios were below 1.25. Friability values of the granules prepared with gum were less than acacia and PVP K-30. Friability values of granules prepared with 2.5% (F1) and 5% (F2) of gum, which were comparable with granules prepared with PVP K-30 in the concentration 7.5% (F7) and 10% (F8). This implies that lower concentration of 2.5% of gum might be used as ideal concentration.

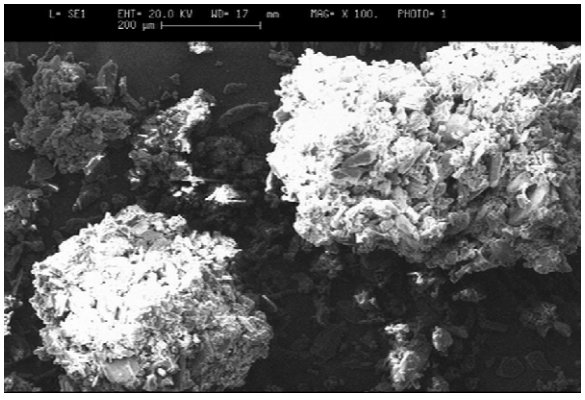

Fig. 2. Microphotograph depicting SEM of paracetamol granules prepared with 2.5% of cashew nut tree gum.

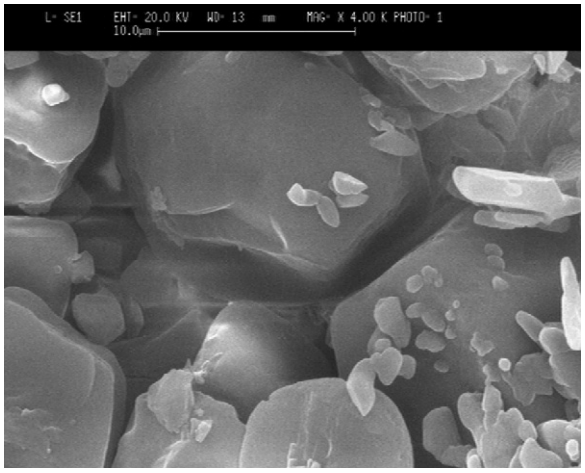

Fig. 3. Microphotograph depicting SEM of tablet without binding agent.

Volume of tablet results showed better consolidation of granules producing more cohesive tablet compact. Apparent density of tablet increased with increase in concentration of gum, but in case of PVP K-30 and acacia, values were almost identical. The values of relative densities or packing fraction, which represents the degree of initial packing in the die as a result of die filling, increased with increased concentrations of the binders. Formulations containing cashew nut tree gum showed higher values than formulations containing PVP K-30 and acacia. This indicates that formulations containing gum (F1–F4) exhibited a higher degree of packing in the die because of better die filling than formulations containing PVP K-30 (F5–F8) and acacia (F9–F12). The surface analysis of tablets prepared with 2.5% of gum (F1) was performed by SEM microphotograph. It was found that there was significant difference between tablets, which were prepared with and without binding agent. The tablets without binding agent were loosely packed as shown in Fig. 3, where as the tablet prepared with binding agent were compactly packed as shown in Fig. 4. Percentage elastic recovery of tablets prepared with gum and acacia in the concentration 2.5 and 5% found similar values, which indicate better binding efficacy resulting better compressibility and tabletability. PVP K-30 tablet batches F5–F8 showed more percentage elastic recovery. Hardness/disintegration × friability ratio has been identified as better index of tablet quality than has traditional hardness-friability ratio. This index not only assesses the tablet strength (i.e. hardness) and weakness (i.e. friability), but it simultaneously evaluates any negative effects of these parameters on disintegration. The

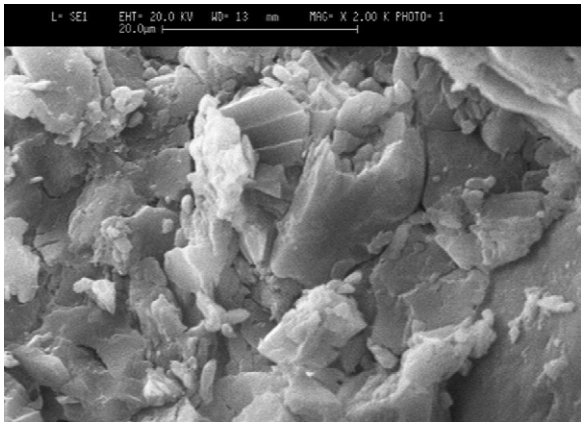

Fig. 4. Microphotograph depicting SEM of tablet with 2.5% concentration of cashew nut tree gum binder.

Table 3
Physical qualities and *in vitro* availability parameters of paracetamol tablets containing cashew nut tree gum, PVP K-30, acacia as binders.

Parameters	Cashew nut tree gum[a]				PVP K-30[b]				Acacia[c]			
	2.5% (F1)	5% (F2)	7.5% (F3)	10% (F4)	2.5% (F9)	5% (F10)	7.5% (F11)	10% (F12)	2.5% (F5)	5% (F6)	7.5% (F7)	10% (F8)
Volume of tablet	404.61 (0.152)	390.8 (0.057)	388.12 (0.152)	382.74 (0.115)	410.95 (0.078)	412.29 (0.018)	412.29 (0.057)	416.32 (0.152)	393.49 (0.045)	393.49 (0.058)	393.49 (0.104)	396.17 (0.098)
Apparent density	1.235 (0.021)	1.279 (0.189)	1.288 (0.154)	1.306 (0.121)	1.216 (0.123)	1.212 (0.114)	1.212 (0.085)	1.200 (0.125)	1.270 (0.125)	1.270 (0.147)	1.270 (0.135)	1.262 (0.114)
Porosity (%)	88.64 (0.152)	89.63 (0.065)	89.75 (0.111)	88.54 (0.105)	89.80 (0.147)	88.26 (0.123)	89.49 (0.089)	89.74 (0.132)	91.41 (0.185)	90.84 (0.157)	90.84 (0.147)	89.54 (0.136)
Packing fraction	0.1903 (0.058)	0.1983 (0.129)	0.1752 (0.089)	0.1985 (0.189)	0.1362 (0.175)	0.1164 (0.125)	0.1564 (0.168)	0.1249 (0.110)	1.690 (0.125)	0.1690 (0.147)	0.1639 (0.125)	0.1893 (0.158)
Percentage elastic recovery	0.66 (0.147)	0 (0.000)	0.34 (0.128)	0.35 (0.045)	1.66 (0.258)	1.66 (0.258)	0.65 (0.068)	0.67 (0.138)	0.68 (0.012)	0 (0.000)	0.68 (0.058)	1.37 (0.147)
Tablet physical stability	1.14 (0.111)	1.658 (0.157)	3.54 (0.156)	2.69 (0.128)	11.35 (0.163)	5.44 (0.157)	5.40 (0.198)	5.30 (0.125)	1.257 (0.154)	1.585 (0.185)	1.217 (0.111)	0.760 (0.114)
Content uniformity (%)	96.689 (0.154)	98.652 (0.189)	98.707 (0.132)	97.251 (0.145)	97.169 (0.081)	96.186 (0.180)	96.45 (0.110)	97.720 (0.154)	96.487 (0.211)	98.189 (0.191)	97.112 (0.152)	98.427 (0.116)
Weight variation (mg)	500 (0.125)	499 (0.156)	498 (0.147)	499 (0.087)	502 (0.026)	502 (0.158)	501 (0.114)	501 (0.187)	500 (0.132)	500 (0.111)	499 (0.098)	499 (0.154)
Hardness (kg/cm^2)	5.8 (0.164)	8.5 (0.331)	10 (0.254)	11.5 (0.447)	12.1 (0.221)	12.3 (0.273)	12.7 (0.144)	13.2 (0.273)	8 (0.241)	12 (0.000)	12.5 (0.335)	13.2 (0.272)
Friability (%)	1 (0.198)	0.72 (0.223)	0.27 (0.358)	0.23 (0.156)	0.43 (0.456)	0.27 (0.212)	0.23 (0.118)	0.19 (0.198)	1.14 (0.323)	0.47 (0.234)	0.44 (0.148)	0.43 (0.322)
Disintegration time (min)	5.08 (0.189)	7.12 (0.223)	10.45 (0.193)	18.55 (0.154)	2.48 (0.458)	8.40 (0.324)	10.25 (0.245)	13.14 (0.198)	5.58 (0.325)	16.12 (0.196)	23.36 (0.198)	40.36 (0.178)
In vitro dissolution t_{50} (min)	5.5	15.5	10.5	16.5	6	16.5	9.5	20.5	10.5	17.5	24.5	17

Values in parentheses represent SD, $n = 3$.

[a] Formulation batches F1, F2, F3 and F4 contains cashew gum with 2.5, 5, 7.5 and 10% binder, respectively.

[b] Formulation batches F5, F6, F7 and F8 contains PVP K-30 with 2.5, 5, 7.5 and 10% binder, respectively.

[c] Formulation batches F9, F10, F11 and F12 contains acacia with 2.5, 5, 7.5 and 10% binder, respectively.

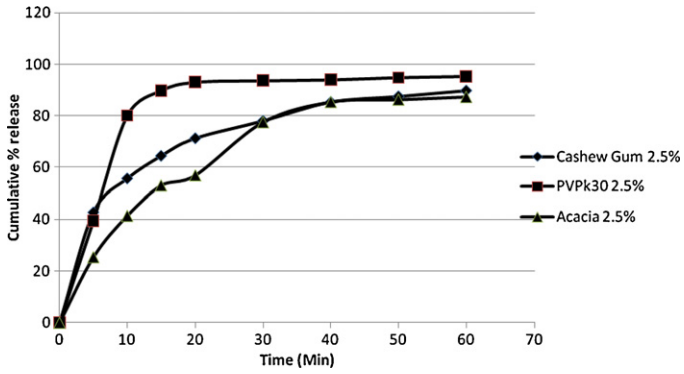

Fig. 5. Comparative *in vitro* dissolution profile of batch F1-2.5% cashew gum (♦), F5-2.5% polyvinyl pyrrolidone (PVP K-30) (■) and F9-2.5% acacia (▲) as binder. *In vitro* study was performed in phosphate buffer of pH 5.8 using USP (XXIII) apparatus II.

rank order effect of binders on tablet quality values was PVP K-30 > gum > acacia (Adebayo & Itiola, 2003). The content uniformity and weight variation of all batches F1–F12 of tablets within the specified USP limits. The hardness of the tablets was increased with increase in percentage of gum, when compared with standard binders. The values were little higher in case of acacia and PVP K-30. The friability values decreased with an increase in percentage of gum. However, overall friability values were less than the specified limits of USP. Friability is especially important because the tablet subjected to various abrasive motions during production and subsequent use. Increasing the concentration of plastoelastic binding agents leads to increase in plastic deformation of formulation during compression and consequently to the formation of more solid bonds in the resulting tablets to provide more resistant to tablet fracture and abrasion (Adebayo & Itiola, 2003). This suggests that at 2.5% concentration gum should be able to provide adequate protection for the tablets against abrasive motions during handling. Disintegration time was increased with increase in concentration of binder. The disintegration time was delayed, which might be reason that the gum facilitated extensive plastic deformation, which would lead to an increase in the area of contact between particles, reducing rate of fluid penetration into interstitial void spaces. This results in the swelling of the disintegrants and disruption of the tablet reduced, which prolonged disintegration (Odeku & Itiola, 2003). Fig. 5 shows dissolution profiles of tablets containing 2.5% of gum (F1), acacia (F5) and PVP K-30 (F9). Tablets with gum as binder produced faster dissolution profile than did those acacia and PVP K-30 binders, which otherwise have comparable profile. Other batches were found to decrease with increase in binder concentration. This was because of a sticky film of hydration on the surface, which might have reduced the diffusion of the drug. It was evidenced from the *in vitro* dissolution T_{50} as shown in Table 3. By considering all the granule and tablet evaluation results 2.5% of gum was selected as an ideal concentration for tablet production to meet all pharmacopoeial limits.

4. Conclusion

The results of the present study show that formulations containing the minimum concentration of 2.5% cashew nut tree gum as binding agent show short disintegration and fast dissolution including good physico-mechanical properties. These suggest that cashew nut tree gum could be useful as an alternative binding agent, for paracetamol tablet production.

References

Adebayo, A. S., & Itiola, O. A. (2003). Effect of breadfruit and cocoyam starch mucilage binders on disintegration and dissolution behavior of paracetamol tablet formulations. *Pharmaceutical Technology*, *3*, 78–90.

Akihiko, I., Onishi, H., Yamamoto, K., & Machida, Y. (2006). Evaluation of binders in the preparation of medicinal carbon tablets by wet granule compression. *Yakugaku Zasshi*, *126*(4), 315–319.

Azeez, O. S. (2005). Production of gum from cashew tree latex. *Leonardo Electronic Journal of Practices and Technologies*, *7*, 17–22.

Banker, G. S., & Anderson, N. R. (1986). In theory and practice of industrial pharmacy. In L. Lachmann, H. A. Lieberman, & J. L. Kanig (Eds.), *Tablets* (3rd ed., pp. 297–325). Philadelphia: Lea and Febiger.

Car, R. L. (1965). Classifying flow properties of solids. *Chemical Engineering*, *72*, 69–72.

de Paula, R. C. M., & Rodrigues, J. F. (1995). Composition and rheological properties of cashew tree gum, the exudate polysaccharide from *Anaccardium occidentale* L. *Carbohydrate Polymers*, *26*(3), 177–181.

de Paula, R. C. M., Heatley, F., & Budd, P. M. (1998). Characterization of *Anaccardium occidentale* exudate polysaccharide. *Polymer International*, *45*, 27–35.

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

Jain, S. (1999). Mechanical properties of powders for compaction and tableting: An overview. *Pharmaceutical Science & Technology Today*, *2*(1), 20–31.

Kumar, R., Patil, M. B., Patil, S. R., & Paschapur, M. S. (2009). Evaluation of *Anacardium occidentale* gum as gelling agent in aceclofenac gel. *International Journal of PharmTech Research*, *1*(3), 695–704.

Martin, A., Bustamante, P., & Cheen, A. H. C. (2002). *Physical pharmacy* (4th ed.). New Delhi: Bi Waverly Pvt. Ltd., pp. 423–490.

Odeku, O. A., & Itiola, O. A. (2003). Evaluation of the effect of Khaya gum on the mechanical and release properties of paracetamol tablets formulation. *Drug Development and Industrial Pharmacy*, *29*, 311–320.

Okoye, E. I., Onyekweli, A. O., Ohwoavworhua, F. O., & Kunle, O. O. (2009). Comparative study of some mechanical and release properties of paracetamol tablets formulated with cashew tree gum, povidone and gelatin as binders. *African Journal of Biotechnology*, *8*(16), 3970–3973.

Onunkwo, G. C., & Okoye, J. (1997). Evaluation of *Anacardium occidentale* gum as binder in lactose based tablet formulations. *Bollettino Chemico Farmaceutico*, *136*, 569–574.

US Pharmacopeia. (2000). *US Pharmacopeia-XXIV, NF–XXIX*. Rockville, MD: US Pharmacopoeial Convention.

Verma, P. R. P., & Balkishen, R. (2002). Studies on *Leucaena leucocephala* seed gum—Rheological properties. *Journal of Scientific and Industrial Research*, *61*, 437–443.