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Evaluation of the Binding Property of *Irvingia Gabonesis* Gum in Paracetamol Tablet Formulations Produced using Two Different Disintegrants

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ABSTRACT

Paracetamol is mainly used as analgesic and antipyretic drug. This study was conducted to evaluate the binding property of *Irvingia gabonensis* gum (IGG) in paracetamol tablet formulations in the presence of either maize starch or microcrystalline cellulose as disintegrant. IGG was isolated by acetone precipitation of the filtrate from the maceration of the powdered seeds of *Irvingia gabonensis* (Irvingiaceae) in distilled water for 24 h. Paracetamol granules were prepared using the wet granulation method. They were produced by using various concentration of IGG as binder, maize starch or microcrystalline cellulose as disintegrants and lactose as filler. The different formulations of paracetamol granules were mixed with magnesium stearate and talc and compressed into the respective tablets. The tablets were evaluated based on uniformity of weight, tablet hardness, friability, disintegration time and *in vitro* drug release.

The tablet hardness for the paracetamol tablet formulations ranged from 2.27±0.09 to 8.00±0.54 Kgf. The friability values ranged from 0.21 ± 0.04 to 3.40±0.10%. The disintegration time ranged from 3.00±0.10 to 23±0.50 min. Tablets from all the formulations released up to 70% of their paracetamol contents within 25 min. For all the formulations, as the binder concentration increased the rate of drug release decreased. For tablets prepared using IGG as binder; formulations that contain microcrystalline cellulose as disintegrant had better release profile than those prepared using maize starch as disintegrant.

The study shows that IGG have good binding property. Paracetamol tablets formulated using IGG as binder have comparable hardness value but lower disintegration time than those formulated using maize starch mucilage as binder.

KEYWORDS: *Irvingia gabonensis* gum, Irvingiaceae, binder, disintegrant, paracetamol, maize starch

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INTRODUCTION

Paracetamol, a 4-hydroxyacetanilide is mainly used as analgesic and antipyretic drug[1]. In clinical care paracetamol is usually effective for the pain associated with mild to moderate inflammation, such as sprains and contusions, but not in patients experiencing significant inflammation associated with rheumatoid arthritis or acute gout[2]. Paracetamol is formulated as tablets[3], syrups[4] and suspensions[5, 6]. Paracetamol tablets are given to adult patients who can swallow tablets for the relief of fever, headaches and other minor aches and pains. Tablet is the most commonly used dosage form. Tablet is produced by compression or molding of a mixture of the active pharmaceutical ingredient (API) and the required excipients. Excipients are inert materials or aids that are added during the production of tablets. Excipients, such as binders, diluents, lubricants and glidants help to impart satisfactory processing and compression characteristics to the tablet formulation while the others such as colours, disintegrants, surfactants, flavours, sweeteners, anti-oxidants, polymers or

hydrophobic materials help to give additional desirable physical characteristics to the prepared tablet[7].

Binders or adhesives are materials added in the preparation of tablets to make the powders cohesive so that after compression the tablet formulation remains intact and also to improve the free flow properties by the formulation of granules of appropriate size and hardness[7]. Materials used as binders include natural gums such as acacia, *Sida acuta* gum[8], semi-synthetic gums such as hyroxymethyl propyl cellulose (HPMC) and synthetic gums such as polyvinylpyrollidone (PVP). Increase in binder concentration, leads to increase in tablet hardness, increase in disintegration time and reduction in friability[3,9].

Disintegrants are materials included in tablet production to facilitate the break-up of tablets into smaller particles when it comes in contact with water in the gastrointestinal tract. They function by sipping water into the tablet, swelling and making the tablet to break-up or burst apart [10]. Starch is the most common disintegrant that is used in tablet formulation. Other disintegrants include microcrystalline cellulose (MCC), HPMC, methylcellulose, guar gum, bentonite, agar etc.

Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Irvingiaceae, is a Southeast Asian and African tree that belongs to the family lrvingiaceae. It can grow to a height of 25m and to a girth of 2m when fully mature. It is commonly known as ogbono, dika nut, bush mango, African mango or wild mango. The pulverized seeds are used as thickener for making soup in various parts of Nigeria and also in Cameroon[11,12].

Irvingia gabonensis gum was successfully used as binder in the formulation of metronidazole tablets that had good granules and tablet properties[12].

Metronidazole tablet formulations prepared with dika nut mucilage extracted from *Irvingia gabonensis* seeds as binder showed faster onset of plastic deformation under compression pressure than those containing gelatin as binder[9]. A study conducted to determine the effect co-precipitation of irvingia gum with egg albumin had on the drug release profile of metronidazole tablets showed that irvingia gums could be used as a binder in the formulation of metronidazole tablets and that co – precipitation of the gums with egg albumin could result in alteration of the drug release profile of the tablets from normal to slow or sustained release[13].

This study was conducted to evaluate the binding property of *Irvingia gabonensis* gum in paracetamol tablet formulation in the presence of either maize starch or microcrystalline cellulose as disintegrant.

MATERIALS AND METHODS

MATERIALS

Paracetamol (BDH chemicals, Poole, England), acetone (Guangdong Guangzhou Chemicals, China), lactose (Pharmaceuticals Aliyali Palghar, India), microcrystalline cellulose (MCC), talc (BDH Chemicals Ltd Poole England), magnesium stearate (Loba Chemie, Mumbia, India), maize starch (Central drug house, CDH, India). All other reagents were of analytical quality.

Identification of *Irvingia gabonensis* seeds

Irvingia gabonensis (ogbono) seeds were purchased from Sapele market in Delta State, Nigeria. It was identified by Dr. Akinnibosun Henry Adewale of the Department of Plant Biology and Biotechnology, Faculty of Life Science, University of Benin, Benin City, Nigeria. It was assigned a voucher number, UBH-I153.

Extraction of *Irvingia gabonensis* gum

The method of Okafo et al [14,15] was used. The dried seeds of the *Irvingia gabonensis* were purchased from Sapele market, Nigeria and pulverized. A 150 g quantity of the powdered seeds was weighed and transferred into a clean plastic container with lid. It was macerated with 2 litres of distilled water for 24 h. It was filtered using a clean muslin cloth and viscous filtrate was precipitated with acetone. It was filtered and the crude gum was washed three times with acetone until it was no longer slippery to touch in order to remove all traces of its fat components. The gum was then dried in a Labtech, Model AI-2a hot air oven (Labtech, India) at 50^0C for 6 h, pulverized in a mortar and passed through a sieve with mesh size 300 µm. The resulting powder was kept in an airtight container until used.

Preparation of granules

Paracetamol granules were prepared using the wet granulation method according to the formula in Table 1. Different paracetamol granules formulations were produced by using varying concentration of *Irvingia gabonensis* gum as binder, maize starch or microcrystalline cellulose as disintegrants and lactose as filler.

The granules were formed by weighing appropriately the paracetamol powder, lactose, maize starch or microcrystalline cellulose and also the binder (*Irvingia gabonensis*) according to the concentrations in the formula. The *Irvingia gabonensis* gum was prepared as mucilage by adding little quantity of warm water as needed to dissolve and it was stirred properly. The mucilage was transferred into the mixture of the other ingredients in a mortar and mixed properly with the aid of a pestle to form a damp or wet mass. The wet mass was passed through a sieve of aperture size 1.18 mm and the granules produced were dried in an oven at a temperature of 60^0C for 20 minutes. The granules were then passed through a 710 µm sieve and dried at 60^0C for 1 h.

Table 1. Composition of paracetamol tablet formulations T1 to T8

Ingredients (mg)	T1	T2	T3	T4	T5	T6	T7	T8
Paracetamol (mg)	500	500	500	500	500	500	500	500
I. gabonenesis gum (mg)	1.10	1.10	2.75	2.75	5.50	5.50	-	-
Maize starch mucilage (mg)	-	-	-	-	-	-	2.75	5.50
Lactose (mg)	13.5	13.5	11.50	11.50	8.75	8.75	11.50	8.70
Maize starch (mg) Powder	27.50	-	27.50	-	27.50	-	-	-
Microcrystalline cellulose (mg)	-	27.50	-	27.50	-	27.50	27.50	27.50
Magnesium stearate (mg)	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
Talc (mg)	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Total (mg)	550	550	550	550	550	550	550	550

EVALUATION OF PARACETAMOL GRANULES

Flow rate of granules: A 25 g quantity of granules was weighed and poured in a funnel. The time taken for the powder to pass through the orifice of the funnel was recorded and the flow rate was calculated using equation 1[16]:

$$Flow\ rate = \frac{weight\ of\ granules\ (g)}{time\ (s)} \quad . \quad . \quad . \quad . \quad 1$$

Angle of repose: A funnel was mounted on a retort stand placed on a bench; the funnel was kept at a height 7.5 cm from the bench. A 25 g quantity of granules was poured into the funnel with the tip closed, the tip-plug was removed and the granule was allowed to pass through the orifice, the height and diameter of the granules heap were measured[16]. The angle of repose was calculated using equation 2:

$$Tan\ \theta = \frac{h}{r} \quad . \quad . \quad . \quad . \quad . \quad 2$$

Where h = height of powder heap and r = radius of the circular base of the heap.

Bulk and tapped densities.

A 20 g quantity of the granules was weighed and transferred into a 50 ml measuring cylinder. The volume was noted as bulk volume. The measuring cylinder was then tapped 100 times on a padded surface. The new volume was recorded as tapped volume. Bulk and tapped densities were calculated using equations 3 and 4 respectively[17,18].

Carr's Index: This was calculated using equation 3.

$$\text{Carr's Index} = \frac{(\text{Tapped density} - \text{Bulk density})}{\text{Tapped density}} x\ 100 \quad . \quad . \quad . \quad 3$$

Hausner's Ratio: This was calculated using equation 4.

$$\text{Hausner's ratio} = \frac{\text{Tapped density}}{\text{bulk density}} \quad . \quad . \quad . \quad . \quad . \quad 4$$

Preparation of paracetamol tablets

The different formulations of paracetamol granules were mixed with magnesium stearate and talc and compressed into the respective tablets with predetermined force using a CJD 316 sixteen station rotary tablet press (Clit Jemkay Engs. Pvt, Ltd. Ahmedabad, India) having a 13 mm punch.

Evaluation of paracetamol tablets

Weight uniformity: Twenty (20) tablets were randomly selected from each formulation and the individual weight of the tablets was determined. The mean was calculated and the individual weights of the tablets were subtracted from the mean weight of the tablets. The parentage deviation was determined[19-21].

Friability: Ten (10) tablets chosen randomly were weighed together and placed in the rotating drum of a friabilator (Veego friability test apparatus, India). It was rotated at 25 rpm for 4 min. The tablets were reweighed after dusting off of any adherent particles[22-24]. Friability was calculated using equation 3:

$$\text{Friability (\%)} = \frac{(w_1 - w_2)}{w_1} x\ 100 \quad . \quad . \quad . \quad . \quad 3$$

Where w_1 = initial weight, w_2 = final weight

Tablet hardness, thickness and diameter: Five (5) tablets were randomly selected and placed individually in the analysis chamber of a model VDIGITAB-1 digital tablet hardness tester apparatus (Veggo, Mumbai, India). The tablet hardness, thickness and diameter values were displayed and recorded[25].

Disintegration test: Six tablets from each formulation were placed in the respective tubes of a disintegration test apparatus (Manesty, Liverpool, England) with water maintained at 37±0.5ºC as the medium. The tubes were immersed and raised at interval and the time it took each tablet to disintegrate and pass through the wire mesh at the bottom of the tube into the medium was recorded[26-27].

Dissolution test: This was done using a Copley dissolution test apparatus (Erweka Apparatebau GMBH, Germany) containing 900 ml of freshly prepared 0.1N hydrochloric acid maintained at 37±0.5ºC and rotated at a speed of 100 rpm. A tablet from each formulation was placed in the

basket of dissolution apparatus and at intervals of 5, 10, 15, 20, 25, 30, 45 and 60 min, 5ml sample was withdrawn and the replaced with fresh preheated dissolution medium.
The samples were filtered and analyzed using a Labtech – 2802 double beam UV/VIS spectrophotometer (Labtech, India) at a wavelength of 277 nm[25].

RESULTS AND DISCUSSIONS

Characteristics of paracetamol granules

The values obtained for the bulk density, tapped density, Carr's index and Hausner's ratio of the paracetamol granules (T1-T8) are shown in Table 2.

Bulk and Tapped densities: The values for tapped and bulk densities from the various formulations are shown in Table 2. The values for the tapped density of all the paracetamol granules formulations were higher than the bulk density values. This showed that the granules had good compaction characteristics.

Angle of repose: The angle of repose obtained also indicated that formulations T2 to T6 had excellent flow property since the angle of repose fell within the range while formulations T1, T7 and T4 had good flow property.

Compressibility index and Hausner's ratio: The results shown in Table 2 indicated that the Carr's index for the different paracetamol formulations were between 7.92 ±0.31 and 20.74 ± 0.29 while the Hausner's ratio values ranged from 1.07 ± 0.03 to 1.26 ± 0.00.
The Carr's compressibility index and Hausner's ratio results obtained for formulation T4 shows excellent flow property, for formulations T2, T3 and T6 shows good flow property, for formulations T5, T7 and T8 fair flow property, for formulation T1 passable flow property. When granules have a poor flow, it signifies that there is a high interparticulate interaction or cohesion. Compressibility index is an indirect means of measuring powder flow. It can be influenced by moisture content, size and shape, surface area and cohesiveness of the particles of materials. When these factors are altered the flow of granules can be improved.

Table 2. Characterization of paracetamol granules (T1-T8)

Batches	Bulk density (g/cm^3)±SD	Tap density (g/cm^3)±SD	Angle of repose (^{o}) ±SD	Carr's index (%) ±SD	Hausner's ratio ±SD	Flow rate (g/s) ±SD
T1	0.51 ± 0.00	0.65 ± 0.00	31.89 ± 0.12	20.74 ± 0.12	1.26 ± 0.00	3. 30 ± 0.12
T2	0.57 ± 0.00	0.66 ± 0.00	29.27 ±0.09	13.70 ± 0.07	1.16 ± 0.00	3.96 ± 0.04
T3	0.54 ± 0.00	0.63 ± 0.00	27.55 ±0.21	14.24 ± 0.05	1.17 ± 0.00	4.26 ± 0.22
T4	0.56 ± 0.00	0.61 ± 0.00	27.60 ± 0.27	7.92 ± 0.31	1.07 ± 0.03	4.00 ± 0.01
T5	0.51 ± 0.00	0.63 ± 0.00	27.07 ± 0.00	17.76 ± 0.00	1.22 ± 0.00	3.99 ± 0.11
T6	0.59 ± 0.00	0.66 ± 0.00	28.16 ±0.04	12.81 ± 0.00	1.14 ± 0.00	3.95 ± 0.05
T7	0.56 ± 0.00	0.67 ± 0.00	31.20 ± 0.00	17.06 ± 0.00	1.21 ± 0.00	2.86 ± 0.20
T8	0.56 ± 0.00	0.69 ± 0.00	31.61± 0.00	18.64 ± 0.00	1.23 ± 0.00	2.50 ± 0.00

Where SD = Standard Deviation.

EVALUATION OF PARACETAMOL TABLETS

Tablets Thickness: The thickness of the paracetamol tablets from the various formulations as shown in Table 3; were between 3.7±0.05 and 3.9±0.04 mm. The uniformity in tablet thickness indicates that, there was uniform die fill.

Weight Variation: The results obtained from weight variation test from the different tablet formulations are shown in Table 3. The various paracetamol tablet formulations had weights that were within 0.54g - 0.55g with a standard deviation that is < 0.5. The maximum percentage mean deviation was within the USP acceptable limit of not more than 5% of uncoated tablets weighing >324 mg of active ingredient. This indicates that there was uniform filling of the die during compression.

Tablet Hardness: The tablet hardness for the different paracetamol tablet formulations (Table 3) ranged from 2.27±0.09 to 8.00±0.54 Kgf. Formulations T1 and T3 failed hardness test. It was observed that for paracetamol tablet formulations prepared with maize starch as disintegrant and IGG as binder (T1, T3 and T5), increase in concentrations of the binder (0.2, 0.5 and 1%) resulted in increase in tablet hardness (2.27±0.09, 3.66±0.07 and 4.01±0.14 Kgf). Also for those tablets prepared with microcrystalline cellulose as disintegrant and IGG as binder (T2, T4 and T6), increase in binder concentrations (0.2, 0.5 and 1%) resulted in increase in tablet hardness (4.76±010, 5.49±0.02 and 6.73±0.06 Kgf). Tablet hardness for formulations T4 (5.49±0.02 Kgf) and T6 (6.7±0.06 Kgf) prepared with IGG as binder were comparable to that of T7 (4.40±0.40 Kgf) and T8 (8.00±0.54 Kgf) prepared with starch mucilage as binder. Tablet hardness for formulations T2 (4.76±010 Kgf), T4 (5.49±0.02 Kgf) and T6 (6.7±0.06 Kgf) prepared with IGG as binder and MCC as disintegrant was higher than those of T1 (2.27±0.09 Kgf), T3 (3.66±0.07 Kgf) and T5 (4.01±0.14 Kgf) prepared with IGG as binder but maize starch as disintegrant. Very hard tablets may not disintegrate at the right time for the conventional oral tablet.

The hardness of a tablet depends on the type and concentration of the binding agent used and also the compression force[8,22]. The same compression force was used for all the tablet formulations; therefore the difference in hardness value probably was as a result of the difference in the type and concentration of binder used.

Friability Test: The values for friability of the tablets from the different formulations are shown in Table 3. It ranged from 0.21 ± 0.04 to 3.40±0.10%. Most of the tablet formulations met the standard, which is that the tablet should not lose more than 1% of its original weight. Formulations T1, T3 and T5 that were prepared with maize starch as disintegrant failed the friability test. Like tablet hardness, friability is affected by the type and concentration of binder and disintegrant, as well as the compression force.

Disintegration Test: The results of the disintegration test for the various paracetamol tablets formulations are shown in Table 3. The tablets from formulations prepared with IGG as binder (T1-T6) disintegrated in less than 15 min, therefore, they passed the disintegration time test. The tablets from formulations T7 and T8 prepared using starch mucilage as binder disintegrated in 20 and 23 min respectively, therefore, they failed the test.

Table 3:.Post compression parameters of formulated paracetamol tablets

Formulations	Hardness (kg/f) ±SD	Weight variation (g) ±SD	Friability (%) ±SD	Disintegration (min) ±SD	Tablet thickness (mm) ±SD
T1	2.27 ± 0.09	0.54 ± 0.07	3.20 ± 0.10	3.00 ± 0.10	3.7 ± 0.05
T2	4.76 ± 0.10	0.54 ± 0.01	0.91 ± 0.08	5.00 ± 0.03	3.8 ± 0.06
T3	3.66 ± 0.07	0.54 ± 0.77	1.77 ± 0.40	3.70 ± 0.10	3.9 ± 0.04
T4	5.49 ± 0.02	0.54 ± 0.02	0.33 ± 0.04	7.00 ± 0.07	3.9 ± 0.01
T5	4.01 ± 0.14	0.54 ± 0.05	1.21 ± 0.50	4.16 ± 0.10	3.8 ± 0.06
T6	6.73 ± 0.06	0.54 ± 0.01	0.21 ± 0.04	8.89 ± 0.09	3.90 ± 0.01
T7	4.40 ± 0.40	0.54 ± 0.02	0.96 ± 0.05	20.00 ± 0.04	3.8 ± 0.05
T8	8.00 ± 0.54	0.54 ± 0.01	0.31 ± 0.37	23.00 ± 0.50	3.9 ± 0.22

Dissolution test: The dissolution profiles of the different paracetamol tablet formulations prepared using *Irvinga gabonensis* gum and maize starch mucilage as binder are shown in Figure 1. Tablets from all the formulations released up to 70% of their paracetamol contents within 25 min. This is in agreement with compendia specification for uncoated conventional tablet[28].

Tablets from formulations T7 and T8 prepared using maize starch mucilage as binder released paracetamol more slowly than the others. For all the formulations, as the binder concentration increased the rate of drug release decreased. For tablets prepared using *Irvinga gabonensis* gum as binder; formulations T2, T4 and T6 that contain microcrystalline cellulose as disintegrant had better release profile than those prepared using maize starch as disintegrant T1, T3 and T5.

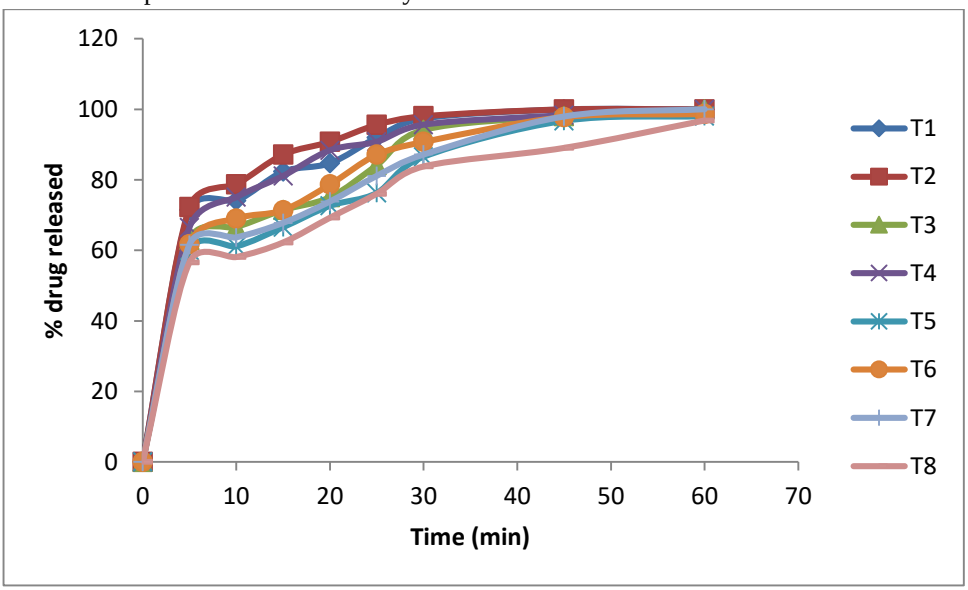

Fig 1. Dissolution profile for paracetamol tablet formulations T1-T8

CONCLUSION

The study shows that *Irvinga gabonensis* gum has good binding property. Paracetamol tablets formulated using *Irvingia gabonensis* gum as binder have comparable hardness value but disintegrated faster than those formulated using maize starch mucilage as binder.

Paracetamol tablets formulated using microcrystalline cellulose as disintegrant show better hardness, friability and disintegration time values than those prepared with maize starch as disintegrants.

Paracetamol tablets formulated using *Irvingia gabonensis* gum as binder and microcrystalline cellulose as disintegrant possess good post-compression properties.

REFERENCES

I. Abebe K, Beressa TB, Yimer BT. In-vitro Evaluations of Quality Control Parameters of Paracetamol Tablets Marketed in Gondar City, Northwest Ethiopia. Drug Healthc Patient Saf. 2020; 12: 273–279. doi: 10.2147/DHPS.S282420

II. Van Rensburg R, Reuter H. An overview of analgesics: NSAIDs, paracetamol, and topical analgesics Part 1. S Afr Fam Pract, 2019; 61(S1):S4-S10.

III. Okafo SE**,** Chukwu A. Evaluation of the Binding Property of *Sida acuta* Gum in Paracetamol Tablet Formulations. World Journal of Pharmaceutical Research, 2017; 6(7): 22-35.

IV. Maheshwari RK , Rajagopalan R. Formulation and Evaluation of Paracetamol Syrup Made by Mixed Solvency Concept. Der Pharmacia Lettre, 2012, 4 (1):170-174.

V. Okafo SE, Chukwu A. Preliminary Studies on the Suspending Properties of *Sida acuta* Gum in Paracetamol Suspension. World Journal of Pharmacy and Pharmaceutical Sciences, 2017; 6(6): 302-313.

VI. Woldu G, Baymot B, Tesfay D, Demoz GT. Evaluation of Aloe elegans Mucilage as a Suspending Agent in Paracetamol Suspension. BioMed Research International, 2021, Article ID 5058372, 12 pages. https://doi.org/10.1155/2021/5058372.

VII. Runic EM, Schwartz JB. Oral Solid Dosage Forms. In: Remington. The Science and Practice of Pharmacy. 21st edition, Pharmaceutical Press, London, UK, 2005 pp. 889–928.

VIII. Okafo SE, Chukwu A. Formulation and Evaluation of Naproxen Tablets Produced Using a Natural Binder, Nigerian Journal of Pharmaceutical and Applied Science Research, 2020; 9(1): 10-17.

IX. Odeku AO, Patani BO. Evaluation of dika nut mucilage (Irvingia gabonensis) as binding agent in metronidazole tablet formulations. Pharm Dev Technol, 2005; 10(3): 439-46. doi: 10.1081/pdt-54477.

X. Banker GS, Anderson NR. Tablets. In: Lachman L, Lieberman HA (Eds.). The Theory and Practice of Industrial Pharmacy, Special Indian Ed. 2009., CBS Publishers & Distributors Pvt. Ltd., New Delhi, 293-344.

XI. Omokhua GE, Ukoima HN, Aiyeloja AA. Fruits and seeds production of Irvingia gabonensis (O' Rorke) and its economic importance in Edo Central, Nigeria. Journal of Agriculture and Social Research (JASR), 2012; 12(1): 149-155.

XII. Jackson TC, Obiakor NM, Aniekan NB, Edem SE, Ita OO, Ucheokoro AS, Okoi SE. Formulation and Evaluation of Metronidazole Tablets Prepared from Irvingia gabonensis as Binder. Nigerian Journal of Pharmaceutical and Applied Science Research, 2022; 11(3):1-7.

XIII. Uzondu AL, Okafo SE, Joe-Ob C. Modification of drug release profile of metronidazole tablet using co-precipitate of irvingia and egg albumin – A proven good technology. World J Pharm Sci 2015; 3(3): 588-595.

XIV. Okafo SE, Alalor CA, Ordu JI. Design and in vitro evaluation of sustained release matrix tablets of metformin produced using *Detarium microcarpum* gum, International Journal of Applied Pharmaceutics, 2020; 12(5): 131-137.

XV. Okafo SE, Avbunudiogba JA, Anizor OB. Evaluation of Mucoadhesive albendazole tablets formulated using *Detarium microcarpum* gum. Research Journal of Pharmacy and Technology, 2022; 15(2): 889-895.

XVI. Ugoeze KC, Nwachukwu N, Okeke CE. The physico-chemical and filler-binder-disintegrant properties of improved hydrophilic powder derived from the fibre of Ipomoea batatas tuber in paracetamol tablet. Thai J Pharm Sci, 2021, 45 (2): 105-112.

XVII. Okafo SE, Moke EG, Obi CS. Formulation and Evaluation of Anti-Diabetic Tablets Containing Aqueous Extract of *Moringa oleifera* Seeds, Journal of Pharmaceutical and Allied Sciences, 2019; 16(5): 3167-3176.

XVIII. Kulkarni VM, Babare SB, Joshi SK, Walode SG, Rudrapal M, Kakade AP, Chatur VM, Formulation and Evaluation of Paracetamol Tablets using Coconut Oil as a Binder, Journal of Drug Delivery and Therapeutics. 2022; 12(1-s):4-7.

DOI: http://dx.doi.org/10.22270/jddt.v12i1-s.5320

XIX. Srivastava P, Malviya R, Kulkarni GT. Formulation and evaluation of paracetamol tablets to assess binding property of orange peel pectin. International Journal of Pharmaceutical Sciences Review and Research, 2010; 3(1): 30–34.

XX. Okafo SE, Chukwu A. Formulation and Evaluation of Diclofenac Matrix Tablets Containing a Hydrophilic Polymer, *Sida acuta* Gum. World Journal of Pharmaceutical Research, 2017; 6(7): 36-47.

XXI. Okafo SE, Alalor CA, Ordu JI. Formulation and evaluation of gastroretentive metronidazole tablets using *Brachystegia eurycoma* gum, International Journal of Pharmaceutical Sciences and Research, 2021; 12(4):2076-2084.

XXII. Gunatilake SK, Samaratunga SS, Adekola FA. Effects of Binder on the Physico-chemical Properties and the Quality of Paracetamol Tablets. Der Pharma Chemica, 2016, 8(4):237-242.

XXIII. Okafo SE, Ikechukwu IL, Alalor C. Formulation and Evaluation of Floating Matrix Tablets of Ciprofloxacin Using *Sida acuta* Gum. International Journal of Drug Development and Research, 2019; 11(1): 04-08.

XXIV. Maddela S, Vemuri S, Harshini, Chukka N, Bhavanam PR.. Formulation and In-vitro Evaluation of Paracetamol and Ibuprofen Immediate Release Tablets by Solid Dispersion Technique. Journal of Cardiovascular Disease Research, 2021; 12(05) : 1492-1500.

XXV. Okafo SE, Okedu O, Alalor C. Formulation and Evaluation of Mucoadhesive Ciprofloxacin Tablet Using *Sida acuta* Gum. African Journal of Pharmaceutical Research & Development, 2017; 9(1): 40-48.

XXVI. Erebor JO, Iwuagwu MA, Uhumwangho MU, Arhewoh MI, Oshoma J. Studies On The Tabletting Characteristics Of Paracetamol Tablets Using Mucilage Extracted From *Dioscorea Alata*. Nig. Journ. Pharm. Sci., 2013; 12(2): 22-29.

XXVII. Okafo SE, Avbunudiogba JA, Alalor CA. The Effects of Lubricants on the Disintegration and Dissolution Profile of Metronidazole Tablets Formulated Using *Sida acuta* Gum as a Binder. Journal of Pharmaceutical Research International, 2021; 33(42B): 350-362.

XXVIII. British Pharmacopoeia, Her majesty‘s stationery office, London, 2012, p. A479.