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EVALUATION OF DISINTEGRANT AND BINDING PROPERTIES OF STARCH DERIVED FROM DISCOREA DUMETORUM ON CIPROFLOXACIN TABLETS

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ABSTRACT

This study aims to extract starch from *Dioscorea dumetorium* (three- leaved yam**)** and utilize the yam extract as a pharmaceutical excipient in the formulation of Ciprofloxacin tablets of 250mg strength and to evaluate the binding and disintegrant properties, in comparison with corn starch. Starch extracted from the trifoliate yam was confirmed by the Iodine and Molisch tests while percentage content of the active pharmaceutical ingredient (API) was determined via chemical analysis and Uv spectroscopy. Tablet formulation was carried out in three batches as: batch A (trifoliate yam starch (TYS), batch B (corn starch (CS) and batch C (TYS+CS) and by intra and extra granular addition of starches at a concentration of 3 and 5%w/w respectively for all the batches. The micrometric studies of TYS indicated good flow character and compressibility properties with a bulk density of 0.521, tapped density of 0.610, angle of repose 29.8^{o}, Hausner's ratio of 1.170 and Carr's index of 14.590. The pre compression analysis of granules showed excellent granular flow properties. The ranking for tensile strength was TYS>(TYS+CS)>CS, although reversed order for friability while for disintegration and dissolution test, the ranking was in the order TYS>CS>(TYS+CS). In overall, the results obtained suggests that starch from *D. dumetorium* yam could be a better alternative in tablet formulations where a high bond strength is essential, but combination of corn and TYS at 1:1 ratio presented better result than other batches hence could be more applicable when faster disintegration/dissolution time of tablets is required.

KEYWORDS: *D. dumetorum*, starch, Evaluation, Disintegrant, Binding, Ciprofloxacin, Tablets.

INTRODUCTION

Starch is a dominant carbohydrate reserve material of higher plants being found in leaf chloroplast and in the amyloplasts of storage organs such as seeds and tubers. The biochemical chain responsible for starch synthesis involves glucose molecules produced in plant cells by photosynthesis. Therefore starch is a homo-polysaccharide made up of glucose units and the polysaccharide consist of amylose (a polymer of low molecular weight consisting of linear chains bound by a α-1,4 glycosides links and behaves essentially as a non-branched molecule while amylopectin has a higher molecular weight and consists of highly branched chains formed by α-1,6 linked to linear glucans unit which form an organized structure.[1]

At normal temperature starch granules are extremely insoluble in water and exert a minimal effect on the osmotic pressure of cells. Most of the starch utilized world-wide, comes from a relatively small number of crops, the most important being maize, wheat, cassava with smaller amounts from rice, sorghum, sweet potato and mung beans.

Starch may contain lipids as well as proteins and these molecules originate from the granules surface and are known to increase the functionality of starch and can impact certain qualities as hardness. They could also contain minerals such as calcium, magnesium, phosphorus, sodium and potassium which may present in the form of monophosphate esters, phospholipids and inorganic phosphate.[2]

Starches may undergo modification to enhance its versatility and satisfy consumer demand and this could be achieved through such processes involving, physical, chemical and genetic approaches.

Functional properties of Starch

Gelatinization, Swelling and Solubility

Starch is insoluble in cold water however upon heating in water at above 52^{O}C, it undergoes a process known as gelatinization involving two stage endothermic process where the first phase involves swelling due to breakage of hydrogen bonds in the amorphous portions of the starch and in the next event hydration and swelling of the amorphous regions occurs in the presence of water acting as a plasticizer. Upon heating the amylopectin

(crystalline) structure may be altered and this could result to decrease in the crystallinity and making more of water to be absorbed and causing several changes including starch solubilization, starch granule swelling and loss of birefringence. All these could be affected by temperature, pH, starch source, salts and presence of water.[3]

Pasting: This involves the rheological activity of the starch and it is important in food and other relative industries involving effects of viscosity. The temperature at which there is a sharp increase in viscosity represents the pasting temperature.

Light Transmittance: Light transmittance gives the information regarding the behavior of starch paste upon absorption and transmittance of the quantity of light which passes through it. The light transmittance of the starch paste could be determined at 640nm. The phosphate monoesters that are covalently attached to the amylopectin result in the increase in starch paste clarity whereas presence of phospholipids bound to the amylose fractions of the starch produces opaque starch pastes resulting in reduced percent light transmittance. Therefore, light transmittance of starch paste is a function of the amount of swollen starch granules in the paste which refract light.[4]

Freeze-thaw stability: This involves the ability of the starch or food containing the starch to uphold its integrity by avoiding the loss of water (syneresis) when food containing starch is exposed to recurrent thermal cycling between freezing and ambient temperature.

Pharmaceutical applications of starch from natural sources.

Starches can be used as tablet disintegrant (3 – 25%) optimum concentration of 15% and the disintegration ability of natural starch is due to wicking and restoration of deformed starch particles in contact with aqueous fluid. Starch becomes an integral part of a formula during manufacture when added in the range of 5-80% w/w to achieve standardized triturates of colorants, potent drugs/low dose active pharmaceutical ingredients (API) and herbal extracts thus facilitating effective handling and subsequent mixing /blending processes during manufacture. Considering the weight uniformity required by reference standards, controlling or enhancing the flow properties of powders/granules through the feed mechanisms using glidants, is of paramount importance. Hence starch could be useful in reducing inter particulate friction at concentrations of 2-10%w/w to improve powder and granule flow especially in the dried form.[5]

Starch could be used as anti-adherent and lubricant at concentration of 3-10%w/w to prevent the sticking of compressed powders/granules to punch faces and die wall during tablet and capsule production.

In tablet formulations, starch prepared to gel by heat treatment of starch dispersion in water could be used at a concentration of 3-20%w/w (usually 5-10% depending on the starch type) as a binder for wet granulation. This provides the necessary binding forces that holds the powder particles together to form the required agglomerates. The quantity of the freshly prepared starch paste is usually determined by optimization studies employing such parameters as friability, hardness, disintegration and dissolution studies.[6]

Starch as film forming polymers: The film forming property of starch can be attributed to the amylose component of starch. Though studies have suggested the improvement of the property by combination of starch with other polymers such as: chitosan, micro crystalline cellulose, flax cellulose nanocrystals etc. and this is attributed to probable hydrogen bonding formation between the functional groups (amino and hydroxyl groups) present on the backbone of the components.

Starch as adjunct to standard oral rehydration solution (ORS): Starch could be a useful adjunct to standard ORS in the treatment of cholera/ diarrhea in children. It promotes fluid and electrolyte absorption and may add additional energy without increasing the osmotic load and also shorten the recovery period from diarrheal disease.[7]

Three leaved yam (*Dioscorea dumetorium*)

D. dumetorium otherwise known as three leaved yam is a food with economic and socio-cultural importance in many tropical countries. Other common names include: African bitter yam, wild yellow yam, trifoliate (three leaved yam and cluster yam).

Figure 1: *D. dumetorum* Yam and Leave tendrils.

The plant is known in south west Nigeria by the Yorubas as e's'ur'u and the Igbo speaking area in South eastern Nigeria as 'ji ona' where it is regarded as food for the adult.

It belongs to the Kingdom; plantae, family: Dioscorium, genus: Dioscorea and species: dumetorum.

The plant has distinctive trifoliate leaves, It's wild form is highly toxic due to the high content of dihydrodiscorine isoclines a heart stimulant and dioscoretine, a hypoglycemic agent. In other to remove toxins, the wild form needs to be leached in water for days and thoroughly cooked.

The yam also contains important minerals such as iron, magnesium, phosphorus, calcium and zinc, even at high level when stored for some time and therefore has some useful applications in the food and Pharmaceutical industries.[8]

Health benefits of the plant includes: Treatment of clinical diabetes, rheumatoid arthritis, stomach pain (colic), menstrual disorder, schistosomiasis and fertility booster where it is found to contain a form of natural progesterone (dioscin). The phytoestrogens and progesterone-like properties in the yam can help to enhance hormonal balance and to regulate the body's menstrual cycles and have an ovulation stimulating substance that can help boost fertility.[9]

Ciprofloxacin

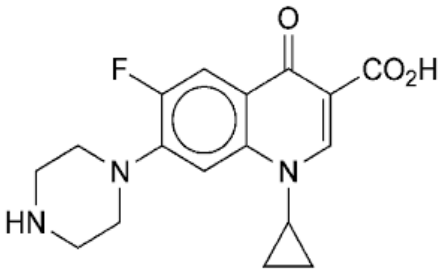

Figure 2: Structure of ciprofloxacin.

Ciprofloxacin has the following properties: **IUPAC ID:** 1-cyclopropyl-6-fluoro-4-oxo-7-piperazin-1-ylquinoline-3-carboxylic acid, molar mass**:** 331.347 $g \cdot mol^{-1}$, Bioavailability: 70%, Metabolism: Liver (incl. CYP1A2), Excretion: Kidney, Protein binding: 30% and Elimination half-life: 3.5 hours.

Ciprofloxacin is a synthetic fluoroquinolone antibiotic used to treat a number of bacterial infections. This includes bone and joint infections, intra abdominal infections, diarrhea, respiratory tract infections, skin infections, typhoid fever, and urinary tract infections, among others.

Ciprofloxacin binds to and inhibits bacteria DNA gyrase an enzyme essential for DNA replication and is more special against Gram-negative than Gram-positive bacteria. It is a second generation fluoroquinolone antibiotic widely used in the therapy of mild to moderate urinary tract infection caused by susceptible organisms. Ciprofloxacin have been linked to rare but convincing instances of liver injury and this could be severe and fatal.[10]

Pharmaceutical Formulation

These include solid (tablets), liquid (suspensions) and semisolid (creams, ointments etc) dosage formulations. Formulation often involve a multistep process where the active drugs is mixed with all components by consideration of the factors of particle size, polymorphism, pH, and solubility.

Benefits and constraints of the API, excipients, associated interactions, and manufacturing procedures are the basic components for a successful pharmaceutical formulation.

Selective use of the non-medicinal agents referred to as pharmaceutical excipients produces dosage forms of various types and they help to solubilize, suspend, thicken, emulsify, preserve, color, flavor, and fashion medicinal agents into efficacious and appealing dosage forms and each type of dosage form is unique in its physical and pharmaceutical characteristics.[11]

The study is aimed at the extraction of starch from the tuber *D.dumetorum*, characterization of the extracted starch and comparison with corn starch then determination of the binding and disintegrant activities of the starches on ciprofloxacin tablet formulation.

MATERIALS

0.1N Hydrochloric acid, distilled water, 0.1N sodium hydroxide, concentrated hydrochloride acid, iodine solution, molisch reagent, ciprofloxacin powder, corn starch, magnesium stearate, talc, measuring cylinder, Oven, Erweka friabilator, dissolution apparatus, disintegration apparatus, uv spectrometer, sensitive weight balance, tableting machine (Siemens), pH meter, sieves (test sieve ASTN E11 BODY 316L MESH S-STEEL/RF, Germany), Atomic Absorption Spectrophotometer (Hitachi model 170-10, micrometer screw guage, oven (Memmert), Distillation Apparatus.
Procurement of *Dioscorea dumetorum* tuber.

The *D. dumetorum* yam tubers were purchased from a local market in Anambra state (Ochanja Market)

Extraction and isolation of starch

The yam tubers were washed, peeled, rewashed with distilled water and cut into small pieces then milled into fine paste dispersed in distilled water for 12 hours. The slurry obtained was sieved through a muslin cloth and the filtrate left to settle. The supernatant was decanted at 8-hour intervals and the starch slurry was re-suspended in distilled water and the procedure repeated up to three times in order to obtain a pure starch sample, the

resulting starch slurry was poured into a muslin bag, tied and allowed overnight to drain out excess water by placing a huge weight on top of the muslin bag, the resulting cake was collected and dried under sunlight for 12 hours and finally in a hot air oven 50 to 60^{O}C for 12 hours. The dried mass was pulverized and then screened through a 250µm mesh sieve. The Powder was collected, weighed and stored properly for further use. The percentage yield of the dried yam starch powder was calculated as follows.[12]

Starch yield (%) = weight of starch portion (g) x 100
Weight of peeled tubers (g)

PROXIMATE ANALYSIS OF TRIFOLIATE YAM STARCH

Moisture content: This was determined by oven drying method

The percent moisture was calculated using the formula.

$$\% \text{ moisture} = \frac{W - W_2 \times 100}{\text{Weight of sample}}$$

Where:

W= initial weight of crucible + Sample
W_2= final weight of crucible + Sample

Note: moisture free samples were used for further analysis.

Ash content

The determination of ash was carried adopting the furnance method at 600^{O}C

Percent ash was calculated by theformula:

$$\% \text{ Ash} = \frac{w - w_2 \times 100}{W}$$

Where:

W= Weight of sample
W_3 = Difference in wt. of Ash

Determination of crude protein

Protein content was determined by application of Kjeldahl method, Involving digestion, distillation and titration procedures.[13]

Percent crude protein content of the sample was calculated by using the following

% crude protein= 6.25*✕%N (*.Correction factor)

$$\%N = \frac{(S\ B) \times N \times 0.014 \times D \times 100}{\text{Weight of the sample} \times V}$$

Where:

S= sample titration reading, B= blank titration reading, N = normality of HCL, D = Dilution of sample after digestion, V = volume taken for distillation, 0.014 = milli-equivalent weight of nitrogen.

Determination of crude fat

By adoption of the dry extraction method using the soxhlet extraction apparatus fat sample was extracted. The percent crude fat was determined by using the following formula:

$$\%\text{crude fat} = w_e \times \frac{100}{Ws}$$

Where, W_e = weight of ether extract and W_s = weight of sample.

Determination of crude fiber

The crude fiber made of cellulose was determined following, digestion and ignition method. The undigested residue collected after digestion was ignited and loss in weight after ignition was registered as crude fiber.

Calculations were done using the formula

$$\%\text{Crude fiber} = \frac{W1 - W2 \times 100}{W0}$$

Where, w1= weight of sample after digestion and cooling
W2 = weight after being dried in a muffle furnace and cooled
W0 = initial weight of wet powder

Mineral analysis of trifoliate yam starch

Wet digestion of sample: For wet digestion of sample, exactly (1.000g) of the powdered sample was taken in digesting glass tube. Twelve milliliters (12ml) of HNO_3 was added to the food samples and mixture was left overnight at room temperature. Then 4.0 ml perchloric acid ($HCLO_4$) was added to mixture and was kept in the fume cupboard for digestion. The temperature was increased gradually, starting from 50^{0}c up to 250-300^{0}c. The digestion was completed in about 70-80 min as indicated by the appearance of white fume. The mixtures were left to cool and the contents of the tubes were transferred to 100ml volumetric flasks and volume of the contents made to 100ml with distilled water. The wet digested solution was transferred to plastic bottles labeled accurately and stored for use in mineral content determination.[14]

DETERMINATION OF IRON (FE), LEAD (PB), ZINC (ZN) AND MAGNESIUM (MG) BY ATOMIC ABSORPTION SPECTROMETRY)

The digested sample was analyzed for mineral content by atomic absorption spectrophotometer (HITACHI MODEL 170-10) in analytical concept ltd, Elenwo, Port Harcourt. This involved a process whereby atoms of an element are vaporized and atomized in a flame. The atoms then absorb light at a characteristic wave length. The source of the light is a hollow cathode lamp and is made up of the same element, which has to be determined. The lamp produces radiation of an appropriate wavelength, which while passing through the flame is absorbed by the free atoms of the sample. The absorbed energy is measured by a photo-detector read-out system and the amount of the energy absorbed is proportional to the concentration of the element in the sample.[15]

particle size determination

A modified method described by Sefa, 1989 was carried in determining the particle size. here 10g of the powdered starch samples were shaken through 2mm, 1mm, 500μm, 250 μm, 63 μm, 45 μm sieve sizes on a mechanical sieve shaker for 5 minutes. After this the weight of the starch residue on the sieves were recorded

and used to determine the percentage retention and percentage fines of the powder. The ease of passage of the starch particle in each of the mesh is an indication of the particle size.

Identification/Chemical test for starch

Molisch test

0.1g quantity of the starch powder was placed was placed in a clean test tube and 2 drops of molisch's reagent (freshly prepared) was introduced into the tube. 1ml of concentrated sulphuric acid was gradually added to the side of the tube to form a layer below the aqueous solution and the result obtained recorded.

Iodine test

0.1g of the dried powder was each placed inside a test tube, to which 1ml of 0.2ml iodine was added. The mixture was them observed for color changes.

Organoleptic properties of the extracted starch

The extracted starches were observed for the physical properties such as color, odor, taste and texture.

Microscopic analysis

Small amount of the starch powder was mounted in an optical micro photographic microscope and viewed at a magnification of x400.

Determination of ph

The pH values of 1%w/v starch suspensions were measured in triplicate using digital pH meter.

Test for the functional properties of trifoliate yam starch

Hydration capacity

A 1.0g of trifoliate yam starch (w_0) was placed inside an already weighed centrifuge tube and the weight (w_1) noted and covered with 10 ml of distilled water. The tube was shaken for 5 minutes and allowed to stand for 15mins before centrifuging at 300rpm for 10mins. The supernatant was decanted and the weight of the powder after water uptake and centrifugation was determined (w_2).

Water-binding capacity was calculated as:

$$\text{HYDRATION CAPACITY} = \frac{W2-W1}{W1-W0} \times \frac{100}{1}$$

Where: W_2-W_1= weight of bound water and W_1-W_0= weight of sample

Swelling index

This test was carried out to investigate the swelling capacity of the starch powder. 1.0g of sample was weighed and transferred into a 50ml measuring cylinder, distilled water was added to make up to 20ml, the measuring cylinder was closed with a stopper, well shaken and left at room temperature for 24 hours to observe for increase in weight.

Characterization of trifoliate yam starch

Bulk Density and Tapped densities

A 20g quantity (w_p) of starch powder was gently poured through a short stemmed glass funnel into a 50 ml graduated cylinder. The volume occupied by the powder was taken as vb. The powder was tapped on a wooden surface from a height of about 7mm until no further change in volume was observed. The volume(vt) was taken as the tapped volume. The bulk and tapped density were computed using the formulas

$$Bd = \frac{WP}{Vb}$$

$$Td = \frac{WP}{Vt}$$

Where, Bd = bulk density; Td = tapped density ; Wp = weight of powder Vp is volume of powder and Vt = tapped volume.

Hausner's ratio (Hr) and Carrs compressibility index

The result obtained were used to calculate the Hausner's ratio (HR) and the carr's compressibility index (CI) using the formula:

$$HR = \frac{\text{tapped density}}{\text{bulk density}}$$

$$CI = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}}$$

Angle of repose

The static angle of repose (θ), was measured according to the fixed funnel and free standing cone method and the angle of repose calculated using the equation

$$\tan\theta = 2h/D$$

where h is the height of the heap powder and D is the diameter of the base of the powder heap.

Identification test for ciprofloxacin

Rapid color identification with acid – base mixed indicator

SOLUTION A: (1:1), 0.1% BROMOTHYMOL BLUE (50% ALCOHOL) AND 0.1% METHYL RED (50% ALCOHOL)

Procedure

The solid sample were dissolved in 0.5 ml of 0.1 N HCl and allowed to stand for 2 minutes. The supernatant was decanted and neutralized with 0.1 N NaoH added in installments of 25 mL till precipitation commenced. The precipitate obtained was washed 2-3 times with distilled water to remove any traces of excess acid or alkali. Finally, the precipitate was suspended in 0.5 ml water. 2-3 drops of solution A, was added and after a few minutes, the color of the supernatant liquid was observed and the ciprofloxacin present gives a yellow color.[16]

Tablet formulation

Ingredients	Concentration
ciprofloxacin	89.3% (250mg)
Starch (intragranular)	5% (14mg)
starch (extragranular)	3% (8.4mg)
magnesium sterate	1% (2.8 mg)
talc	1.5% (4.76mg)

Three batches of the formulation were made and captioned as: BATCH A (*D. dumetorum* used alone as binder & disintegrant), BATCH B (Corn starch used alone as binder & disintegrant), BATCH C (*D.dumetorum* + Corn starch used in a 1:1 ratio as binder & disintegrant)

Tablet formation

Wet granulation technique was employed and involved incorporation of components as (both intra and extra-granular) for the granule formation before tableting. The intra- granular components included, the active pharmaceutical ingredient (API) and the binder(s), while the extra- granular components involved the addition of disintegrants, lubricant and glidants. The formed granules were tableted using a single punch tableting machine at a pressure of about 5KgF to obtain a targeted tablet weight of 280mg.

Quality control of the tablet

The compressed tablets were assessed for their characteristic color and odor as it is a reflection of the identification or degradation of the tablet.

The thickness of about five tablets were measured using a micrometer screw gauge. The tablet thickness was controlled using a ±5% variation and expressed in mm.

The crushing strength of the tablet was determined using the Mosanto hardness tester and the force of the fracture recorded in KgF.

Friability of the tablets were determined using a Roche friabilator where 10 tablets were dedusted, weighed and placed in the friabilator and operated at a speed of 25rpm for 4 minutes. The tablets were removed, dedusted and reweighed. The difference in the weights is used to calculate for friability and the value expressed in percentage as:

$$\% \text{ Friability} = \frac{\text{Weight of tablets before testing}}{\text{Weight of tablets after the test}}$$

Weight Uniformity Test

This was done by sorting 20 tablets individually, determining the average weights and comparing the individual tablet weight (W_1) to the average weight (W_2). The weight variation is expressed in percentage as:

$$\text{Weight Variation} = \frac{W_1 - W_2}{W_2} \times 100\%$$

Beer- Lamberts Plot

Pure 50mg sample of ciprofloxacin powder was placed in a 100ml volumetric flask and dissolved in 50 ml of 0.1N Hydrochloric acid. Serial dilutions of 0.01, 0.015, 0.02 and 0.025 ml of the stock solutions were made. The absorbance obtained at 275nm wavelength was plotted against the various concentrations to obtain a line drawn to the origin.

Percentage drug content determination.

About 20 tablets were crushed and the average weight obtained. The powdered tablet was placed in a 100ml volumetric flask and made up to 100 ml with 0.1N HCl. The solution was filtered and 0.2 ml of the filtrate was placed in a 10 ml volumetric flask and made up to 100ml with same solvent then the absorbance determined using a UV spectrophotometer at 275nm. The result was used to calculate for the percentage active ingredient while the limit value for ciprofloxacin lies between 90-110%.[17]

Disintegration test

Using the basket method, the disintegration of the tablets was determined. In this case, one tablet was placed in each tube positioned in a 700ml solution of 0.1 N Hydrochloric acid such that the tablet remain 2.5cm below the surface of the liquid and then moved through a distance of 5 to 6cm at a speed of 30 cycles per minute for up to 60 minutes and the results recorded appropriately.

Dissolution test

Using the erweka dissolution apparatus, 900 ml of 0.1N HCl was employed as the dissolution medium and equilibrated at a temperature of 37 ± 0.5^{O}C. A tablet was placed on the perforated plastic discs placed on the media after taking care to exclude air bubbles.

The apparatus was allowed to run at 75rpm for 60 minutes and after an interval of 5minutes, 5ml aliquot of the medium was withdrawn, filtered and quickly replaced with equal volume of fresh medium.

The UV spectrophotometer was used to determine the absorbance at 275nm and the results recorded appropriately.

RESULTS

Percentage yield of starch from the *D. dumetorum* is 56.7%

Table 1: Preliminary confirmatory tests.

Tests	Observation	Inference
Molisch Test	Violet color observed at the junction of the two layers	Carbon hydrate present
Iodine test	Blue-black color observed	Starch present

Table 2: Physical and organoleptic properties.

Colour	Odour	Taste	Texture	Solubility
White	Perculiar	Tasteless	Smooth/powdery	Insoluble in cold water, and organic solvents but gelatinizes in the presence of hot water

Table 3: Physicochemical properties of *D. dumetorum* and corn starch.

Property	Corn starch	*D. dumetorum* starch extract
pH	7.00	6.88
Swelling index	8.33	6.67
Water binding (hydration) capacity	76.15±1.15	95.3±2.26
Bulk density	0.55±0.003	0.54±0.006
Hausner' quotient	1.200±0.006	1.192±0.004
Carr's Index	16.642±1.152	16.124±1.822
Angle of repose (θ)	37.303±1.525	34.492±1.950

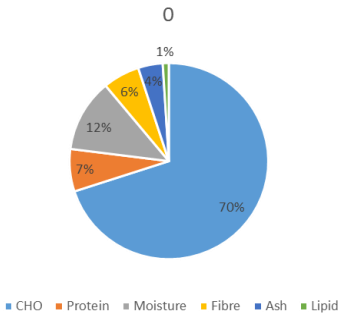

Figure 4: Proximate analysis of *D. dumetorum* starch.

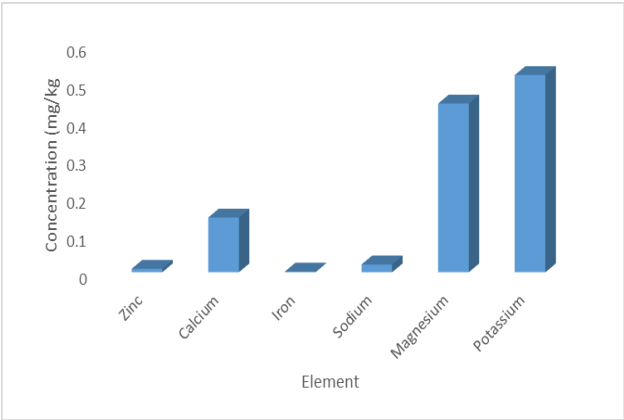

Figure 5: Elemental analysis of sample.

Table 5: Physico- Technical properties of formed Ciprofloxacin granules and resultant Tablets.

Properties	Samples		
	Batch A (Corn starch)	Batch B (*D. dumetorum* starch)	Batch C (Corn starch + *D. dumetorum* starch (1:1)
Bulk density (g/ml)	0.4±0.003	0.553±0.015	0.549±0.067
Tapped density (g/ml)	0.435±001	0.606±0.031	0.606±0.010
Hausner's ratio	1.088±0.005	1.098±0.008	1.104±0.012
Carr's index (%)	8.046±1.708	8.911±2.012	9.406±1.023
Angle of repose (θ)	30.224±2.113	31.323±2.012	30.652±1.822
% Friability	0.217	0.071	0.174
Crushing strength (KgF)	4.575	5.900	5.225
Weight uniformity	0.278±0.000	0.285±1.931	0.280±0.000
% API content	108.4	93.21	94.18

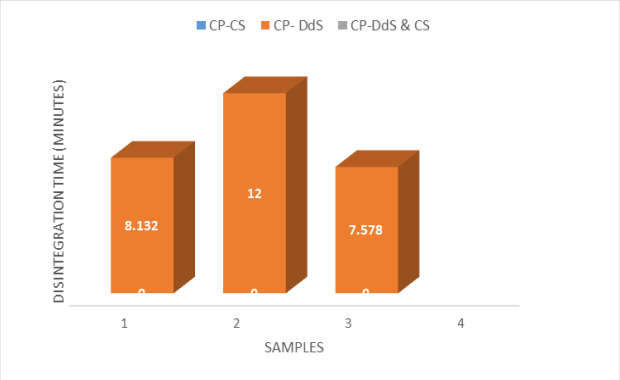

Figure 6: Disintegration time of three batches of formulated ciprofloxacin tablets.
Batch A (CP-CS = Ciprofloxacin + corn starch), Batch B (CP-DdS = Ciprofloxacin + D. dumetorum starch)
Batch C (CP-DdS & CS = Ciprofloxacin + *D. dumetorum* & Corn starch (1:1)

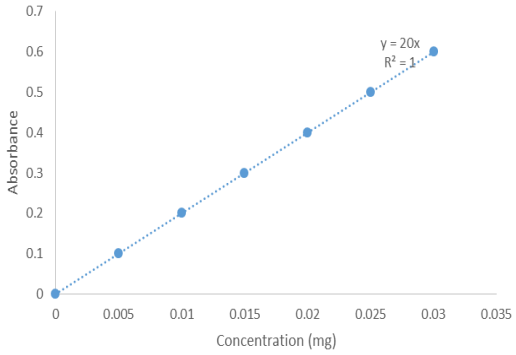

Figure 7: Beer Lambert' plot for ciprofloxacin pure powder.

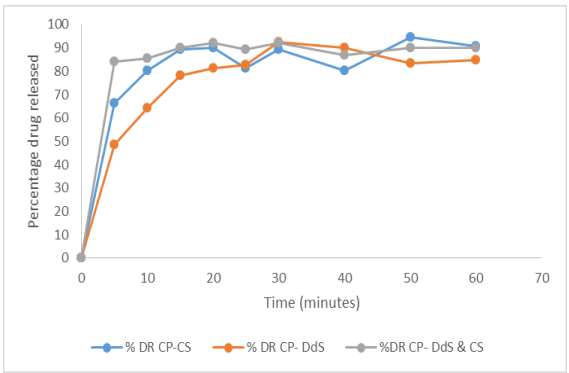

Figure 8: Dissolution profile for formulated ciprofloxacin tablet.
Note* DR = dissolution rate

DISCUSSION

The isolated starch from the *D,dumeturum* is colorless, tasteless and smooth/powdery substance with peculiar odor. The starch is composed mainly of monosaccharide units of xylose, manose, galactose and glucose and the average yield of dried starch obtained was 56.7%.

Results of physicochemical characterization of the starch is as shown in Table 3 in which there was observed variation in the swelling and water hydration capacity of the starches from the various batches. This difference could be attributed to the difference in intensities of molecular bonding forces inside the granules. This forces may be governed by factors such as the amylose/amylopectin content, molecular weight structural conformation, degree of polymerization and degree of branching of the amylopectin. Thus *D.dumetorum* starch seems to be relatively resistant to swelling than corn starch but generally intrinsic swelling power and water resistant capacity has been recognized as qualitative assessment of starch in tablet formulation Since, the flow properties of the powder mixture are important for the uniformity of mass of the tablets, the flow of the powder mixture was analyzed before compression to tablets. Bulk density was found to be between 0.54 g/ml and tapped density between 0.67 to 0.75 g/ml, bulkiness between 1.73 to 1.92, Carr's index between 16.12±1.822%, Hausner's ratio between 1.192±0.004 and angle of repose was found to be between 34.49± 1.822, indicating fair to good flow properties. Results of Pre compression parameters are as shown in Table 5, as tablets were prepared using wet granulation. The tablets obtained are of uniform weight due to uniform die fill, with acceptable weight variation relative to pharmacopoeial specification.

Hardness of the all the formulations were measured in kg/F, and the hardness of all batches formulated was found to be in the range of 4.5-5.9 kg/kgF.

Drug content of the formulations containing the starch extract from *D.dumetorum* either used singly or in combination with corn starch (1:1) were found to be in the range of 93-94.8% while that of corn starch used alone was 108.4%, and these are within acceptable limits. Friability values of all the formulations were within the limit i.e. is less than 1.0% indicating that the tablets had a good mechanical resistance.

Results of Post compression parameters are shown in Table 5. Wetting time/ swelling capacity of granules were used as parameter to correlate with disintegration time *in vivo*. This is an important criterion for understanding the capacity of disintegrants to swell in presence of water. Since the dissolution process of a tablet depends upon the wetting followed by disintegration of the tablet, the measurement of swelling index could be used as another confirmative test for the evaluation of tablets. The wetting time of formulated tablets was found in the range of 30- 87s.

The disintegration times of all the formulations were within official requirements and are less than 15minutes.[18] Comparison between the disintegration time (*Invitro*) of the powder resulting from the formulations are shown in Figure 6. Disintegration time *in-vitro* occurred within 12 minutes for *D.dumetorum* starch powder and the result of the study showed good correlation between disintegration time and wetting time for all formulations. The designed formulations using *D.dumetorum* starch powder and corn starch showed rapid dissolution and percent drug release (%DR) which at the end of 10 minutes about 80-85% drug release was observed as shown in Figure 7. The batch containing *D.dumetorum* + cornstarch powder was selected as optimized batch and as super disintegrant in 5% w/w concentration and has less disintegration time. The dissolution study carried out with the batch showed that 85% of drug release occurred within 12 minutes.

When tablets were kept at real time (30 ± 2^{O} /65±5% RH) and accelerated (40 ± 2^{O} /75±5% RH) storage conditions, both disintegration time and hardness values decreased significantly indicating that tablets have lost the mechanical integrity leading to more friability loss.

These results obtained in over all, reveals that, at higher relative humidity, tablets containing high concentration of *D.dumetorum* get softened and hence, must be protected from atmospheric moisture.

CONCLUSION

In overall, results obtained suggest that starch from *D. dumetorium* yam could be a better alternative in tablet formulations where a high bond strength is essential, but combination of corn and TYS at 1:1 ratio had better result output than other batches hence could be useful and applicable especially when faster disintegration/dissolution time of tablets is required.

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