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Comparative Evaluation of *Solanum tuberosum* L. and *Manihot esculenta* Starch as Pharmaceutical Excipients: Assessment by Preformulation Studies

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Abstract

This investigation was aimed at comparing the newly developed starches from two grains; Potato (*Solanum tuberosum*) and Cassava (*Manihot esculenta*). The presence of starch in as these grains vary and thus their use as pharmaceutical excipients will depend on the degree of their starch functionality. The organoleptic and physicochemical characteristics such as viscosity, swelling capacity, moisture sorption capacity, pH, flow rate, Carr's index, and Hausner's ratio were evaluated. The powders passed the identification and solubility tests as required by the British Pharmacopoeia. Cassava starch showed the least Carr's index, Hausner's ratio and moisture sorption capacity but displayed more angle of repose and true density than the potato starch. In contrast, potato starch showed the highest hydration and swelling-capacity. That is why, potato starch could be a better tablet disintegrant compared to cassava starch. The results obtained demonstrated that between the two starches in relation to their flow ability, cassava starch possesses the best flow property. Infrared (IR) spectra of potato and cassava starch with the drug sample (Etoricoxib) were seen to retain the individual peak of potato and cassava starch and the IR spectra showed that there was no interaction of starch with the drug.

Key words: Starch; Viscosity; Flow property; Etoricoxib.

Introduction

Natural polymers have been used in different pharmaceutical formulations. They are easily available, non-toxic, biodegradable and cost effective to be used as pharmaceutical excipients. When formulating tablets, the choice of excipients is extremely critical. It must fulfill certain requirements such as compressibility, good binding functionality, powder crystallinity, flow ability and acceptable moisture content. Moreover, it is essential to have a well designed particle size distribution for favorable mixing conditions with drugs (Hasan *et al*., 2012).

Pharmaceutical starches are used for binding, carrying, disintegrating, thickening and coating in a myriad of application. They are widely available and have been very useful in tablet production due to their inertness and cheapness. Choosing the right excipient can make all the differences in the efficient production of robust tablets. A pharmaceutical manufacturer can replace a polymer binder, a super disintegrant and a portion of standard filler with a multifunctional partially pregelatinized starch (PPG starch) and achieve remarkable results (Alebiowu *et al*., 2003). The PPG Starch improved the tablet's physical properties and dissolution properties with fewer processing steps, leading to a less complex formulation and dramatically low costs (Alebiowu *et al*., 2001).

Some of the earliest works on the use of locally available starches as pharmaceutical raw materials was reported by (Mital and Ocran, 1968) who found that yam (sweet potato) and cassava starches could be used as tablet disintegrant. Recently starches have been developed for various purposes. This includes a comparative study of modified starches of maize, rice, cassava and cocoyam in direct compression of chloroquine phosphate tablet was evaluated by (Okafor *et al*., 2000). The effect of acid treatment on the consolidation and plasto-elasticity of tapioca powder was evaluated by (Uhumwangho *et al*., 2006). The effects of maize starches on mechanical properties of paracetamol tablet formulation were evaluated (Alebiowu and Itiola, 2003). A comparative

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investigation of the fundamental and derived properties of starches from some species of yam (*Dioscorea* sp.) was conducted with a view to establishing their suitability as excipient in tablet and capsule formulation (Riley *et al.,* 2006). Influence of cassava, yam starch and maize starch BP on the brittle fracture of paracetamol tablets has been investigated (Uhumwangho *et al*., 2006). The effects of pigeon pea and plantin starches on the compressional, mechanical and disintegration properties of paracetamol tablets have been investigated (Kunle *et al.,* 2006). Ibezim *et al.(* 2008) have also investigated the role of ginger starch as binder in acetaminophen tablets. The performance of starch obtained from *Dioscorea dumetorium* as disintegrant in sodium salicylate tablets have been studied by (Ibezim *et al.,* 2008).

The aim of this study was to investigate the properties of starches and also asses their advantages and disadvantages relative to each other. The objectives therefore are, to extract cassava-and potato-starches from their natural plant sources and process them to pharmaceutical grade starch and to compare the physical properties of these starches in the powdered state relative to each other.

Materials and Methods

Collection and identification of starches: Solanum tuberosum L. (Potato) and *Manihot esculenta* Crantz (Cassava) were purchased from BADC market at Mohammadpur in Dhaka and were identified at the Department of Botany, Faculty of Biological Sciences in Jahangirnagar University, Bangladesh.

Extraction of cassava and potato starches: Potato and cassava were thoroughly washed and all foreign materials were removed. The washed seeds were allowed to steep in water for about 24 hours. The outer layer of cassava and Potato was peeled off and the white part was washed and cut into the pieces. These pieces grains were crushed using a blender (Philips HR2001, China). Enough quantity of water was added to the pulp which was then passed through a sieve. The starch as a residue was collected, allowed, to settling and 0.1N sodium hydroxide was added to separate the starch and proteins as well as to neutralize the slight acidity. Excess sodium hydroxide was removed by washing several times with distilled water. The clear supernatant was poured away while sediment starch was collected on a tray and the wet starch was dried with a suitable oven at temperature of 60^0 C for about 2-4 hours. The dried starch was ground again with a blender and powdered starch was collected for the experiment.

Characterization of starch

Solubility test: 1g of each starches (Cassava and Potato) were weighed and poured into a beaker containing 1ml, 2ml, 10ml, 1L and 10L distilled water at 25°C and was stirred, and the solubility was observed. Same procedure was repeated using 65% alcohol as a solvent.

Iodine test: Using BP (2010) starch identification test, 1g of each starches (Cassava and Potato) were boiled with 15ml of water and allowed to cool. A few drops of 0.1N iodine solution were added to 1ml of the mucilage and the color changes recorded.

Determination of pH: One gram (1g) of the individual starches was made into mucilage with 100 ml of distilled water and the pH was determined an electronic pH meter.

Moisture content determination: One gram (1g) of the powder was weighed and then dried in an oven at 105°C for about 1 hour and then weighed again until constant weight was observed and the percentage of loss on drying was calculated.

$$\text{Moisture content} = (W_f / W_i) \times 100$$

Where, W_f is final weight of powder after drying and W_i is initial weight of powder before drying.

Microscopic observation: A small quantity of each starch was mounted in a drop of glycerol on a glass slide and covered with a cover slip. The size and shape of starch particles were determined with a microscope (Olympus, Germany) equipped with a micometer using 40 × magnification.

Determination of flow properties of starch

Angle of repose: Angle of repose was measured for the starch batches before granulation, as to observe the flow properties of starch particles. The method employed a funnel secured with its tip at a given height (*h*), above the graph paper placed on horizontal surface. Starch powders were poured through the funnel until the apex of the conical pile touches the tip of the funnel. The angle of repose was calculated using the following formula:

$$\tan \Ø = h / r$$

Where, Ø is the angle of repose and r is the radius of conical pile. The mean angle of repose was calculated from three determinations. This method is known as fixed height method.

Determination of starch density

Bulk and tapped densities: Bulk and tapped densities were determined by using 50g (*Wp*) of the starch powder. This was gently poured through a short stemmed glass funnel into a 100 ml graduated cylinder. The volume occupied by the powder was taken as *Vp*. The powders were tapped on a wooden surface at height of 7 inches until no further change in volume was observed. This volume (VpT) was taken as the tapped volume.

$$B_d = (Wp / Vp)$$

$$T_d = (Wp / VpT)$$

Where, B_d = bulk density and T_d = tapped density

Carr's index: The difference between the tapped and bulk density divided by the tapped density was calculated and the ratio was expressed as a percentage.

Hausner ratio: The ratio of tapped density to bulk density was calculated for all starches.

Determination of starch true density: The specific gravity bottled method was adopted and xylene was used as displacement fluid. The bottle was cleaned and filled with xylene, all spilled over liquid (xylene) was wiped off with an absorbent cloth. The weight of the bottle filled with xylene was noted as (a), the bottle was emptied and cleaned, 2 g of starch was weighed into the specific gravity bottle, the weight of the starch powder was noted as (w). The specific gravity bottle containing the starch was almost filled with xylene, stirred with glass rod and allowed to stand for 10 minutes for air bubbles to be released. The bottle was then carefully filled with xylene and the final weight of the bottle was noted as (b). Starch true density was calculated as:

$$l = w / [(a + w) - b] S$$

Where, l is the particle density of starch and the specific gravity of xylene, S = 0.86

Swelling capacity: The swelling capacity of the starch powders was determined by the method of Iwuagwu *et al*. (2004). The tapped volume occupied by 5g of the powder V_x was noted. The powder was then dispersed in 85 ml of distilled water and the volume made up to 100 ml with more water. After 24 hours of standing, the volume of the sediment, V_v was estimated and the swelling capacity, S, was computed as:

$$S = [(V_v - V_x) / V_x] \times 100$$

Moisture sorption capacity: Moisture sorption capacity of the starch was determined by modified method of Ohwoavworhua *et al.* (2005). Two grams (2g) of the individual starch powders (W) were weighed and put into a tarred petri dish. The samples were then placed in a desiccator containing distilled water at room temperature and the weight gained by the exposed samples at the end of a five-day period (W_g) was recorded and the amount of water absorbed (W_a) was calculated from the weight difference as:

$$W_a = W_g - W$$

Hydration capacity: One gm (1g) of starch was in placed in 15ml plastic centrifuge tube, 10 ml distilled water was added and then closed. The contents were shaken for 2 min and then allowed to stand for 10 min and immediately centrifuged at 1000 rpm for 10 min in a bench centrifuge. The supernatant water was decanted and the weight of the wet starch was recorded. The hydration capacity was determined using the equation below:

$$\text{Hydration capacity} = W_S/W_D$$

Where, W_S and W_D are the weights of the sediment formed and weight of the dry sample respectively.

Porosity: The powder porosity (E) was calculated by the method of Ohwoavworhua *et al*. (2007) as:

$$E = [1 - (B_d / D_t)] \times 100$$

Where, B_d is bulk density, D_t is true density of starch.

Packing fraction: The packing fraction (P_f) was expressed as the ratio between the bulk density (B_d) and the true density (D_t) as

$$P_f = (B_d / D_t)$$

FT-IR compatibility test: The drug excipient interactions were investigated by FTIR studies. The FTIR spectra of pure drug and mixtures of pure drug and starch phosphate (1:1) were recorded on a Perkin Elmer, IR spectrophotometer model: Spectrometer RXI, using KBr disc as reference. Compatibility of Etoricoxib, a widely prescribed NSAIDs in Bangladesh with cassava and potato starch was studied by IR spectra (Shimadzu FT-IR 8400S, Japan).

Results and Discussion

The identification tests showed that both potato and cassava starches were insoluble in water and alcohol (95%) at room temperature. The starches gave positive to mucilage and iodine tests. Potato starch was little bit acidic than the cassava starch as shown in Table-1. The closeness of the starches to pH 7 could be a plus point because neutral pH might cut down the propensity of interaction of excipients with active pharmaceutical constituent. The pH was up to standard limit of 4.5-8 (Rowe *et al*., 2006). The color, odor, taste, solubility test for this two starches were within the official recommendation (BP, 2010). Both the starches were found tasteless. In terms of color, potato starches were yellowish but the cassava starches were white (Table 1).

Table 1. Results of identification tests of cassava starch and potato starch.

Parameter	Potato starch	Cassava starch
Color	Yellowish	White
Odor	Odorless	Odorless
Taste	Tasteless	Tasteless
Test for mucilage	Positive	Positive
Solubility test	Insoluble in H_2O & C_2H_5OH	Insoluble in H_2O & C_2H_5OH
Iodine test	Positive	Positive
pH	6.52	6.54

Microscopic of studies: Figure 1 shows the photomicrograph of the starches at X40 and X100 magnification. Cassava starch particle were small angular polyhedral. The particle shapes of the potato starches were mainly spherical and round. The large particle size is an advantage because large particle has small surface area and hence small surface activity. Larger particles flow better than smaller particles because particulate function is more of surface phenomenon by generation of resistance to flow. The small particles (large surface area) having more surface energy to attract with one another tends to adhere together have more resistance to flow (Ohwoavworhua *et al*., 2007). It is however pertinent to note that not only particle size that is involved in the flow of powders, other characteristics of excipients such as densities and moisture content may also affect flow properties of powder (Hasan *et al*., 2012).

Physicochemical parameters of starch: The physicochemical parameters of the starches are shown in Table 2. The hydration capacity of potato starch was higher than that of the cassava starch. It is understood that the hydration of starch represents the water absorbed by the particle or the particle surface (Ohwoavworhua *et al*., 2007). As observed earlier, the smaller the particle size, the larger the surface area for absorption of water. The potato starch has higher moisture content than the other starch this might be as a result of larger particle size of the potato starch. Regulation of moisture in formulation is very important as high moisture content may interfere with active ingredient (Muazul *et al*., 2011). The moisture sorption capacity is a measure of moisture sensitivity of a material and it reflects the relative physical stability of the tablets formulated with the material when stored under humid conditions (Ohwoavworhua *et al*., 2010). The results show that cassava starch absorbed the less moisture followed by potato starch. This could indicate that cassava starch when used in tablet formulation would absorb the least moisture and thus eventually give tablets with better physical stability than potato. The common feature of all theories of disintegration is that penetration of water (or liquid medium) must precede disintegration and this can be assessed by the determination of hydration capacity, swelling capacity and porosity (Caramella, 1991). The swelling capacity which reflects increase in volume of the starches showed potato starch having the highest increase in volume followed by the other. This suggests that potato starch may be a better disintegrant than the other starch and if incorporated in tablet formulation as a disintegrant, would probably produce tablet disintegration by two mechanisms: capillary or wicking and swelling (Hasan *et al*., 2012).

Morever, from the results of bulk and tapped densities, porosity and packing fraction in Table 2, cassava starch exhibited the largest maximum volume reduction due to packing while potato starch exhibited the lowest.

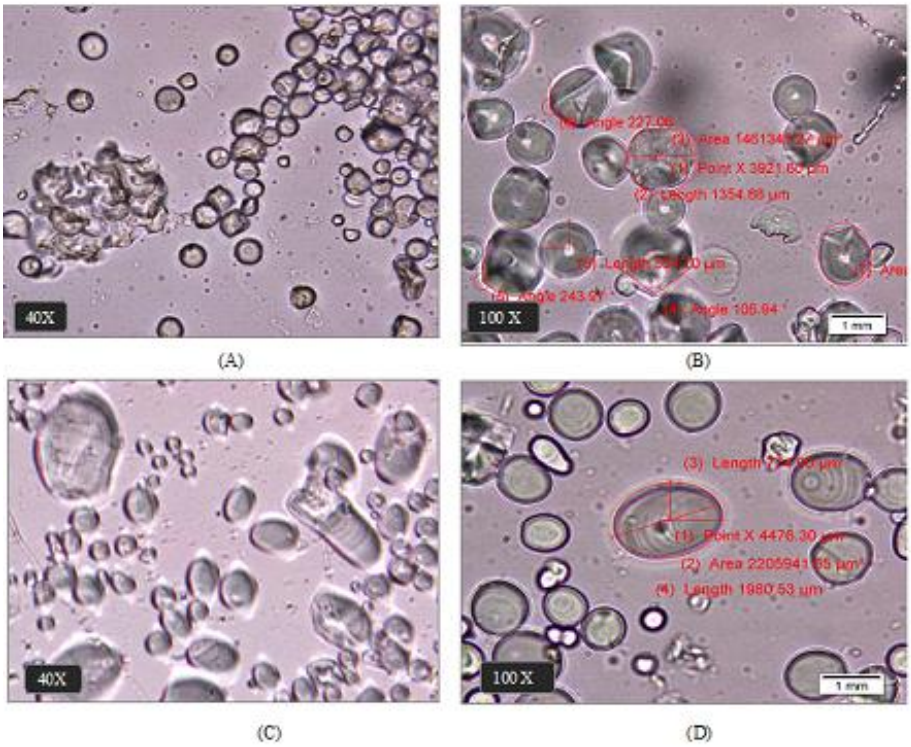

Figure 1. Photomicrograph of cassava- (A & B) and potato (C & D) starches at 40x and 100x magnification. The photomicrographs were taken with Olympus DP 72 microscope. Angle, centre and length of both starches are schematically illustrated under 100x magnification.

The flow characteristics of the starch were measured using angle of repose. The angle of repose of cassava starch was greater than those of potato starch. Angle of repose above 50° is an indication of poor flow characteristics of powder. Both of the starches were within the limit.

The Carr's index and Hausner ratio predict the flow and compressibility of powders, Hausner ratio below 1.25 and Carr's index above between 5-15% indicate good flow or good compressibility. Although both starches were within the limit in terms of Hausner ratio but beyond the limit in provisions of Carr's index.

The swelling power of potato starch and cassava starch were almost close in terms of numeric value. This parameter is an indicator of disintegrating property of starch.

Compatibility of Etoricoxib with potato and cassava starch was evaluated by IR spectra and found that both Etoricoxib is compatible along with potato and cassava starch (Figure 2).

Table 2. Comparative studies of phytochemical properties of both starch powder.

Parameter	Potato starch	Cassava starch
Viscosity (pa-sec)	5.4	5.34
Bulk density(gm/cm^3)	0.69	0.78
Tapped density(gm/ cm^3)	0.89	0.99
Carr's index	22.4	21.2
Hausner ratio	1.2	1.2
Moisture content (%)	09	7
Moisture sorption capacity (%)	0.081	0.074
Swelling capacity (%)	69.5	68.8
Hydration capacity	2.33	2.26
Angle of repose	34	37
Porosity (%)	52	49
Packing fraction	0.48	0.51
True density (gm/cm^3)	1.42	1.52

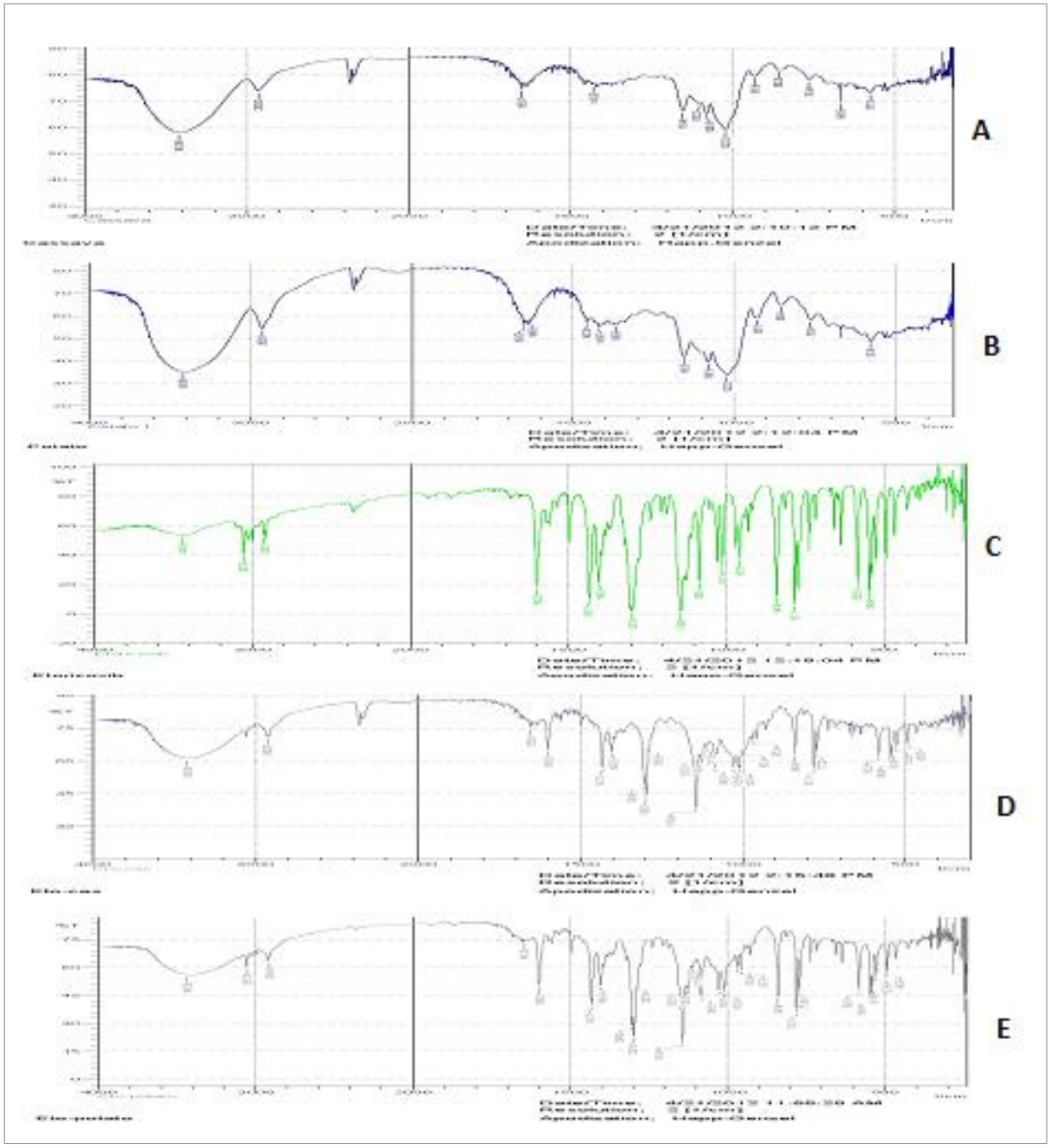

Figure 2. IR spectra of compatibility studies (A. Cassava starch; B. Potato starch; C. Etoricoxib; D. Etoricoxib and Cassava starch; E. Etoricoxib and potato starch).

Conclusion

The characterization of these starches shows that cassava starch with the lowest cohesiveness would be the starch of choice when fair flow ability is desirable. It shows that the moisture content, moisture sorption capacity, porosity swelling capacity and hydration capacity are greater for the potato starch compared to that of cassava starch. reason why potato starch could be a better tablet disintegrant.IR spectrum of Potato and cassava starch shows that, the individual peak of potato and cassava starch are found in case of drug-starch combination peak. This suggests that there is no considerable interaction between the drug, Etoricoxib and starch. These findings would be useful in the handling of

these starches and in their use as pharmaceutical excipients in the production of powders, tablets and other relevant drug delivery systems.

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References

Alebiowu, G. and Itiola, O.A. 2003. The effects of starches on mechanical properties of paracetamol tablet formulations. I. Pregelatinization of starch binders. *Acta Pharm.* **53**, 231-237.

Alebiowu, G. and Itiola, O.A. 2001. Effects of natural and pregelatinized sorghum, plantain and corn starch binders on the compressional characteristics of paracetamol tablet formulations. *Pharm. Tech*. **26-30**.

Caramella, C. 1991. Novel methods for disintegrant characterization, part 1. *Pharm Technol*. 1991, 48-56.

Hasan M.M., Chowdhury S.S., Lina S.M.M., Bhoumik, N.C. and Ashab, I. 2012. Comparative evaluation of *Zea mays* (L.) and *Ipomoea batatas* (L.) as a pharmaceutical excipient. *IOSR-JPBS* **3**, 31-36.

Ibezim, E.C., Ofoefule, S.I., Omeje, E.O., Onyishi, V. I. and Odoh, U.E. 2008. The role of Ginger starch as a binder in acetaminophen tablets. *Sci. Re. Ess.* **2**, 46-50.

Iwuagwu M.A, and Okol,i P.C. 1992. The disintegrant properties of pregelatinized cassava and white yam starch. *Pharm. World J.* **9**, 49-53.

Kunle, O.O., Akin-Ajani, D.O., Okoli, O.A., Itiola, O.A. and Odusote, O.M. 2006. Effects of Pigeon pea and plantain starches on the compressional,mechanical, and disintegration properties of paracetamol tablets. *Drug. Dev. Ind. Pharm.* **32**, 357-365.

Mital, H. C. and Ocran, J. 1968. Cassava and yam starches as tablet binder and disintegrants. *Pharm. Acta. Helv*. **43**, 493.

Muazu1, J, Musa, H, Isah, A.B, Bhatia, P.G, and Tom1, G.M. 2011. Extraction and characterization of Kaffir potato starch: a potential source of pharmaceutical raw material. *J. Nat. Prod. Plant Resour.* **1**, 41-49.

Ohwoavworhua F.O., Adelakun, T.A. and Kunle, O.O. 2007. A comparative evaluation of the flow and compaction characteristics of α-cellulose obtained from waste paper. *Trop. J. Pharm. Res*. **6**, 645-651.

Ohwoavworhua, F.O, and Adelakun, T.A. 2010. Non-wood fibre production of microcrystalline cellulose from *Sorghum caudatum*: characterization and tableting properties. *Ind. J. Pharm. Sci.* **72**, 295-301.

Ohwoavworhua, F.O., Kunle, O.O, Ofoefule, S.I. 2004. Extraction and characterization of microcrystalline cellusose derived from luffa cylindrica plant. *Afr. J. Pharm. Res. Develop*.**1**, 1-6.

Ohwoavworhua, F.O, Ogah, E. are Kunle, O.O. 2005. Preliminary investigation of physicochemical and functional properties of alpha cellulose obtained from waste paper - a potential pharmaceutical excipient. *J. Raw Mat. Res*. **2**, 84-93.

Okafor, I.S., Ofoefule, S.I. and Udeala, O.K. 2000. A comparative study of modified starches in direct compression of a water soluble drug-chloroquine phosphate. *Boll. Chim. Farm*. **139**, 252-255.

Riley, C.K., Adebayo, A.S., Wheatley, A.O. and Asemota, H.N. 2006. Fundamental and derived properties of yam (Dioscorea spp.) starch powders and implications in tablet and capsule formulation. *Afr. J. Biotec*. **5**, 1528 – 1536.

Rowe, R.C., Sheskey, P.J. and Quinn, M. 2006. Handbook of Pharmaceutical Excipients Pharmaceutical Press, UK, 6th edition.

Uhumwangho, M.U., Okor, R.S., Eichie, F.E. and Abbah, C.M 2006. Influence of some starch binders on the brittle fracture tendency of paracetamol tablets. *Afr. J. Biotec.* **5**, 1950-1953.