FUNCTIONAL PROPERTIES OF STARCH ISOLATES FROM THE SEEDS OF *Delonix Regia* (FLAME OF THE FOREST) AND *Lonchocarpus Sericeus* (SENEGAL LILAC)

Abdulrasaq Oyedeji* & Bibilomo Odeyemi

Department of Science Laboratory Technology
The Federal Polytechnic, Ilaro, Nigeria
olalekan.oyedeji@federalpolyilaro.edu.ng

ABSTRACT

Functional properties are intrinsic physico-chemical attributes that affect the behaviour of properties in food systems during preparation, processing, manufacturing and storage. The functional properties of starches from the seeds of *Delonix regia* and *Lonchocarpus sericeus* were evaluated to determine their potential practical applications. The starches were isolated from the seeds after wet milling using the alkaline method and sedimentation. There was a significant difference between bulk and tapped density, oil and water absorption capacity, the effect of temperature on swelling power and effect of pH on solubility of the two starches. However, there was no significant difference between light transmittance, the effect of pH on swelling power and effect of temperature on solubility. The bulk and tapped density for *D. regia* and *L. sericeus* were 0.46±0.00 and 0.54±0.00 g/cm^3, and 0.6±0.00 and 0.67±0.00g/cm^3, respectively. Swelling power and solubility for *D. regia* were 5.09-2.59 g/g and 13-6.67%, respectively, and 5.35-4.67 g/g and 10.67-17.7%, respectively for *L. sericeus*. Oil and water absorption capacity for *L. sericeus* (93±0.05 and 126.67±0.12 ml/g, respectively) is lower than *D. regia* (144±0.18 and 333.33±0.23 ml/g, respectively). An increase in pH resulted in increased in swelling and solubility also for the two starches. Values obtained in the present study for the different parameters compared well with those reported in the literature for starches from popular legumes. The two starch isolates are therefore suggested for further studies, especially regarding the modification of their functional properties so they could be explored to meet the increasing demand for starch for domestic and industrial applications.

KEYWORDS: Functional properties, protein isolates, *Lonchocarpus sericeus*, *Delonix regia*

INTRODUCTION

Lonchocarpus sericeus (L. sericeus) is a leguminous plant commonly called cube root or Senegal lilac with pinnate leaves and purple or lilac color flowers. It is a dry deciduous tree that can grow from 2–15 and 1.2–1.4 m in height and span, respectively. It is native to the West Africa sub-region including Cameroun. Its stem bark extract has been employed as a laxative, and in the treatment of ailments including convulsion, backache and as a liniment for parasitic skin infections. It is reported to be rich in the insecticide rotenone, a violent poison and other bioactives including include quercetin, coumaric acid rutin, β-sitosterol, pterocarpans and isoflavonoids (Agbonon & Gbeassor, 2009; Abdullahi et al., 2013; Iwu, 2014; Oyedeji et al., 2015). *Delonix regia*, an underexploited legume, belonging to the family of fabaceae (legumes) with its golden-yellow flowers is widely cultivated and may be seen in estates and parks in tropical cities all over the world. It stands hard pruning and can be kept at a small size, and even grown in the conservatory (Nawrocki, 2004). All the parts of *D. regia* grown have not been exploited as foods or feeds. However, Agunsoye et al., (2019) had employed *D. regia* seeds as reinforcement for the production of polymeric composites and found it to be suitable in engineering applications. Oyedeji et al, (2019) also examined the seeds of *D. regia* for its nutritional benefits and concluded that it is rich in minerals including sodium, iron and zinc. The seed was also reported to be abundant in amino acids such as glutamic acid and methionine, and its oil very rich in linoleic and palmitic acids.

Legumes contain about 60% carbohydrates including starch, reducing and non-reducing sugars, and oligosaccharides belonging to the raffinose family. Legumes are an excellent source of carbohydrates and starch constitutes the main portion of legume carbohydrates (Sathe & Salunkhe, 1981), and contributes significantly to the textural attributes of numerous foods and has many industrial uses (Sirivongpaisal, 2008). The growing starch necessities alongside its increasing industrial usage call for the use of starch from underutilised legumes such as *L. sericeus* and *D. regia*.

This study, therefore, seeks to evaluate the functional properties of starch isolates from the two underutilised leguminous seeds for practical applications due to a growing demand for new starch sources.

Materials and method

Sample collection

Delonix regia and *L. sericeus* seeds were collected from the premises of Federal Polytechnic, Ilaro East Campus, Ilaro, Ogun State where they are planted as shaded tree in the compound. All other chemicals are analytical reagent grade.

2.2 Isolation of starch

Isolation of starch was carried out by the method of Lawal and Adebowale, (2005). The sample was milled and the milled sample (flour) was soaked in distilled water and the pH was adjusted between the range of 8.0 – 9.0 using NaOH solution (0.2 %) at room temperature for four hours with continuous stirring. The suspension obtained was screened using muslin cloth and was centrifuged for thirty (30) minutes at 4600 rpm. The starch obtained was washed twice before drying in the air for 48 hours at 30ºC.

2.3 Methods

2.4 Bulk and tapped density

This was determined by the method of Wang and Kinsella (1976). 250 ml capacity graduated cylinder was filled with 50 g of the starch sample. This was done by gently tapping the bottom of the cylinder on the laboratory bench several times until there is no further decrease of the sample level after filling to the graduated cylinder. Result was expressed as g/cm^3.

2.5 Swelling power and solubility

Determination of the effect of temperature on swelling power and solubility was carried out in the temperature range of 55 – 95ºC, using the method of Leach et al., (1959). 0.2 g of starch samples was accurately weighed and was quantitatively transferred into a clear dried test tube and the weight noted as (W_1). 20 ml of distilled water was added to the test tube and the mixture was mixed thoroughly on a horizontal mixer for 30 s. The resulting slurries were heated at desired temperatures, varied between 55 and 95ºC for 30 minutes (using a temperature regulated water bath). The mixture was cooled to room temperature and centrifuged (5000 rpm, 15 min). The residue after centrifugation with the water it retained and the test tube was weighed (W_2).

$$\text{Swelling power} = \frac{W_2 - W_1}{\text{Weight of starch } W_3}$$

Aliquot (10 ml) of the supernatant obtained after centrifugation was dried to a constant weight at 110ºC. The residue obtained after drying the supernatant represented the amount of starch solubilized in water. Solubility was calculated as g/100 g of starch on dry weight basis.

2.6 Effects of pH on swelling power and solubility

The effects of pH on swelling power and solubility was investigated using the method of Sathe and Salunke (1981). 0.2 g of the sample was weighed into a test tube, 10 ml of water was added to the portion and was shake for 30 sec. The pH was adjusted to desired value (2 - 12) with 0.1 M HCl or 0.1 M NaOH. Then the slurry was poured into measuring cylinder and little water was added to make a total volume of 20 ml. and was allowed to stand for one hour at room temperature, centrifuged at 5000 g for 15 minutes, then 10 ml was pipette for solubility determination, the remaining supernatant was discarded. The centrifuge tube with the sample in it was weighed. The pipette supernatant in a weighed beaker was dried in the oven at 110ºC. After drying, the beaker and the residue was weighed to determine the percentage solubility of the starch.

2.7 Oil and water absorption capacity

The method of Beuchat (1997) was used to determine oil and water absorption capacity of the starch. 10 ml of distilled water or oil (Power Oil) was added to 1 g of sample. The mixture was mixed thoroughly on a mixer for 30 s and allowed to stand for 30 min. then the volume of the supernatant was recorded. The mass of oil and water absorbed was expressed as g/100 g starch on a dry weight basis.

RESULTS AND DISCUSSION

The results for the bulk and tapped density for the two starches are indicated in Fig.1. The bulk and tapped density for *D. regia* are 0.46 and 0.6 g/cm^3, respectively and theses values are lower than the 0.54 and 0.67 g/cm^3, respectively for *L. sericeus* starch. However, there is a significant difference between the bulk and tapped density of D. *regia* and *L. sericeus*. Similar observations were reported on bulk density for two cowpea cultivars, WCS (0.58 g/cm^3) and BCS (0.60 g/cm^3). The higher the bulk density, the coarser the particles of the sample and this affects the the seed shape, as seeds with the higher bulk density tend to be more round (Ashogbon & Akintayo, 2013).

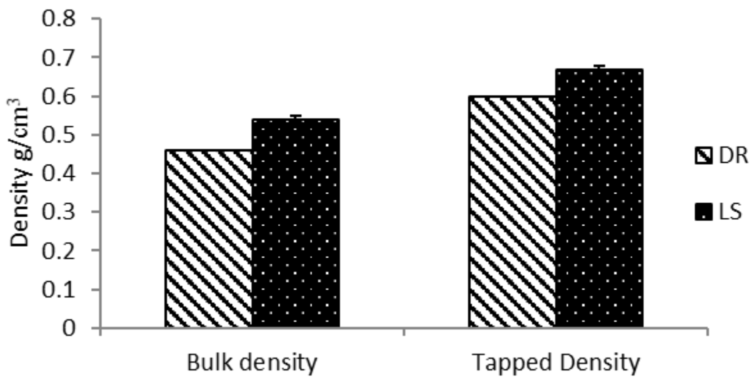

Fig 1: Bulk and tapped density of starches for DR and LS. Error bars: starndard deviation. Results are mean of triplicate determinations. DR: D. regia; LS: L. *se*riceus

Swelling power and solubility of starches were temperature dependent and the temperature range from 55 - 95ºC. Fig. 2 indicates the swelling power for both *D. regia* (5.09 – 2.59 g/g) and *L. sericeus* (5.35 – 4.67 g/g) decrease with increase in temperature. This observation is at variance with the report of Ashogbon and Akintayo, (2013) that observed an increase in swelling and solubility of starches from cowpea with increase in temperature.

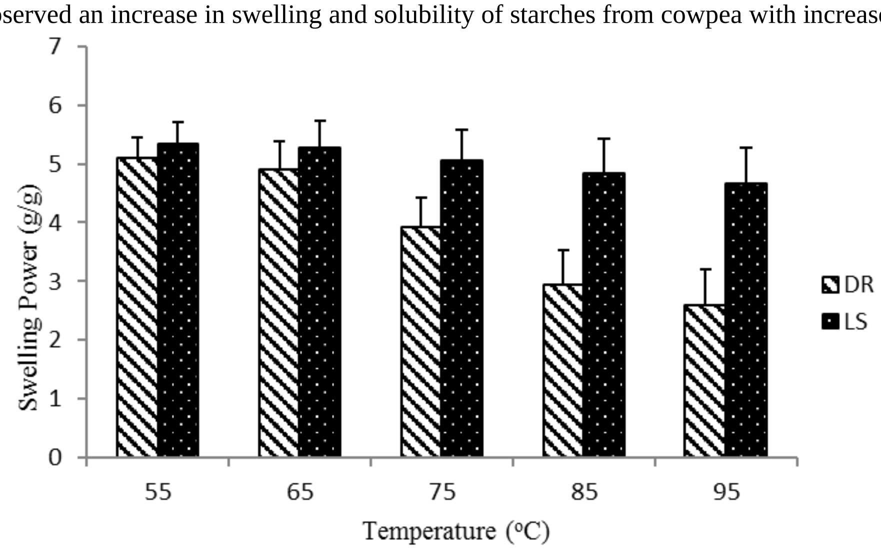

Fig 2: Effect of temperature on swelling power of starches for DR and LS. Error bar: standard deviaton. Results are means of triplicate determination. DR: Delonix regia; LS: Lonchocarpus sericeus

The solubility of *D. regia* (24.69 – 13.31 %) decreases and *L. sericeus* (23 – 12.32 %) increases with increase in temperature respectively. And also the solubility of *D. regia* and *L. sericeus* are not significantly different. Similar observations were reported for black bean starch 17.91% (Lai and Varriano-Marston, 1979) for solubility at 95 ^{o}C, and improved bean starch for three varieties ranged between 17.69 to 20.42% (Shimelis et al., 2006) which increase with increase in temperature. Halah et al. (2015) observed a decrease in solubility for barley starches (8.9 %), Hizukuri et al. (1998), reported a low solubility of water chestnut starch. Water chestnut starch exhibited slightly lower water solubility than corn starch.

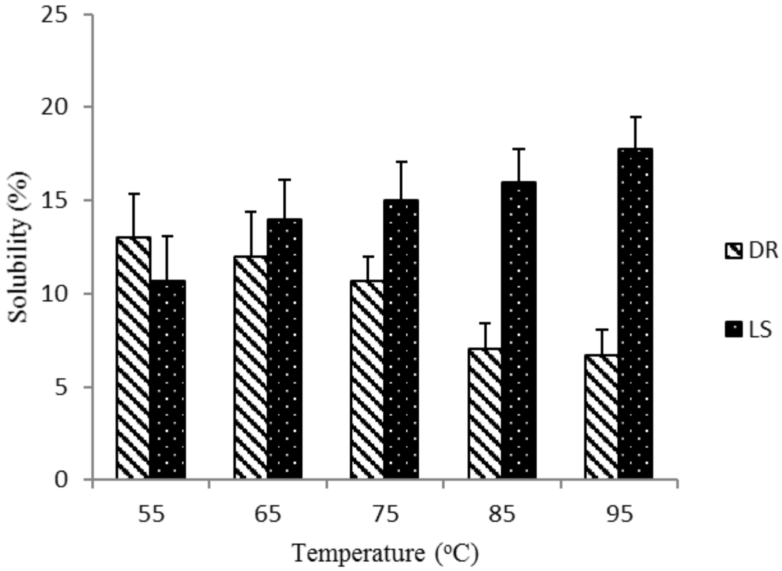

Fig 3: Effect of temperature on solubility of starches of D. regia and L. sericeus. Error bars: Standard deviation Results are means of triplicate determinations. DR: Delonix regia starch; LS: Lonchocarpus sericeus starch.

It was observed from this study that swelling power is pH dependent as indicated in Fig.4. The swelling power of *D. regia* increased from 5.0 – 6.34 g/g while it decreased for *L. sericeus* from 5.74 – 3.38 g/g with pH increase. There is no significant difference between the effect of pH on swelling power for *D. regia* and *L. sericeus*. Lawal, (2004) observed an increase in swelling power for native hybrid maize starch with increase in pH. Under alkaline conditions, starches may undergo partial gelatinisation, thus resulting in higher swelling and solubility. This accounts for higher swelling and solubility of the starches at the extreme of the alkaline range (Lawal, 2004) as observed in this study.

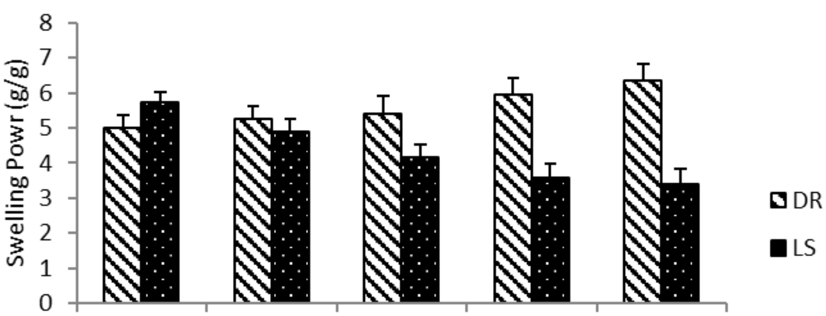

Fig 4: Effect of pH on swelling power of starches for DR and LS. Error bar: starndard deviation. Results are menas of triplicate determinations. DR: Delonix regia; LS: Lonchocarpus sericeus

From Fig 5, both the oil and water absorption capacity of *D. regia* (144 and 333.33 % respectively) are higher than that of *L. sericeus* (93 and 126.67 % respectively). There is significant different between the oil and water absorption capacity. These results agree with the observations reported for the water and oil absorption capacities flours and starches from improved bean (Shimelis et al., 2006) and the starch of Great Northern Bean. The high water absorption at 21ºC may have been due to the nature of the starch and a possible contribution to water absorption by the cell was material which was not removed completely (Sathe & Salunkhe, 1981). The formation of hydrogen bonds between the hydroxyl groups of different starch chains reduces their water binding capacity. Water binding by starches is a function of several parameters including shape, size, conformational characteristics, steric factors, hydrophilic-hydrophobic balance in the starch molecule, lipids and carbohydrates associated with the proteins, physicochemical environment, and thermodynamic properties of the system and solubility of starch molecules. (Shimelis et al., 2006).

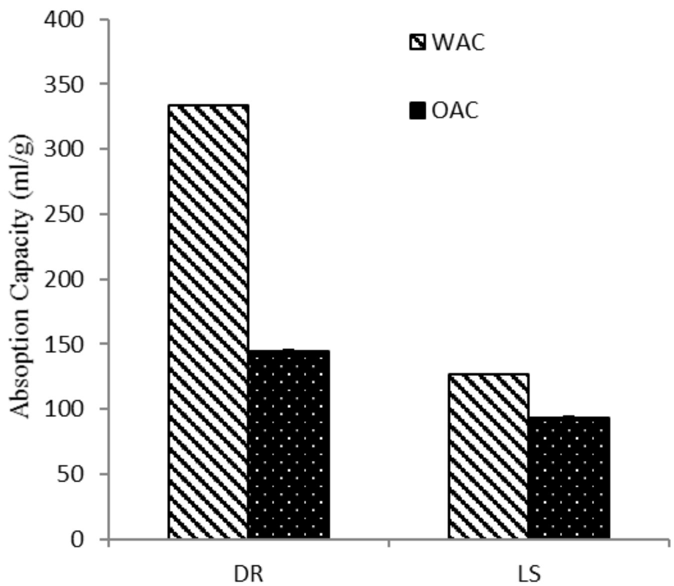

Fig 5: Water and oil absorption capacities of starches of DR and LS. error bars: standard deviation. Results are means of triplicate determinations. DR: *Delonix regia* starch; LS: *Lonchocarpus sericeus* starch; WAC: water absorption capacity; OAC: oil abso

CONCLUSIONS

Upon evaluation of the functional properties of *D. regia* and *L. sericeus* starches, the two starch samples exhibited good potential as functional ingredient that could be useful as starch supplements and ingredient in human diet upon further evaluation of their composition and anti nutrient constituents. The starches can also be used in the food processing industry and non-food applications of starch such as in paper and textile industries.

5.0 REFERENCES

Abdullahi, S. M., Musa, A. M., Abdullahi, M. I., Sani, Y. M., and Sule, M. I. (2013). A new prenylated chalcone from the stem-bark of *Lonchocarpus sericeus* Poir (Papilionaceae). *African Journal of Pharmaceutical Research & Development*. **5(1)**:8-10.

Agbonon, A. & gbeassor, M. (2009). Hepatoprotective effect of *Lonchocarpus sericeus* leaves in CCl_4- induced liver damage. *Journal of Herbs*, *Spices & Medicinal Plants*, **15**:216–226.

Agunsoye, J. O., Bello, S. A., and Adetola, L. O. (2019). Experimental investigation and theoretical prediction of tensile properties of *Delonix regia* seed particle reinforced polymeric composites. *Journal of King Saud University - Engineering Sciences*, **31(1)**:70-77.

Ashogbon, A. O., and Akintayo, E.T. (2013). Isolation and characterisation of starches from two cowpea (*Vigna unguiculata*) cultivars. *International Journal of Food Preservation,* **20(6)**:3093-3100.

Beuchat, l. R. (1997). Functional And Electrophoretic Characteristics Of Succinylated Peanut Flour Protein. *Journal Of Agricultural And Food Chemistry,* **25(2)**:258-261.

Halal, S. L., Colussi, R., Pinto, V.Z., Bartz, J., Radunz, M., Carreno, N.L.V., and Zavareze, E. R. (2015). Structure, morphology and functionality of acetylated and oxidised barley starches. *Food Chem*istry, **168**:247-256.

Iwu, M. M. (2014). Pharmacognostical profile of selected medicinal plants from: Handbook of African Medicinal Plants CRC Press. https://www.routledgehandbooks.com/doi/10.1201/b16292-4. Accessed on: 11th June, 2019.

Lawal, O. S. (2004). Composition, physicochemical properties and retrogradation characteristics of native, oxidized, acetylated and acid-thinned new cocoyam (*Xanthosoma sagittifolium*) starch. *Food Chemistry*, **87**:205-218.

Lawal, O. S., and Adebowale, K. O. (2005). Physicochemical characteristics and thermal properties of chemically modified jack bean (*Canavalia ensiformis*) starch. *Carbohydrate Polymers,* **60**:331-341.

Lawal, O. S., Adebowale, K. O., Ogunsanwo, B. M., Barba, L. L., and Ilo, N. S. (2005). Oxidized and acid thinned starch derivatives of hybrid maize: functional characteristics, wide-angle x-ray diffractometry and thermal thermal properties. *International Journal of Biology and Macroorganisms*, **35**:71-79.

Leach, H. W., Mccowen, L. D., and Scoch, T. J. (1959). Structure of the starch granule, Swelling and solubility patterns of various starches. *Cereal Chem*istry, **36**:534-544.

Nawrocki, P. (2004). *Delonix regia*. Floridata.com lnc, Tallahassee, Florida, USA.

Oyedeji, O. A., Azeez, O, Osinfade, B. G., and Bamimore, M. O. (2015). Flavonoid profile, anthocyanin, carotenoid, sugar and vitamin compositions of *Lonchocarpus sericeus* seeds. *African Journal of Food Science and Technology,* **6(5)**:131-135.

Sathe, S. K., and Salunkhe, D. K. (1981). Isolation, partial characterization and modification of the great northern bean (*Phaseolus vulgaris*). *Starch,* **46**:617 – 621.

Shimelis, E. A., Meaza, M., and Rakshit, S. K. (2006). Physicochemical properties, pasting behavior and functional characteristic of flours and starches from improved bean *(Phaseolus vulgaris l.)* Varieties grown in East Africa. *International Journal of Agriculture and Engineering,* **8**:1-19.

Sirivongpaisal, P. (2008). Structure and functional properties of starch and flour from Bambarra groundnut. *Songklanakarin Journal of Science & Technology,* 30(1), 51-56.

Wang, J. C., and Kinsella, J. E. (1976). Functional properties of novel proteins: Alfalfa leaf protein. *Journal of Food Science*, **41(2)**:286-292.