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COMPARATIVE STUDY ON FUNCTIONAL AND PASTING PROPERTIES OF STARCHES PRODUCED FROM SELECTED CEREALS AND TUBERS

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ABSTRACT

The comparative study on functional and pasting properties of starches produced from selected cereals and tubers was investigated. The starches were produced from corn, sorghum, millet, rice, cassava, cocoyam, yam and sweet potato and the sediment was dried and milled into powder and was analyzed for functional and pasting properties. The data obtained were subjected to statistical analysis. The results showed that the functional properties of starches ranged from 2.17 to 2.635%, 0.51 to 0.85g/cm^3, 1.07 to 3.58%, 1.00 to 17.00%, 196.00 to 316.00 N/m^2, 6.56 to 23.26% and 76.74 to 93.44% for water absorption capacity, bulk density, swelling index, solubility index, gelation strength, amylose content and amylopectin, respectively. The pasting properties of starches for peak, trough, breakdown, final viscosity, set back, peak time and pasting temperature of the starches ranged from 671.50 to 6779.00 RVU, 565.00 to 4729.50 RVU, 106.50 to 3210.00 RVU, 936.50 to 7556.00 RVU, 371.50 to 2826.50 RVU, 4.00 to 5.867 min and 51.28 to 85.58 ^{o}C, respectively. However, cassava and rice starches have the best functional properties compared to other tubers and cereals. Yam and millet starches have the best pasting properties compared to other tubers and cereals.

KEYWORDS: Starch, cereals, tubers, functional properties; pasting properties.

INTRODUCTION

Starch is the most abundant carbohydrate reserve in plants and is found in leaves, flowers, fruits, seeds, different types of stems and roots. Starch is used by plants as source of carbon and energy (Smith, 2001). The biochemical chain responsible for starch synthesis involves glucose molecules produced in plant cells by photosynthesis. Starch is formed in the chloroplasts of green leaves and amyloplasts, organelles responsible for the starch reserve synthesis of cereals and tubers (Smith, 2001; Tester *et al*., 2004). The main location of starch synthesis and storage in cereals is the endosperm. Major starch sources are cereals (40 to 90%), roots (30 to 70%), tubers (65 to 85%), legumes (25 to 50%) and some immature fruits like bananas or mangoes, which contain approximately 70% of starch by dry weight (Santana and Meireles, 2014). Starch is used extensively in the food industry and can be isolated from several sources (Makroo *et al*., 2021).

The starches in food can also be derived from grains or seeds (wheat, corn, rice, and barley), tubers (potato) and roots (cassava) according to Waterschoot *et al*. (2015). Due to the high surge in demand across varying sectors especially in the food, paper, and textile industries in developing nations as Africa, in addition with existing challenges such as the underutilization of diverse available indigenous materials, dearth of technical expertise, inadequate research contributions, and lack of working machinery in the extraction of starch have led to high importation rate of starch resulting in high cost and scarcity. Hence, there is a need to extract starch from selected cereals and tubers, and also to carry out a comparative study on the extracted starch. This study is therefore focused on the comparative study of the functional and pasting properties of starches produced from selected cereals grains (corn, sorghum, millet, and rice) and tubers (yam, sweet potatoes, cocoyam and cassava).

MATERIALS AND METHODS

Materials

Cereals (maize, sorghum, millet and rice grains) and tubers (cassava, yam, cocoyam, and sweet potato), were purchased from Arada Market, Ogbomoso, Oyo State, Nigeria. All chemicals used were of analytical grades which were obtained in the Department of Food Engineering Laboratory.

Starch extraction

Starch was extracted according to the method described by Paraginski *et al*. (2019) and Aprianita *et al.* (2009) for cereal and tuber starches, respectively. The extracted starches were dried, milled and packaged until they were needed for further analysis.

Functional properties

Bulk density was determined using the method described by Shakir *et al*. *(*2002), with some modifications, while water absorption capacity was determined as described by Adebowale and Lawal (2003) and swelling index and solubility index, gelation strength, amylose and amylopectin were determined according to the method described by Sanni *et al*. (2008).

Pasting properties

The pasting properties of the starch samples were determined using the rapid visco analyzer (RVA) according to (Newport scientific, Australia) as described by previous researcher Oyeyinka *et al*. (2015)

Statistical analysis

The result of the experiment was subjected to analysis of variance (ANOVA) and the mean was separated with the use of Duncan's multiple range test to detect significant difference ($p<0.05$) among the sample values using the Statistical Package for the Social Science (SPSS).

RESULTS AND DISCUSSION

The result of functional properties of tubers starch and cereals starch are as shown in Table 4.1. The water absorption capacity (WAC) of tuber starches ranged from 2.17 to 2.48% with cocoyam starch having the lowest water absorption capacity while sweet potato starch had the highest value. Moreso, the water absorption capacity of cereal starches ranged from 2.20 to 2.62% with millet starch having the lowest water absorption capacity while rice starch had the highest value. The water absorption capacity results were found significantly ($p<0.05$) different from each except for sorghum and millet flours. Similar results of water absorption capacity were obtained for *Nhyria*, *Tona* and *Adom* cowpea varieties as 1.89, 2.15 and 2.13%, respectively by Appiah *et al*. (2011). Also, Adebowale *et al*. (2005) reported water absorption capacity results ranging from 1.20 to 2.00% for full fat and 1.40 to 2.20% for defatted in six mucura apecies.

Bulk density of tuber starches ranged from 0.69 to 0.82 g/cm^3 with cassava starch and sweet potato starch having the lowest bulk density while yam starch had the highest value and the bulk density of cereal starches ranged from 0.51 to 0.72 g/cm^3 with millet starch having the lowest bulk density while rice starch had the highest value. Ariwaodo *et al.* (2017) also observed similar result of bulk density of the starches high in cassava sample as (0.81 g/cm^3).

Swelling index of tuber starches ranged from 1.20 to 3.58 % with sweet potato starch having the lowest swelling index and cocoyam starch had the highest value and the swelling index of cereal starches ranged from 1.07 to 1.62 % with rice starch having the lowest swelling index and corn starch had the highest value. Nuwamanya *et al*. (2010) observed swelling power to be low in potato at all temperatures and relatively the same among cereals except being low for maize at 90 °C.

The solubility index of tuber starches ranged from 1.00 to 7.00% with sweet potato starch having the lowest value while cassava starch had the highest value and the solubility index of cereal starches ranges from 1.50 to 17.00% with millet starch and sorghum starch having the lowest value while rice starch had the highest value. This was in agreement with the work of Nuwamanya *et al.* (2010) where low solubility values were observed for sweet potato and high values for cassava and millet starch which showed low average solubility values compared with other cereal starches.

Gelation strength of tuber starches ranged from 200.00 to 265.00 N/m^2 with sweet potato starch having the lowest gelation strength while cassava starch had the highest value and the gelation strength of cereal starches ranged from 196.00 to 316.00 N/m^2 with corn starch having the lowest gelation strength while rice starch had the highest value. Cassava starch showed lower gelation temperature than cocoyam and sweet potato. This is in line with the works of Erikson *et al.* (2014) who also reported lower gelatinization temperature for cassava starch.

The amylose content of tuber starches ranged from 6.56 to 23.26% with cocoyam starch having the lowest amylose content and yam starch had the highest value and the amylose content of cereal starches ranged from 7.19 to 16.34% with rice starch having the lowest amylose content and millet starch had the highest value. A similar amylose content in the cassava starches was observed by Charles *et al.* (2005), who reported that cassava starch varieties with smaller granule dimensions contained higher amylose contents. The amylopectin content of tuber starch ranges from 76.74 to 93.44% with yam starch having the lowest amylopectin content and cocoyam starch had the highest value and the amylopectin content of cereal starch ranges from 83.66 to 92.80% with millet starch having the lowest amylose content and rice starch had the highest value. Starch granules become increasingly susceptible to shear disintegration as they swell and starches with higher amylopectin content swell more than those with lower amylopectin content.

Pasting properties of starch

The result of pasting properties of tubers and cereals starch are as shown in Tables 4.2. The peak of viscosity of tuber starches ranged from 5086.00 to 6779.00 RVU with cocoyam starch having the lowest value while yam starch had the highest value. Moreso, the peak of viscosity of cereal starches ranged from 671.50 to 3131.50 RVU with rice starch having the lowest value while sorghum starch had the highest value. Peak of viscosity value was found to be lowest for cocoyam starch (5086.00 RVU) and highest for yam starch (6779.00 RVU) and lowest for rice starch (671.50 RVU) and highest for sorghum starch (3131.50 RVU) for cereals. This indicates that sorghum and yam starches have the highest water- holding capacity and could develop large Peak of viscosity at a low pasting temperature. This was also reported by Ariwaodo *et al.* (2017) that cocoyam starch has the lowest value of peak viscosity.

The trough viscosity of tuber starches ranged from 2166.00 to 4729.50 RVU with cassava starch having the lowest value while yam starch had the highest value and the trough viscosity of cereal starches ranged from 565.00 to 1678.50 RVU with rice starch having the lowest value while millet starch had the highest value. This result is in agreement with the work of Arisa *et al.* (2013) who reported a high trough viscosity value of 259.25 RVU for blended millet. The breakdown viscosity values of tuber starches ranged from 2049.50 to 3210.00 RVU with yam starch having the lowest value while cassava starch had the highest value and the breakdown viscosity values of cereal starches ranged from 106.50 to 1494.50 RVU with rice starch having the lowest value while corn starch had the highest value. This is in agreement with the work of Adebowale *et al*. (2005) who reported high breakdown viscosity.

The final viscosity of tuber starches ranged from 2707.50 to 7556.00 RVU with cassava starch having the lowest value while yam starch had the highest value and the final viscosity of cereal starches ranged from 936.50 to2775.00 RVU with rice starch having the lowest value while sorghum starch had the highest value. The setback of tuber starches ranged from 541.50 to 2826.50 RVU with sample cassava starch having the lowest value while sample yam starch had the highest value and the setback of cereal starches ranged from 371.50 to 1163.0 RVU with sample rice starch having the lowest value while sample sorghum starch had the highest value. Yam and sorghum with the highest apparent amylose concentration shows the highest setback value; in contrast cassava and rice with the lowest apparent amylose concentration has the lowest setback value. Ashogbon *et al.* (2011) and Adebowale and Lawal (2003) also recorded difference in setback or retrogradation among different starches.

The pasting temperature for tuber starches ranged from 51.28 to 81.53 °C with cassava starch having the lowest value while yam starch had the highest value and the pasting temperature for cereal starches ranged from 58.65 to 85.58 °C with millet starch having the lowest value while rice starch had the highest value. Similar pasting temperatures for cassava starches were reported in other studies: 66.4–69.6 °C (Mtunguja *et al.*, 2016), 63.7–71.7 °C (Morante *et al.*, 2016), 67.9–74.4 °C (Aldana *et al.*, 2013) and 62.0–68.0 °C (Schmitz *et al.*, 2017).

Table 4.1: Functional Properties of Cereal and Tuber Starch.

Sample	WAC (%)	Bulk Density (g/cm³)	Swelling Index (%)	Solubility Index (%)	Gel Strength (N/m²)	Amylose (%)	Amylopectin (%)
Tuber							
A_1	2.27^{b}	0.82^{d}	1.37^{c}	3.00^{b}	235.67^{de}	23.26^{e}	76.74^{a}
A_2	2.17^{a}	0.71^{d}	3.58^{e}	2.00^{a}	212.67^{c}	6.56^{a}	93.44^{e}
A_3	2.49^{c}	0.69^{cd}	1.20^{b}	1.00^{a}	200.00^{b}	12.70^{b}	87.30^{d}
A_4	2.20^{a}	0.69^{cd}	1.50^{d}	7.00^{d}	265.00^{e}	17.01^{d}	82.99^{c}
Cereal							
B_1	2.20^{a}	0.51^{a}	1.20^{b}	1.50^{a}	223.00^{d}	16.34^{d}	83.66^{b}
B_2	2.47^{c}	0.68^{c}	1.60^{d}	1.50^{a}	237.67^{de}	14.72^{c}	85.28^{c}
B_3	2.47^{c}	0.60^{b}	1.62^{d}	6.00^{c}	196.00^{a}	14.10^{c}	85.90^{e}
B_4	2.62^{d}	0.72^{d}	1.07^{a}	17.00^{e}	316.00^{f}	7.20^{a}	92.80^{e}

Mean with the same superscript along the same column are not significantly different ($p>0.05$)

A is tuber starch while subscripts 1, 2, 3 and 4 are for yam, cocoyam, sweet potato and cassava, respectively.

B is cereal starch while subscripts 1, 2, 3 and 4 are for millet, sorghum, corn and rice.

Table 4.2: Pasting properties of starch.

Samples	Peak (RVU)	Trough (RVU)	Break down (RVU)	Final Viscosity (RVU)	Set back (RVU)	Peak time (Min)	Pasting Temperature (°C)
Tubers A_1	6779.00^{b}	4729.50^{d}	2049.50^{ab}	7556.00^{d}	2826.50^{c}	4.80^{c}	81.53^{c}
A_2	5086.00^{b}	2466.00^{bc}	2620.00^{ab}	3065.00^{ab}	599.00^{ab}	4.80^{c}	67.63^{abc}
A_3	5919.50^{b}	3122.50^{c}	2797.00^{ab}	3709.50^{c}	587.00^{ab}	4.50^{b}	69.63^{abc}
A_4	5376.00^{b}	2166.00^{bc}	3210.00^{b}	2707.50^{b}	541.50^{a}	4.00^{a}	51.28^{a}

Cereals							
B_1	3131.50[ab]	1678.50[d]	1453.00[ab]	2512.50[b]	834.00 [ab]	5.33[f]	58.65[ab]
B_2	2808.00[ab]	1612.00[ab]	1196.00[ab]	2775.00[b]	1163.00[b]	5.17[e]	80.23[bc]
B_3	2971.00[ab]	1476.50[ab]	1494.50[ab]	2318.50[b]	842.00[ab]	4.87[d]	75.88[bc]
B_4	671.50[a]	565.00[a]	106.50[a]	936.50[a]	371.50[a]	5.867[g]	85.58[c]

Mean with the same superscript along the same column are not significantly different ($p>0.05$)

A is tuber starch while subscripts 1, 2, 3 and 4 are for yam, cocoyam, sweet potato and cassava, respectively.

B is cereal starch while subscripts 1, 2, 3 and 4 are for millet, sorghum, corn and rice.

CONCLUSION

The studies on the different tuber crops reveal the vast variability available among them, which is not generally observed in the case of cereal starches. The high viscosity of yam and sorghum starches makes these starches very useful in many food and industrial applications especially where high thickening power is desired. The low viscosity of cassava and rice starches can be exploited in paper industries where lower viscosity and good film forming capacity are preferred. Similarly, the good gelation strength of these starches, especially cassava and rice starches can be utilized in a wide array of food products. The easy gelatinization of cassava and rice starches can make them suitable in the manufacture of hydrolysis products derived from starch.

REFERENCES

1. Adebowale, K.O. and Lawal, O.S. Microstructure, functional properties and retrogradation behaviour of mucuna beans (*Mucuna pruriens*) starch on heat moisture treatments. *Food Hydrocolloid*, 2003; 17: 265-272.
2. Adebowale, K.O., Olu-Owolabi, B.I., Olawumi, E.K. and Lawal, O.S. Functional properties of native, physically and chemically modified breadfruit (*Artocarpus artilis*) starch. *Industrial Crops Production*, 2005; 21: 343–351.
3. Aldana, A.S. and Quintero, A.F. Physicochemical characterization of two cassava (*Manihot esculenta* Crantz) starches and flours. *Reviewed Science Agroaliment*, 2013; 1: 19–25.
4. Appiah, F., Kumah, P., Sebe, A.T. and Asibuo, J.Y. Physicochemical and functional properties of seeds of three local cowpea (*Vigna unguilata* L. Walp) cultivars in Ghana. Acta Horticulturee, 2011; 911: 437-446.

5. Aprianita, A., Purwandari, U., Watson, B. and Vasiljevic, T. Physicochemical properties of flours and starches from selected commercial tubers available in Australia. *International Food Research Journal*, 2009; *16: 507-520.*
6. Arisa, N.U., Adelekan, A., Malomo, O.O. and Dudu, O.E. Physicochemical and sensory properties of blends from beniseed, trifoliate yam and wheat flours. *African Journal of Food Science and Technology*, 2017; 8(5): 067-073.
7. Ariwaodo, C.A., Ezeama, C.F. and Nwabueze, T.U. Morphology, rheology and functional properties of starch from cassava, sweet potato and cocoyam. Asian Journal of Biology, 2017; 3(3): 1-13.
8. Ashogbon, A.O., Ololade, I.A., Aliu, Y.D. and Abitogun, A.S. Morphological, hydrolytic and thermal properties of legume starches. *Pakistan Journal Science Industrial Research,* 2011; 54(3): 155-174.
9. Charles, A.L., Chang, Y.H. and Ko, W.C. Influence of amylopectin structure and Amylose content on the gelling properties of five cultivars of cassava starches. *Journal Agricultural Food Chemistry*, 2005; 53: 2717–2725.
10. Eriksson, E., Koch, K., Tortoe, C., Akonor, P. and Oduro-Yeboah, C. Evaluation of the physical and sensory characteristics of bread produced from three varieties of cassava and wheat composite flours. *Food Public Health*, 2014; 4(5): 214-222.
11. Makroo, H.A., Naqash, S., Saxena, J., Sharma, S., Majid, D. and Dar, B.N. Recovery and characteristics of starches from unconventional sources and their potential applications: A review. Applied Food Research, 2021; 1(1): 1-9.
12. Morante, N., Ceballos, H. and Sánchez, T. Discovery of new spontaneous sources of amylose free cassava starch and analysis of their structure and techno-functional properties. *Food Hydrocolloid*, 2016; 56: 383–395.
13. Mtunguja, M.K., Thitisaksakul, M. and Muzanila, Y.C. Assessing variation in physicochemical structural, and functional properties of root starches from novel Tanzanian cassava (*Manihot esculenta* Crantz.) landraces. *Starch‐Stärke*, 2016; 68: 514–527.
14. Nuwamanya, E., Baguma, Y., Emmambux, N., Taylor, J. and Rubaihayo, P. Physicochemical and functional characteristics of cassava starch in Ugandan varieties and their progenies. *Journal of Plant Breeding and Crop Science*, 2010; 2(1): 001-011.
15. Oyeyinka, S.A., Singh, S., Adebola, P.O., Gerrano, A.S. and Amonsou, E.O. Physicochemical properties and modification of Bambara groundnut starch. *Food Hydrocolloids*, 2015; 75: 62-71.

16. Paraginski, R.T., Colussi, R., Dias, A.R.G., Zavareze, E.R., Elias, M.C. and Vanier, N.L. Physicochemical, pasting, crystallinity, and morphological properties of starches isolated from maize kernels exhibiting different types of defects. *Food Chemistry*, 2019; *274*: 330-336.
17. Sanni, L.A., Adebowale, A.A., Olayiwola, I.O. and Maziya, D. Chemical composition and pasting properties of iron fortified maize flour. *Journal of Food Agricultural Environment*, 2008; 6: 172-175.
18. Santana, A.L. and Meireles, M.A.A. New starches are the trend for industry applications: a review. *Food and Public Health*, 2014; 4(5): 229-241.
19. Schmitz, G.J.H., Peroni-Okita, F.H.G., do Nascimento, J.R.O., Campanha, R.B., Valle, T.L., Franco, C.M.L. and Cordenunsi-Lysenko, B.R. Selected physicochemical properties of starches isolated from ten cassava varieties reveal novel industrial uses. *Starch-Stärke,* 2017; 69: 1–9.
20. Shakir, M.S., Hassan, A. and Abdul R. Effect of salts on bulk density, particle density and porosity of different soil series. *Asian Journal of Plant Sciences*, 2002; 1(1): 5-6.
21. Smith, A.M. The biosynthesis of starch granules. *Biomacromolecules*, 2001; 2(2): 335-341.
22. Tester, R.F., Karkalas, J. and Qi, X. Starch - Composition, fine structure and architecture. *Journal of Cereal Science*, 2004; 39(2): 151 - 165.
23. Waterschoot, J., Gomand, S.V., Fierens, E. and Delcour, J.A. Production, structure, physicochemical and functional properties of maize, cassava, wheat, potato and rice starches. *Starch/Stärke*, 2015; 67: 14–29.