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EXTRACTION OF STARCH FROM SWEET POTATO AND ITS MODIFICATION TO COLD WATER SOLUBLE BY ALKALINE-ALCOHOLIC TREATMENT

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ABSTRACT
Nigeria is among the largest world producers of sweet potato (Ipomoea batatas), but with all its potentials, sweet potato is only generally being consume as local food mostly in rural commununities. Famers encounter perennial problems with sweet potato because it is highly perishable; at post-harvest during storage and at pre-harvest on maturity, this causes huge economic burden. The goal of this work is to create ways of adding value to sweet poato produced in Nigeria. In this research, starch was extracted from sweet potato produced in Kano Nigeria, using wet milling method and filtration with 20µm 30µm and 40µm fabric filters obtaining dry weight percentage yield of starch to be 56.50%, 62.60% and 71.60% respectively, physico-chemical properties of all the isolated starch was found to match with standards sets for starch quality, yet starch extracted using 30µm filter exhibited better quality. The isolated starch was later subjected to modification into cold water soluble using alkaline-alcoholic treatment with different proportion of 3M NaOH and 40% aqueous ethanol lebelled P1, P2, P3, P4 and P5 each at three experimental temperatures of 25˚C, 30˚C and 35˚C. The results obtained showed that: at temperature of 25˚C P1, P2, P3, P4 and P5 treatments has percentage solubility in water as 43.30%, 47.20%, 55.50%, 66.10% and 81.40% respectively,at temperature of 30˚C P1, P2, P3, P4 and P5 treatments has percentage solubility in water as 46.10%, 50.80%, 56.90%, 65.70% and 85.00% respectively and at temperature of 35˚C P1, P2, P3, P4 and P5 treatments has percentage solubility in water as 50.10%, 55.40%, 63.20%, 74.20% and 90.30% respectively. Temperature and alkali equivalent demonstrate direct relationship with percentage cold water solubility of the potato starch with exeption of P4 at tempreture of 25˚C and 30˚C where it exhibited drop in solubility, while alcohol equivalent exhibits indirect relationship with percentage cold water solubility of the potato starch. The modified starches could be suitable raw material for different application in food and confectionary production, based on their percentage of cold water solubility.
Keywords: Starch, Cold-Water-Soluble, Modified starch, Alkaline, Alcoholic .

INTRODUCTION

The exponential rise in the Nigerian population without proper implementation of strategic plans to accomodate it, has fostered challenges such as unemployment, insecurity and enviromental degradation in the country. Harnessing the untapped potential in the agricultural value chain is one of the fastest ways towards rapid and sustainable socio-economic development. Empirical literature has established a link between success of agribusinesses growth both domestically and internationally, to the factors that drive the increasing competitiveness of the sector. (Dethier, J. J., & Effenberger, A. 2012). For example, value addition and innovation which then cascades into a strong contribution to gross domestic product (GDP).Agribusiness contributes thirteen times more to GDP than pure agriculture in the United States, while in South Africa this ratio is 4:1. This agribusiness/agriculture ratio defines the sophistication of the sector and how it impacts positively on the economy (Adenle, A. A *et al.*, 2017).

Starch, the second most abundant biomass in nature, offers a highly versatile polymerthat is readily modified chemically, physically, enzymatically and biologically (Ghasemlou, M. *et al.*, 2013).

The rationale for choosing the starch industry is because it is under-exploited in Nigeria and has great potential for driving agribusiness development based on its availability at low cost, high calorific value, inherent excellent physicochemical properties and the ease of its modification to other derivatives. Nigeria is one of the largest producer of sweet potatao (*Ipomoea batatas*) in the world, and first in sub-saharan Africa producing 4 million metric tonnes of sweet potato annually. (Udemezue, J.C. 2019). Yet ironically contributes less than 2% of the global starch production because of its fragmented, unsophisticated agricultural, industrial, research and development structure. In fact, over 95% of Nigerian industrial starch needs are imported where about $580 million is spent annually (Okojie, J. 2017).

Sweet potato has many advantages over other root and tuber crops, These include: low demand on soil nutrient, high drought tolerance, relatively higher yields, growth in ecological zones where other crops would fail, lower requirements for external inputs such as fertilizer, flexibility in planting and harvesting period, and high calorie return per unit land area (Motsa, N. M. *et al*, 2015).. Some researchers opined that 100 g of sweet potato can provide enough beta-carotene to produce 100% of the suggested daily vitamin A requirement (350 ug) per day for infants and young children (Wickramasinghe, H.A.M. *et al* 2009).

Starch is modified to enhance its functional properties to suit any of pharmaceutical, paper, textile, food and beverage industries and bio-products like bio-plastics for packaging, construction and design can be produced (Marichelvam, M. K *et al*., 2019). It may be modified to enhance stability (antioxidants, UV absorbers), optimize or modify drug release (disintegrants, hydrophilic polymers, wetting agents, biodegradable polymers), provide essential manufacturing technology functions (binders, glidants, lubricants), enhance consumer acceptance or aid in product identification (flavours, colorants). (Mohammed, K.G. 2017).

In the pharmaceutical industry, without non-toxicological inert filling materials like starch, it would be almost impossible to produce acceptable potent drug forms suitable for patient administeration. (Adetunji O. A. 2019). Modified starch are thus critical to the design of the drug delivery system and play a major role in its quality and performance (Mohammed, K.G. 2017). On the other hand, food grade starches are modified mainly to increase paste consistency, smoothness and clarity, and to impart freeze-thaw and storage stabilities (Singh, A., *et al* 2007). Bio-products produced from starch include bio-plastics, nanoparticles, biomedical products, and drug-delivery materials (Xie, F. *et al*., 2013). Starch-based plastics and films have advantages in food applications because of their transparency, high oxygen barrier and absence of flavour and odour (Acosta, S. *et al*., 2016).

Starch is used to sweeten; influence or control such characteristics as texture, moisture, consistency and shelf stability. It can be used to bind or to disintegrate; to expand or to densify; to clarify or to opacify; to attract or to inhibit moisture; to produce smooth or pulpy texture, soft or crisp coatings; stabilise emulsions or to form oil-resistant films (Miyazaki, M. *et al*., 2006).

Sweet potato starch has immense potential for growth through innovation and competiveness both for industrial and human uses. The unique properties of their starches suggest their use for speciality markets such as baby foods, non-allergenic products and food for hospitalized persons. Their starches can be modified to provide characteristics that are required and can compete with most starches for the production of starch for sizing paper and textiles, glues and adhesives, monosodium glutamate (MSG), sweetners, pharaceutical disintegrating pills, biodegradable products, butanol and acetone, explosives, corrugated boxes, and bioplastics (Jonhed, A. 2006).

Each starch needs to be modified to increase its usefulness and value, Starch modification involves alterating the physical and chemical characteristics of the native starch to improve its functional characteristics and, to suit specific applications. Possibilities for new modified-starch products other than physically modified products, are offerred by control of reaction sites within granules; control of reaction sites on molecules, and biological modification of existing, commercial base starches. (Bemiller, J.N., 1997). In its native form without modification, starch has a limited number of applications and used mainly as a binder or thickner. However, upon heating in water, the helices within the amylopectin of starch melt and the granule starts to swell, increasing the viscosity of the solution. Further heating and stirring leads to disintegration of the granule structure, the solubilization of the starch and a loss of viscosity. Upon cooling, the linear chains re-associate into aggregates, precipitate and set to form a gel. Its low shear resistance, thermal resistance, thermal decomposition and high tendency towards retrogradation limit its use in some industrial food applications. Controlling these processes is a key factor in starch functionality, which is achieved mainly by modification of the starch when it is in a granular state (Jobling, 2004).

MATERIALS AND METHODS

MATERIALS

Ethanol (CH_3CH_2OH) (95 %)-Sigma-Aldrich USA, NaOH pellets-Spectrum-chemical USA, distilled water, metabisulfite ($Na_2S_2O_5$)- Sigma-Aldrich USA, (All chemicals are of analytical grade).Ultra-Turrax T25, 600W, Tekmar, Cincinnati, Helmreasinn 80-2 electric laboratory centrifuge, 20 µm, 30 µm and 40 µm nylon filters, water bath rectangular-infraLab India, Mettler AE 104, Toledo, OH, 351101 Advanced Bench pH meter. Jenway, UK. Sweet potato tubers were obtained during harvest, freshly from farm, in Kano Nigeria., around September, 2021,

Methods

Extraction of starch

Starch Extraction; Sweet potato tubers was obtained and cleaned to remove foreign material, before analysis. According to modified method of Ji. Y., *et al.,* (2004). 10, 15, or 20 g of tubers were steeped in 25 mL of 1% sodium metabisulfite solution (~0.67% SO2) at 45°C for 24, 48, or 72 hr. The separated endosperm was placed in a 50-mL centrifuge tube with 10 mL of distilled water and homogenized using a vortex type tissue homogenizer (Ultra-Turrax T25, 600W, Tekmar, Cincinnati, OH) at 20,500 rpm for 30 sec. The homogenized slurry was filtered by using a 30µm nylon filter under vacuum with several washes, the total volume of wash water is 500 mL.Coarse and fine fibers and part of the protein will be removed during filtration. The starch-protein mixture from the filtrate was further separated by sedimentation. Each sample was separated three times, with 250 mL of distilled water used for each of the three separations. All treatments was performed in replicates of five, and the average results taken.

Centrifugation Procedure

The starch slurry is to be centrifuge at 5,219 × g force for 30 min. The supernatant will be decanted, the protein layer will be scraped off, and more water (250 mL) added to the partly cleaned starch, with centrifugation and decanting repeated three times. The resulting sediment will be air-dry.

Sedimentation Procedure

The starch slurry was allowed to settled at 4°C for 2 hr and the supernatant drained. The starch was rinsed with 250 mL of water, drained twice, and the resulting sediment air-dried.

Starch Yield

In this study, the dried material obtained from both procedures is refered to as starch, even though the material may not be completely pure. The dried matter recovered after wet milling might contain very minor amounts of protein, fiber, and other residues. Starch yield wsa determined as

$$\%\ \text{yield} = \frac{\text{dry weight of starch recovered from extraction} \times 100}{\text{dry weight of whole tuber}}$$

The weights of dried starch and tuber were measured on the same balance (0.01 g accuracy) to enhance accuracy (Mettler AE 104, Toledo, OH).

Preparation of cold water soluble starch-chemical by alkaline-alcoholic Treatment

The modified method reported by Chen, J., & Jane, J. (1994)was employed to prepared CWS, this is by treating extracted starch with mixture of ethanol and NaOH solution (30M) at different proportion and at different temperature of 25, 30 and 35˚C. according to the table 1 below

Table 1 Amounts of NaOH (aqueous solution) and Ethanol for different treatments

treatment	Proportions Starch(g)	3M NaOH (g)	40% EtOH (g)
P1	100	200	400
P2	100	250	350
P3	100	300	300
P3	100	350	250
P5	100	400	200

The above treatments were carried out at three different temperatures of 25˚C, 30˚C and 35˚C, each treated starch will be neutralize and tested for solubility in cold water.

Swelling volume and solubility

The swelling volume and solubility of the starch pastes was determined according to standard procedures (Crosbie, G. B. (1991) and Schoch, T. J. (1964)), as follows: 100 mg of starch was weighed into a 100 mL conical flask and 10 mL distilled water added. The samples is then kept in a boiling water bath for 20 min.

After cooling, the samples was transferred to centrifuge tubes; the volume was made up to 10 mL and centrifuged at 3000 rpm for 20 min. The height of the gel was measured and converted to volume of gel per unit dry weight of the sample. From the supernatant 5 mL was transfer into a previously weighed Petri dish and dried in an oven at 60˚C overnight. The weight of the residue also measured. The percentage solubility was determined using the equation

$$\% \text{ Solubility} = \frac{\text{Weight of the residue (g)} \times (10 - \text{volume of swollen portion}) \times 100}{\text{Weight of the starch taken (g)} \times 5}$$

Miscellaneous tests

Other tests to be conducted are; starch quality tests according to standard proceedures e.g Iodine test for starch quality. Density bottle method for starch density determination. Starch pH determination using pH meter. Determination of whiteness of starch by using light refraction (refractor meter) etc.

RESULTS AND DISCUSSION

Extraction and purification of starch

Table 2 Extraction of starch from sweet potato using different filters

Amount of sweet potato (g)	Added water in the slurry (cm^3)	Filter used (μm)	Starch yield (g)	Percentage of starch yield (%)	Dried weight percentage of starch yield (%)	Starch color	density (g/cm^3)
1000	4000	20	175	17.5	56.5	white	1.48
1000	4000	30	194	19.4	62.6	white	1.49
1000	4000	40	222	22.2	71.6	dense white	1.48

Amount of water Water: **69%**

Table 3. Physical properties of starch produced/starch quality

PROPERTY	RESULT
Appearance	White powder
Density	1.49g/ml
pH	6.3
Solubility in water	insoluble
Iodine test	Positive
Melting Point	Decomposes
Sensory	Tasteless and odorless
Yield	31% of fresh Potato

Table 4 Results of chemical modification of starch to water soluble using different ratio of 3M $NaOH_{(aq)}$ and 40% ethanol at tempretures of 25˚C, 30˚C and 35˚C

Treatment	Proportions			Temperatures (˚C)	Percentage Solubility at room temp (%)
	Starch(g)	3M $NaOH_{(aq)}$ (g)	40% $EtOH_{(aq)}$ (g)		
P1	100	200	400	25	43.3 ± 3.3
P2	100	250	350	25	47.2 ± 2.1
P3	100	300	300	25	55.5 ± 3.0
P4	100	350	250	25	66.1 ± 1.9
P5	100	400	200	25	81.4 ± 2.1
P1	100	200	400	30	46.1 ± 3.2
P2	100	250	350	30	50.8 ± 2.4
P3	100	300	300	30	56.9 ± 2.1
P3	100	350	250	30	65.7 ± 3.5
P5	100	400	200	30	85.0 ± 3.2
P1	100	200	400	35	50.1 ± 2.7
P2	100	250	350	35	55.4 ± 2.2
P3	100	300	300	35	63.2 ± 2.4
P3	100	350	250	35	74.2 ± 2.8
P5	100	400	200	35	90.3 ± 0.9

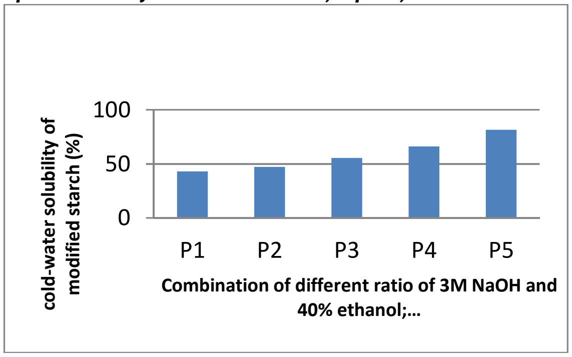

Figure 1 showing percentage cold-water solubility of modified starch after various alcoholic-alkaline treatments at 25˚C

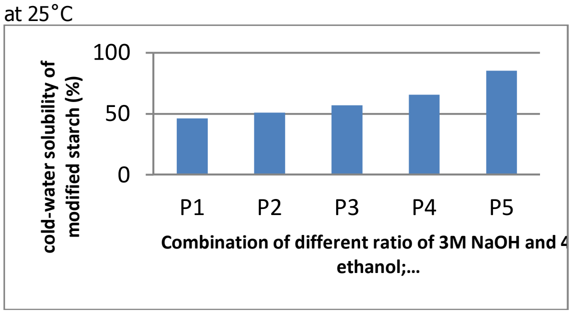

Figure 2 showing percentage cold-water solubility of modified starch after various alcoholic-alkaline treatments at 30˚C

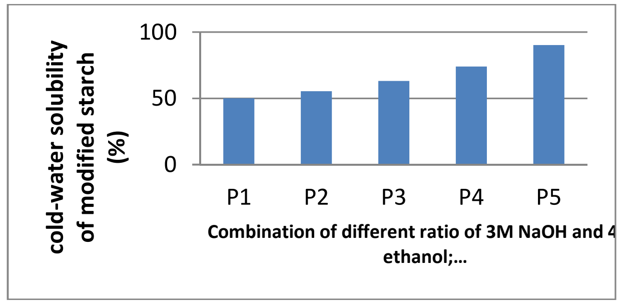

Figure 3 showing percentage cold-water solubility of modified starch after various alcoholic-alkaline treatments at 35˚C

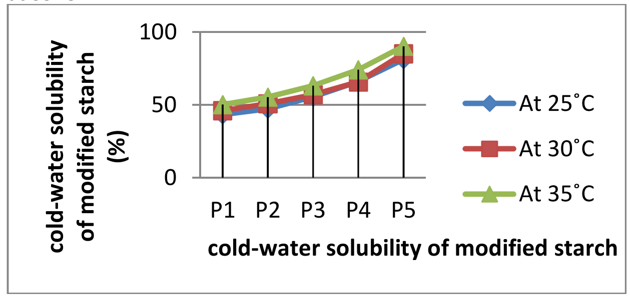

Figure 4 showing percentage cold-water solubility of modified starch after various alcoholic-alkaline treatments at 25˚C, 30˚C and 35˚C

Extracted starch and its qualıty

From the table 2 it can be seen that; using 20µm, 30µm and 40µm yielded 17.5%, 19.4% and 22.2% of native starch respectively, starch was reported several time by researchers to have granular size from 1µm to 100µm (Fuentes, C., *et al*, 2019) the same was also reported that sweet potato starch has granular size of 15µm to 30µm (Perez S, Bertoft E, 2010), but Chen, J., & Jane, J. (1994) earlier reported sweet potato to have 5µm - 25µm granular starch size. From our result here in using 30µm nylon filter yielded starch amount of 19.4% which is in conformity and within the ranged of starch percentage of different root tubers as reported (. Fakir, M. S. A., *et al.,* 2012). Based on this it can be said that; the 30µm nylon filters produced better potato starch isolation with percentage yield that agreed with the above cited literature. İn this work 30µm nylon filter was considered for better isolation of sweet potato starch. The density of starch from all three filters show almost the same value and it approximately tallied with starch density of 1.5g/cm^3

The quality or physical properties of the extracted/isolated starch was determined, and the result was presented in table 3 above. From table the extracted starch showed positive to starch-iodine test and this confirmed the good quality of the isolated starch. The confirmatory test and observation was similar to that reported by Fleischer, H. (2019). In this work the pH of the isolated starch was found to be 6.3. Although there is no available literature that compared the pH of native starch, but the work of Pudjihastuti, I., *et al.,* (2018) reported that: starch is a weak acid, but stronger than water. Therefore and based on our finding starch showed pH of 6.3 it can be said to exhibit a pH of a very weak acid character. Another research on sweet potato reported that starch has a pH of 5.9 (Bayor, M. T., *et al* 2013). The density is another qualitative property of any chemical compound and our finding here showed that: the isolated starch from sweet potato has density of 1.49g/cm^3, as compared to 1.15g/cm^3 - 1.18 g/cm^3 reported by Bayor, M. T., *et al* (2013). The starch exracted from sweet potato also is not soluble in water, the solubility test was carried out and ~100% of starchy matter settled down as sediment after centrifugation. Another starch property tested was its behavior on heating, the isolated starch on dry heating at 100˚C, turned to brown and then started to decompose.

Effect of double alkali: alcohol treatment

The results of alcoholic-alkaline treatment conducted on the sampled starch is presented in Table 4, different ratio combinations of 3M NaOH (Alkali) and that of 40% Ethanol (alcohol) were applied at three different temperatures as stated.

At a temperature of 25˚C P1, P2, P3, P4 and P5 treatments, the percentage solubility in water were found to be 43.30%, 47.20%, 55.50%, 66.10% and 81.40% respectively. At 30˚C P1, P2, P3, P4 and P5 treatments has percentage solubility in water as 46.10%, 50.80%, 56.90%, 65.70% and 85.00% respectively and at temperature of 35˚C P1, P2, P3, P4 and P5 treatments has percentage solubility in water as 50.10%, 55.40%, 63.20%, 74.20% and 90.30% respectively. Here it can clearly be seen that; the higher the equivalence of 3M NaOH the more water solubility of the modified starch. Han, J. A., & Lim, S. T. (2004). hypothetically recommended by that; Alkaline condition facilitates changes in structure of starch molecules, leading to lost of some of their intermolecular bonding more especially hydrogen bond thereby allowing the molecules to absorb more water and render them water soluble in the process.

Effect of alkali concentratıon

Han, J. A., & Lim, S. T. (2004) hypothetically suggested that, alkaline condition causes some changes in starch granule structure, opening it up thereby resulting in the breaage of intermolecular forces thereby enhancing the water solubility of a modified starch. Figure 1, 2 and 3 showed how changes in proportions of 3M sodium hydroxide affects changes in solubility of the modified starch in a direct proportion relationship pattern and figure 4 depicted the whole trend. Another trend in our finding here in this research is that, increase in amount of 3M sodium hydroxide solution from P1 (ratio of 1) to P5 (ratio of 2) at 25˚C, 30˚C and 35˚C resulted to an increase in cold water solubility of sweet potato native starch from 43.30% to 81.40%, 46.10% to 85.00% and 50.10% to 90.30% respectively, showing almost a complete double increase in cold water solubility within all the three temperatures. Unlike the Chen J., Jane J. (1994) work, our own here changes 3M sodium hydroxide amount upwards alongside changing 40% Ethanol amount downwards, unlike their work that only sodium hydroxide amount was changed sequentially while keeping all other factors constants, this may explain the reason why the two results may have some variations. It has been established in the earlier research on effect of alkali concentration on starch conversion to more cold water soluble that; the more concentrations of sodium hydroxide the more extent starch molecules swells Leach H. W., (1965). Another work also reported similar development on this regard (Lancaster, E. B., & Conway, H. F. (1968), BeMiller, J. N., & Pratt, G. W. (1981))

Effect of amount of alcohol

Another factor that may seem to play important role in changing cold water solubility of the modified starch is ethano, 40% (v/v). Ethanol was chosen in this work because several literatures reported 40% ethanol as optimum concentration for alkaline-alcoholic treatment of starch Yu, Y., *et al* (2018). From the result presented in table 4 and the figures 1, 2 1nd 3 it can be observe that; there is inverse relationships between amount or volume of 40% ethanol and percent cold water solubility of the modified starches. It can be observe that; across P1 to P5 as the amount of 40% ethanol decreases, the cold water solubility of the starch increases. At temperature of 25˚C P1, P2, P3, P4 and P5 has percentage of cold water solubility as 43.30%, 47.20%, 55.50%, 66.10% and 81.40% respectively, at 30˚C P1, P2, P3, P4 and P5 has percentage of cold water solubility of 46.10%, 50.80%, 56.90%, 65.70% and 85.00% respectively and lastly at 35˚C P1, P2, P3, P4 and P5 has percentage of cold water solubility of 50.10%, 55.40%, 63.20%, 74.20% and 90.30% respectively. The changes was as a result of activities 3M sodium hydroxide and 40% ethanol as they works in tandem or synergy, but the patterns of inverse proportionality exhibited as in the figures is an indication that; the more tghe amounts ethanol used the more the decrease of cold water solubility of the modified starch. This observation is in line with some reported findings. Chen & Jane (1994b)., reported that: alcohol presence restricts the swelling of granules by lowering the effectiveness of water concentration and thereby conserving the granules integrity. The same authors Chen, J., & Jane, J. (1994) in another work reported that; for every double increase in 40% to 60% (v/v) of ethanol there is corresponding decrease in percentage of cold water solubility of modified starch with 0.4 fold decease, where according to them: by keeping other factors constant, increasing ethanol concentartion from 40% to 60% (v/v) resulted in producing 50% cold water soluble starch and 37% cold water soluble starch respectively.

Effect of temperature

Another very important independent factor contributing to swelling, gelatinization and cold water solubility of starch is temperature, from our finding it has been observed that; there is considerable increase in percentage of cold water solubility under the same treatment of P1,P2,P3,P4 and P5 at different temperatures of 25˚C, 30˚C and 35˚C.

From table 4.3 across change of temperature from 25˚C, 30˚C and 35˚C; percentage of cold water solubility of modified starches at P1 treatment it changes from 43.3%, to 46.1% and to 50.1% respectively, at P2 treatment it changes from 47.2 %, to 50.8 % and to 55.4 % respectively, at P3 treatment it changes from 55.5 %, to 56.9 % and to 63.2 % respectively, at P4 treatment it changes from 66.1 %, to 65.7 % and to 74.2 % respectively and finally at P5 treatment it changes from 81.4 %, to 85.0 % and to 90.3 % respectively. According to Lancaster, E. B., & Conway, H. F. (1968); there is an exponential relationship between increasing temperature and increases in percentage of cold water solubility of an alkaline treated modified starch. In one research instance researchers, Chen, J., & Jane, J. (1994) discovered that; changing temperature from 25˚C to 35˚C causes percentage of cold water solubility of a normal maize starch to increase from 23% to 84% under same condition of alkali and alcohol, comparing this result with our finding at same temperature interval of 25˚C to 35˚C P1 treatment changed from 43.3% to 50.1%, P2 treatment changed from 47.2 % to 55.4 %, P3 treatment changed from 55.5 % to 63.2 %, at P4 treatment changed from 66.1 % to 74.2 % and P5 treatment changed from 81.4 % to 90.3 % this show a clear considerable increase under the same conditions of all factors but temperature. Looking at figure 4.4 one can visibly see how percent cold water solubility curves are placed over one another according the different temperatures of treatment, from 30˚C to 35˚C there is significant changes of the overall solubility curve, but very little difference compared to change from 25˚C to 30˚C and more better from 25˚C to 35˚C. Although our finding is not directly agreeing with the just cited literature of exponential rises in solubility by temperature increase of 10˚C, but having different type of starch under study between our work and their work may explain the discrepancies which the authors even attributed it to differences in amylose/amylopectin ratio. Other investigators Jivan, M. J., *et al* (2014) using potato starch interestingly found similar results to ours, where a sample of native potato starch shows Percentage of cold water solubility of ~4% in cold water at room temperature of 25 °C; and the percentage cold water solubility increased to ~23% as the temperature increased to 35 °C on the same native potato starch. On modifying the starch by alcoholic-alkaline treatment the cold water solubility of the modified potato starch amplified to 51 % at 25 °C and 74 % at 35 °C signifying the effectiveness of the alcoholic-alkaline treatment on the native starch, comparing this work of changes from 51 % at 25 °C and 74 % at 35 °C and our finding where at 25˚C to 35˚C P3 treatment changed from 81.4% to 90.3% and all other treatments in similar pattern also (see table 4 and figures 1 to 3 above)

CONCLUSION

In conclusion, from this work conducted it can be said that; sweet potato can be an ulternative source of quality starch. The native starch extracted from sweet potato sample has all properties needed for a quality starch that can be use as food and raw materials for starch consuming industries. After subjecting the native starch obtained from the sweet potato to alkaline-alkoholic treatments, the process resulted in modifying the starch sample into cold water soluble starches with different percentage solubilities based on nature of the treatment procedure. The characteristic differences in percentage of cold water solubilities of the alkaline-alkoholic treated/modified starches is good because, different percentage cold water solubility has different applications as raw materials for industries, although testing the modified starches produced to see wheather they can suit a perticular industrial raw material specifications is beyond the scope of this resaerch work, but based on their solublities they can be a promising raw material candidates, especially in textile, food and confectionary industries, (where starch gelling property, its solubility at low tempretures and its stability in solutions are some of the desired quality).. Finally, this means values can be added to sweet potato produce in northern Nigeria, and also this could go a long way in creating wealth from sweet potato and reducing wastage of fresh sweet potato during post-harvest, as it is one of the most perishable root tubers. Farm based modular starch extracting and refining machines, can be use by farmers of sweet potato in producing quality starch from harvested sweet potato, this could help them to overcome the problrms of sweet potato's decay on storage. Likewise the starch that coulb produce can be use by local industries, hence this can also help in reducing over dependence on imported starch.

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