EFFECTS OF DRYING METHODS ON PHYSICO-CHEMICAL PROPERTIES OF HYDROCOLLOIDS ISOLATED FROM PEEL FLOUR OF SOME SELECTED ROOT AND TUBER CROPS

ABSTRACT

Hydrocolloids isolated from the flour of peels of selected root and tuber crops were purified and their physiochemical properties were determined using standard procedures. The experimental material used were the peels of three species of *Dioscorea*: *a~~A~~lata* (water yam), *d~~D~~umentorum* (trifoliate yam), *r~~R~~otundata* (white yam) and *bulbifera* (aerial yam); *~~c~~Colocasia esculenta* (cocoyam); white and yellow flesh of *Ipomoea batatas* (sweetpotato). ~~The fresh~~The fresh peels were dried under three drying method (oven, sun and air-~~dried)~~dried). ~~-~~Proximate composition gave 4.4~~02~~ to 10.7~~668~~% for moisture content, 0.40~~0~~ to 6.10~~0~~% for ash content, 0.32~~18~~ to 4.13~~0~~% for crude fibre and in carbohydrates it ranges from 81.3~~270~~ to 93.~~65~~57%.There were no fat and protein in the experimental samples. Oven dried *~~Alata~~ alata* peel flour gave the highest swelling index value 1.44~~1~~% while, air dried had the highest value ~~of (~~of (4.00%) ranking the highest in foaming capacities. The highest in water and oil absorption capacities were sun dried (2.05~~0~~) *~~Dumentorum~~ dumentorum* peel and *~~Rotundata~~ rotundata* peel air dried (2.21~~05~~). In emulsifying capacity and freezing thawing stability the highest results were observed in *colocasia* peel oven dried (54.3~~45~~%) and white flesh *Ipomoea batatas* peel sun dried (74.3~~25~~%). Yellow flesh *Ipomoea batatas* (0.31 ~~09~~g/ml) gave the lowest in bulk density. ~~Gelation temperature~~Gelation temperature ranges from ~~70°c~~ 70 to 83°~~c~~ ~~with~~C with ~~-~~pH of 6.6 to 7.6.

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Keywords: Physicochemical, root and tuber crops, hydrocolloids, flour, peels.

INTRODUCTION

Root and tuber crops are grown in Nigeria and sub-S~~s~~ahara Africa, it forms a major part of the staple food consumed by the ~~people .Root~~people. ~~crops~~Root crops are the edible energy-rich underground plant structure developed from modified roots while tuber crops edible carbohydrate-rich storage organs ~~is developed~~is developed wholly or partly from underground stems. Peels are generated during processing of tubers such as cassava, sweet potato, cocoyam and yam into different added-value products, and also consumption of the tubers.

Tuber peels are mostly generated at the consumption level through household, chopbars, food vendors etc. Peel losses are considerable high in some cases for instance yam peels constitute about 14% of the volume of yam consumed, bulbifera having the highest peel lost (Vietnam News, 2014).

Tuber peels are being used currently to add value to waste by turning it into profit making ventures (Gratitude, 2014) while peels from sweetpotato has been used as a source of dietary fiber in bread making (Toma, 2006). Tuber crops production has steadily increased to the tunes of 688 metric ~~tones~~tons in 2001 to 740 million in 2007 (FAO, 2014). Peels from the tubers could become a viable panacea to poverty alleviation in the developing countries (Dekalu, 2014).

Food gums that are complex carbohydrate derived from plants ~~sources ,that~~sources, that are water soluble are hydrocolloids; hydro means water ,while colloids means dispersion of small particles in another medium (Chaplin,2014). They help give many of the food we eat their characteristic shape or consistency (IFAC, 2014).

This study ~~-~~evaluates ~~P~~physicochemical properties of the ~~hydrocolliods~~hydrocolloids isolated from- selected root and tuber crops peels flour.

MATERIALS AND METHODS

Sources ~~of raw~~of raw materials

White and yellow flesh sweetpotato (*Ipomoea batatas*), two species of yam (*Dioscorea* ~~*rotundata* and~~*rotundata* and *Dioscore aalata*) and cocoyam (*Colocasia esculenta)* were purchased from Ubani market Umuahia, while *Dioscorea dumentorum* was purchased from Orien-Ntigha in Isi-alaNgwa North of Abia State. The aerial yam (*Dioscorea bulbifera*) was purchased from the Abakiliki main market in Ebonyi State.

Sample preparation of the fresh tubers

Each of the tuber samples (Sweetpotato, yams and cocoyam) ~~was washed~~was washed, peeled and chopped into smaller units of about 5-6 cm long (Ofori and Hahn, 1994). The peels and flesh were divided into three (3) portions each. Each of the three portions were dried to constant weight using sun, air and oven drying method respectively.

Sun drying: A portion of the various tuber samples (fresh and peels) were kept in the sun between 9 am to 4.30pm daily and were dried to constant weight for four (4) days.

Air drying (Room Temperature): A second portion of each flesh and peels samples were placed in spread platform in an airy room to shed the samples from sun ray. These were dried to constant weight for 8 days.

Oven drying: A third portion of each flesh and peels tuber samples were placed in an ~~electrothermal~~electro thermal oven (model; ~~DHG) and~~DHG) and dried to constant weight at 65^{o}C for 48 hours.

Flour Processing

The chips of fresh sweetpotato, yams and cocoyam flesh and peel samples that were sun, air and oven dried to a constant ~~weight respectively~~weight respectively were milled into fine powder using Thomas Willey mill and Binatone blender model BLG-401. Each of the samples flour was obtained from the fine powder by sieving with 150 µm aperture sieve. They were placed in plastic bag and stored in air-tight plastic container.

Defatting of the flesh and peels flour (cold method)

The peels and fresh flour samples were defatted as described by Size-Tao and Sathe (2004~~).The~~). The flour samples were soaked with n-hexane to ratio of 1:10 (w/v) for 24 hours. It was then filtered using filter paper and the residue (defatted samples) obtained.

Extraction and purification of the defatted flour samples

The extraction and ~~purification was~~purification was done by the methods of Oladipo and Nwokocha (2011); Onwueluzo*et al*. (1993). 120g of fresh and peels of the defatted samples were dispersed in 800 ml of distilled water in 1000 ml beaker and the supernatant was

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~~decanted.The~~decanted. The content left in the beaker was passed through muslin cloth. Each of the residue was re-constituted with 500 ml distilled water and sieved again with muslin cloth. Excess cold 99.9% ethanol was added to the residue. The precipitate formed was collected as a residue when ~~the content~~the content in the beaker was filtered using muslin cloth. The crude food gum was scooped ~~into 500~~into 500 ml beaker using table spoon. The crude extract ~~was purified~~was purified by dissolving in distilled water, homogenized and gradually precipitated with twenty (20) percent Ammonium sulphate and then washed with distilled ~~water.The~~water. The residue after washing was placed in 500 ml beaker and precipitated with excess cold 99.9% ethanol. This procedure was done severally until the washing was negative to biuret test. The precipitate extracts were dewatered and was oven dried at 65^{o}C for 48 hours.

Analysis on the ~~extracted purified~~extracted purified hydrocolloids

Proximate composition

Proximate composition (moisture, crude fiber, ash, crude protein, fat) was determined using standard methods described by Association of Official Analytical Chemistry (AOAC, 2000). The percentage carbohydrate ~~was estimated~~was estimated by difference (Miller and John, 1990; Onwuka, 2005).

Functional properties

Swelling index was determined as described by the method of Iwuoha (2004). Bulk density was determined as described by Nep and Conwey (2011~~).Aqueous~~). Aqueous solubility was done by the method as described by Nwanekezi et al (2001).). Gelatinization temperature (GT), emulsification capacity (EC), oil and water capacity (OAC/WAC), foaming capacity (FC) and pH measurement were determined by the method as described by ~~G.I.,Onwuka~~G.I., Onwuka (2005).

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA). Means were separated using Duncan's new multiple range test (DNMRT) using the statistical package for social science (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA).

Results and Discussion

Proximate composition of the isolated purified hydrocolloids

The proximate compositions of the purified hydrocolloids are shown in Table 1. Moisture contents of the hydrocolloids were all below 10%, which suggests reduction in the growth of microorganisms thereby increased in shelf life (Scott, 1991) and these are favourable to food processors and producers. The moisture content ranged from 4.40~~2~~ to 10.7~~668~~% with *Colocasia esculenta* peel air dried (4~~,~~.40~~2~~%) ranking the lowest. In the peel samples *builbifera* peel air dried (6.10~~0~~%) ranked the highest in ash content, having no significant differences ($p<0.05$) with *dumentorum* peel air dried (5.425%), the lowest were in White fresh sweetpotato peel sun dried (0.400%). The ash contents were higher than purified locust bean gum (2.06%) (Sidley, 2013) and cashew gum (1.2%) (Kwabena *et al.*, 2010; Raquel *et al*., 2002). ~~d~~*Dumentorum* peel air dried (4.130%) ranked the highest in crude fibre content, ~~The~~the resulting values recorded are

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comparable with cashew gum (4.8%) (Kwabena *et al*., 2010). Gelatin (2.56%) (Atuonwu *et al.*, 2010) and *Delonix regia* food gums (0.37%) (Okenwa and Nwokocha, 2014). while *Colocasia esculenta* peel air ~~dried ranked~~dried ranked the highest in c~~C~~arbohydrates (93.7~~655~~%). There were no fat and protein contents after their determination. These portray thorough defatting during processing and complete removal of protein content during purification process of the extracted hydrocolloids.

Table 1: Proximate composition of the tuber peels hydrocolloids samples

Sample names	Moisture (%)	Ash (%)	Crude fibre (%)	Carbohydrates (%)	Fat (%)	Crude protein (%)
dumetorum peel oven drying	10.7~~668~~^{a}	3.23~~0~~^{f}	4.13^{a}	82~~1~~.0~~972~~^{f}	-	-
Sun drying	10.0~~12~~^{a}	4.8~~4~~5^{d}	3.87~~3~~^{b}	81.3~~270~~^{f}	-	-
Air drying	9.79~~1~~^{ab}	5.43~~25~~^{b}	2.25~~48~~^{d}	82.3~~294~~^{f}	-	-
bulbifera peel oven drying	8.11~~06~~^{c}	5.05~~0~~^{c}	1.55~~0~~^{h}	85.3~~294~~^{de}	-	-
Sun drying	8.6~~07~~1^{c}	3.30~~0~~^{f}	1.04~~0~~^{i}	87.0~~53~~^{d}	-	-
Air drying	7.~~8~~90~~6~~^{c}	6.10~~0~~^{a}	0.88~~75~~^{k}	85.1~~29~~^{e}	-	-
rotundata peel oven drying	8.91~~3~~^{bc}	1.73~~25~~^{a}	0.43~~28~~^{lm}	88.9~~34~~^{cd}	-	-
Sun drying	10.1~~49~~^{a}	1.22~~0~~^{h}	0.32~~18~~^{n}	88.3~~13~~^{d}	-	-
Air drying	8.34~~39~~^{c}	1.54~~35~~^{g}	0.43~~2~~^{lm}	89.7~~694~~^{cd}	-	-
alata peel oven drying	5.31~~05~~^{efg}	3.56~~55~~^{e}	0.46~~3~~^{j}	90.7~~677~~^{bc}	-	-
Sun drying	5.47~~4~~^{defg}	1.18~~75~~^{h}	0.32~~0~~^{n}	93.0~~31~~^{a}	-	-
Air drying	5.~~49~~50^{defg}	3.15~~0~~^{f}	0.37~~3~~^{mn}	91~~0~~.0~~982~~^{b}	-	-
Colocasia esculenta peel oven drying	4.62~~2~~^{efg}	1.05~~0~~^{hi}	0.81~~08~~^{k}	93.5~~20~~^{a}	-	-
Sun drying	5.0~~7~~8^{efg}	0.90~~0~~^{lj}	0.81~~09~~^{l}	93.~~29~~3^{a}	-	-
Air drying	4.40~~2~~^{efg}	1.09~~0~~^{hi}	0.85~~3~~^{kl}	93.7~~655~~^{a}	-	-
White peel *sweetpotato flesh* oven drying	6.14~~1~~^{de}	0.6~~0~~0^{k}	2.51~~1~~^{c}	90.8~~748~~^{bc}	-	-
Sun drying	5.68~~3~~^{def}	0.4~~0~~0^{k}	2.50^{c}	91.417^{b}	-	-
Air drying	6.58~~1~~^{d}	0.5~~0~~0^{k}	2.513^{c}	90.407^{bc}	-	-
Yellow peel *sweetpotato flesh* oven drying	5.66~~4~~^{def}	0.9~~0~~0^{ij}	2.312^{e}	91.124^{b}	-	-
Sun drying	5.9~~8~~9de	0.82~~15~~^{J}	2.100^{g}	91.096^{b}	-	-
Air drying	6.13~~2~~^{de}	0.94~~0~~^{iJ}	2.215^{f}	90.713^{bc}	-	-
LSD	.063~~1~~	.058	.006	.051	-	-

Samples means with the same superscript down the columns are not significantly different (P>0.05).

Table 2 shows the ~~the~~ functional properties of the purified extracted hydrocolloids. *Alata* peel oven dried (1.441~~) ranked~~) ranked the highest in swelling index, while *Colocasia esculenta* peel air dried (1.005) was the lowest. Ikegwu., *et al* () that fat and protein content of food gum

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effluences their swelling index, thus the result of the swelling index could be due to no protein and fat in the hydrocolloids samples. However, the result was higher than the swelling index obtained in purified cashew gum (0.5) (Kwabana *et al*., 2010). In foaming capacities, *dumentorum* peel oven ~~dried (~~dried (4.0~~00~~%) and *dumentorum* peel air dried (4.000%) ranked the highest in values having no significant differences (P<0.05) with *dumentorum* peel sun dried (3.85~~0~~%). ~~-~~*Colocasia esculenta* peel (70.9~~05~~%) ranked the highest in the percentage solubility values recorded having no significant differences with *alata* peel oven dried (70.6~~40~~%). In oil absorption capacities (OAC), *rotundata* peel air ~~dried (~~dried (2.2~~05~~1) recorded the highest with the lowest in *Colocasia esculenta* peel sun dried (1.03~~25~~). While in water absorption capacities(WAC), *dumentorum* peel sun dried~~—(~~ (2.050) and *builbifera* peel sun dried ~~–~~(2.050) of the peel samples were the highest, *builbifera* peel air dried (1.050) was the lowest. ~~The results~~The results were ~~higher than~~higher than gum Arabic (0.280) and Bovine ~~Gelatin~~ gelatin (0.00) in WAC, also higher than xanthan gum (1.28) gum Arabic (1.00) and Bovine gelatin (1.06) in OAC (Atuonwu *et al.*, 2010). WAC and OAC are used in reducing syneresis and modifying the texture of foods therefore the extracted purified hydrocolloids from ~~the peels~~the peels of tuber crop can be applied in food formulation in this aspect. The highest emulsifying capacities ~~of the~~of the peel samples were in *Colocasia esculenta* peel oven dried (54.3~~45~~%),the lowest were in *builbifera* flesh sun dried (38.9~~25~~%) and *alata* peel sun dried (36.5~~05~~%).There were significant differences (P<0.05) in Freeze thawing stability of the peel samples respectively. White flesh sweet potato peel sun dried (74.3~~25~~%) ranked the highest in the peel samples, however there were no significant differences between White flesh sweet potato peel (74.2~~21~~ to 74.3~~25~~%) and in *builbifera* peel (74.3~~260~~%). The results of the bulk density recorded showed White flesh sweet potato peel sun dried (0.510g/ml) ranked the highest and Yellow flesh sweet potato peel oven/air dried (0.309g/ml) the lowest. The results recorded may be ~~attributed to~~attributed to the defatted tuber flours before extraction of the hydrocolloids which aid in the bulk density (Adebowade *et al.*, 2005). The highest value obtained in peels samples were higher than guar gum (0.474 g/ml) and diodea gum (0.504 g/ml) (Mirhosseini and Amid, 2013; Buiders *et al.*, 2012), but lower than gum Arabic (0.61) (Martins *et al.*, 2009). Lower bulk density indicate higher porosity (Ikoni *et al.*, 2012~~-~~; Krokida and Maroulis, 1997), thus, Yellow flesh sweetpotato peel oven/air dried with the lowest bulk density will have high porosity compared with other peels samples.

Table~~2 :Functional~~2: Functional properties of the hydrocolloids samples

Sample names	S.I	FC	Sol (%)	OAC	WAC	EC (%)	FTS (%)	D_B (g/ml)
dumetorum peel oven drying	1.057^{cdef}	4.00~~0~~^{a}	67.~~45~~5^{e}	1.205^{fg}	1.505^{bc}	47.7~~4~~^{f}	73.1~~090~~^{b}	0.455^{ef}
Sun drying	1.027^{ef}	3.85~~0~~^{a}	66.7~~05~~^{fg}	2.050^{ab}	2.050^{a}	47.7~~15~~^{f}	72.0~~25~~^{c}	0.456^{ef}
Air drying	1.050^{cdef}	4.00~~0~~^{a}	65.2~~170~~^{i}	1.305^{ef}	1.050^{e}	48.8~~85~~^{d}	73.0~~45~~^{b}	0.462^{e}
bulbifera peel oven drying	1.035^{def}	0.201^{d}	67.5~~20~~^{e}	1.705^{c}	1.605^{b}	46.9~~25~~^{g}	74.2~~60~~^{a}	0.452^{f}
Sun	1.029^{ef}	0.150^{d}	66.5~~15~~^{gh}	1.605^{cd}	2.050^{a}	46.8~~65~~^{g}	65.8~~750~~^{g}	0.454^{ef}

drying								
Air drying	1.235^{bc}	0.200^{d}	66.00^{hi}	1.905^{b}	1.050^{e}	47.825^{f}	65.8750^{g}	0.452^{f}
rotundata peel oven drying	1.057^{cdef}	1.900^{b}	51.565^{k}	1.405^{def}	1.305^{cd}	43.9860^{j}	68.635^{ef}	0.375^{g}
Sun drying	1.057^{cdef}	1.900^{b}	50.071^{l}	1.500^{de}	1.401^{bcd}	43.745^{j}	68.645^{ef}	0.331^{h}
Air drying	1.309^{ab}	1.900^{b}	51.071^{k}	2.205^{a}	1.550^{b}	45.340^{h}	69.635^{d}	0.332^{h}
alata peel oven drying	1.441^{a}	2.105^{b}	70.640^{ab}	1.410^{def}	1.305^{cd}	37.7650^{L}	68.545^{ef}	0.456^{ef}
Sun drying	1.105^{cdef}	2.000^{b}	61.510^{j}	1.305^{ef}	1.200^{de}	36.505^{m}	68.535^{ef}	0.456^{ef}
Air drying	1.215^{bcd}	2.000^{b}	65.450^{hi}	1.300^{ef}	1.205^{de}	37.660^{l}	68.550^{f}	0.457^{ef}
Colocasia esculenta peel oven drying	1.050^{cdef}	2.000^{b}	70.905^{a}	1.055^{g}	1.305^{cd}	52.3275^{b}	68.810^{ef}	0.484^{cd}
Sun drying	1.095^{cdef}	2.000^{b}	70.301^{b}	1.025^{g}	1.200^{de}	51.3250^{c}	68.205^{ef}	0.486^{cd}
Air drying	1.005^{ef}	2.000^{b}	69.2150^{c}	1.045^{g}	1.300^{cd}	54.345^{a}	69.305^{de}	0.481^{d}
White peel *sweetpotato flesh* oven drying	1.205^{bcde}	0.230^{d}	67.241^{ef}	1.305^{ef}	1.400^{bcd}	44.905^{i}	74.315^{a}	0.501^{b}
Sun drying	1.211^{bcde}	0.215^{d}	67.206^{ef}	1.305^{ef}	1.400^{bcd}	44.911^{i}	74.325^{a}	0.510^{a}
Air drying	1.211^{bcde}	0.210^{d}	67.006^{efg}	1.301^{ef}	1.400^{bcd}	45.905^{h}	74.221^{a}	0.491^{c}
Yellow peel *sweetpotato flesh* oven drying	1.057^{cdef}	1.230^{c}	68.501^{d}	1.450^{de}	1.600^{b}	40.511^{k}	73.235^{b}	0.309^{i}
Sun drying	1.110^{cdef}	1.230^{c}	68.505^{d}	1.300^{ef}	1.505^{b}	40.525^{k}	72.6555^{bc}	0.310^{i}
Air drying	1.105^{cdef}	1.230^{c}	68.935^{cd}	1.455^{de}	1.555^{b}	40.521^{k}	72.545^{bc}	0.309^{i}
LSD	.050	.051	.055	.504	.053	.073	.052	.058

Samples means with the same superscript down the columns are not significantly different. (P>0.05)

Table 3. shows gelation temperature and pH measurement of the extracted purified hydrocolloidspurified hydrocolloids samples from flour of peels experimental materials. The peels samples were 70^{o}C to 83^{o}C of gelation temperature with pH of 6.6 to 7.6 These were within the range of gellan gum gelation temperature of 65^{o}C to 83^{o}C (Gohel *et al*., 2009) and pH of proscopis African gum of 6.8 to 7.1 (Achi and Okolo, 2004). This result showed that the extracted purified hydrocolloids may be included in the group of gelling polysaccharide like carragenaan, pectin, agar, alginate (Rss feed, 2014), and also may be applied in food industry for formulation of shape or structure generated at certain temperature (Konjac, 2014).

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Table 3: Gelation temperature and pH~~h~~ of the hydrocolloids samples

Samples code	Gelation Temperature (^oC)	pH
D. dumetorum oven drying	70.0	7.0
Sun drying	70.0	7.0
Air drying	70.0	7.1
D. bulbifera oven drying	80.0	7.5
Sun drying	79.0	7.3
Air drying	80.0	7.6
D. rotundata oven drying	81.5	7.2
Sun drying	80.0	7.1
Air drying	80.0	7.1
D. alata oven drying	83.0	6.6
Sun drying	83.0	6.6
Air drying	82.0	6.7
Colocasia esculenta oven drying	75.5	6.8
Sun drying	75.0	6.8
Air drying	75.0	6.8
White flesh *Ipomoea batatas* oven drying	82.0	6.9
Sun drying	82.0	6.9
Air drying	82.0	6.9
Yellow flesh *Ipomoea batates* oven drying	80.0	7.0
Sun drying	80.0	7.0
Air drying	80.0	7.0

CONCLUSION

This study showed that hydrocolloid can be extracted from the selected tuber crops ~~There were~~There were noticeable differences between the samples in the proximate composition, functional properties and ~~viscosity~~

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~~The~~viscosity. The results as outlined in this work suggest the usefulness of these purified hydrocolloid in food design, manufacturing and formulation. Oven-dried and air-dried methods should be used in drying of fresh tuber crops for extraction and purification of hydrocolloids.

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Hydrocolloids from *Colocasia* ~~*esculenta* peel~~*esculenta* peel, Yellow flesh sweet potato peel White flesh sweetpotato peel, *rotundata* peel air dried , *bulbifera* peel air dried, *dumentorum* peel oven dried that have very good qualities should be used both domestically and commercially for their specific functionalities. These hydrocolloids can replace some existing one and also increase the availability of hydrocolloids. These will aid in reduction of post-harvest losses or waste of these tuber crops, and enhance sustainable development geared towards income generation for both farmers and consumers in Nigeria

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