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AFRICAN STAR APPLE (*CHRYSOPHYLLUM AFRICANUM*) GUM AND ITS OXIDIZED DERIVATIVES AS STABILIZER FOR WATER MELON JUICE

J. M. Nwaedozie D. G. Adekanmi M. D. Faruruwa & A. E. Olowofoyeku

Department of Chemistry, Nigerian Defence Academy, Kaduna, Nigeria.

ABSTRACT: *The gum obtained from the pulp of Chrysophyllum africanum is highly insoluble. Chemical oxidation through hydrogen peroxide was used to degrade the gum. Physicochemical properties of the native and oxidized gums were determined while Fourier transform Infrared spectroscopy was used to study functional group changes. The amount of recovered gum reduced as the degree of oxidation increased and there was increase in the carboxyl content to a maximum of 57.06 %. Lower moisture content and high ash content were recorded for the oxidized gums. The oxidized gums were more soluble than the native gum. Viscosity reduced as the degree of oxidation increased. The maximum viscosity of the oxidized gum at 1% concentration was 2.385 mP.a.s. Maximum juice clarity and viscosity at 1% gum concentration were 81.56% and 2.974 mPa.s respectively. Oxidation improved the stability of water mellon juice over the storage period and therefore the potentials of the gum as stabilizer in drinks.*

KEYWORDS: African Star apple, *Chrysophyllum africanum*, Gums, Oxidation, physicochemical properties

INTRODUCTION

Food additives are materials included in food formulation to perform specific functions. These functions include colour, sweetening, consistency, bulking, texture modification, viscosity enhancement and preservation. Food additives could be natural, semi-synthetic or synthetic (Mepham, 2011). Not less than 2500 food additives have been documented. Some food products especially drinks, juice and suspensions tend to precipitate on storage (Carocho *et al*. 2014). Gums and hydrocolloids of plant origin are common examples of biopolymers that are used as food additives. Gums are used to furnish satisfactory taste and stabilize juice and emulsions. A common semi-synthetic hydrocolloid is carboxymethlcellulose and its average concentration in food formulation is between 0.1 to 0.4%. The quantity of carboxymethlcellulose needed for good stability in drinks and juice is dependent on the soluble solids content and concentration of the juice (Zecher and Van Coillie 1992). Drinks with more insoluble solids such as fruit pulp tend to settle faster and so use gums to increase their dispersibility and turbidity (Akkarachaneeyakorn and Tinrat, 2015). Although gums have soluble and insoluble portions, highly insoluble gums are unusable in food formulations.

Chrysophyllum africanum is of the Sapotaceae family and has the common name African Star Apple. Its order Ericales has eight hundred species with each producing milky latex (Gill, 1988). There are more than three hundred species in west Africa. The tree which grows up to 36 metres produces dark green balls which turn yellow or orange as they ripe (Asare *et al*., 2015). The nutritional value of the fruit includes its richness in vitamin C, pectin and antioxidants (Manganaris *et al*., 2014). It is also known to be rich in minerals especially potassium and magnesium (Adeleye *et al*., 2016; Iheanyichukwu *et al*., 2017). Some authors (Aboaba *et al*., 2006; Amaechi *et al*., 2009; Okoli an Okere, 2010) have reported it as a rich source of anti-inflammatory and anti-hemorrhoidal compounds. Potentials of the seed flour (Akubor *et al*. 2013) and seed oil (Anang *et al*., 2019) have been reported. The seed and pulp gums have been extracted and characterized (Eichie *et al*., 2015; Okoye and Ndiwe, 2016, Bakre and Akinsanya, 2019). The pulp gum is an acidic, mineral rich insoluble gum. While insolubility has been a drawback for the gum in food applications, its compares favourably in drug formulation with gum taragacanth. (Bakre and Akinsanya, 2019).

One of the routes for obtaining polysaccharides with altered properties is chemical modification. Chemical modifications introduce unique properties and can eliminate limitations (Verbeken *et al*., 2003). Through chemical modification, polysaccharides which are useful in drug delivery, texture modification, confectionaries and bakery products, frozen foods, baby foods, salad dressings, textile design, paper finishing and food formulation have been synthesized (Olayinka *et al*., 2015, Afinjuomo *et al*., 2020). Some studies (Olayinka *et al*., 2015; Lovegrove *et al*., 2017) have reported changes in proximate and physicochemical properties of polysaccharides. Oxidation increases the hydrophilicity of gums through depolymerization and addition of carboxylic groups. Reported oxidizing reagents used in modifying gums include hydrogen peroxide, nitrous oxide and NaBr/NaOCl (Kristiansen *et al*., 2010; Duan and Kasper 2011).

This study will oxidize African Star apple (*Chrysophullum africanum*) gum and characterize it, then establish the effect of the gum and its oxidized derivative on water mellon juice stability when stored at ambient temperature. The water melon juice test was carried out to investigate the applicability of the gum and its derivatives in liquid food systems.

MATERIALS AND METHODS

Sample Collection

Ripe African Star Apple fruits were obtained from three local markets within Kaduna metropolis (Station Market, Kakuri Market and Kawo Market), Kaduna state, Nigeria. They were authenticated by a botanist in the Biology department of Kaduna State

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University. The fruits were rinsed in flowing water to remove the soil and attached leaves. Composite samples were obtained by mixing equal weights of the pulp after removing the skin of the fruits (Ayorinde *et al*., 2018).

Extraction and Purification of the gum

The wet pulp of African Star apple (*Chrysophyllum africanum*) fruits were soaked in distilled deionized water for three days, after which the solution was sieved with fine muslin sieve. Ethanol in the ratio 3:1 was added to the solution obtained from the sieving to precipitate the gum. The gum was thereafter washed with acetone and dried at 40 ºC (Ayorinde *et al*., 2018). The yield of the gum was determined relative to the mass of the fruit as represented in Equation 1.

$$\%\ \text{Yield} = \frac{\text{Weight of native gum}}{\text{Weight of African Star apple fruit used}} \times 100\% \qquad (1)$$

Oxidation of gum

Oxidized African Star apple gum was prepared using the method of Lu *et al*. (2019). In brief, 10 ml of concentrated hydrogen peroxide was added to 10% gum solution in a 250 ml beaker. The beaker and its contents were placed in a water bath preheated to 60 ºC for 4 hours and the contents of the beaker were stirred at 20 minutes interval. The oxidized gum was precipitated with ethanol and washed with acetone. The procedure was repeated with 20, 30, 40 and 50 ml of hydrogen peroxide. The effect of temperature on the modification was studied by using 30 ml of the oxidizing reagent at room temperature (RT) 70 and 80 ºC respectively. All modifications were carried out in triplicates. The yield of the modified gum was obtained are represented in the equation (2). The samples were labelled OX 60 1, OX 60 2, OX 60 3, OX 60 4, OX 60 5, OX RT and OX 80 respectively.

$$\%\ \text{Yield} = \frac{\text{Dry weight of modified gum}}{\text{Dry weight of native gum used}} \times 100\% \qquad (2)$$

Physicochemical properties

The proximate properties (moisture content, ash content, fat and crude fibre) of the gum unmodified and oxidized gums were determined with the AACC (2000) method. The carr's index also known as the compressibility index was gravimetrically determined (equation 3) while the Hausner ratio was calculated using equation 4.

$$\text{Carr's Index} = \frac{\text{Bulk density} - \text{Tapped dnsity}}{\text{Bulk density}} \times 100\% \qquad (3)$$

$$\text{Hausner ratio} = \frac{\text{Tapped dnsity}}{\text{Bulk density}} \qquad (4)$$

Oil binding capacity and water bunding capacity were determined using the method of Afolabi and Adekanmi (2017). The gum samples were digested and concentration of nine

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elements were determined using atomic absorption spectroscopy (Sodium, Magnesium, Calcium, Manganese, Lead, Nickel, Iron, Zinc and Aluminium)

Determination of Carboxyl Percentage

The carboxyl content was determined by the method of Lu *et al*. (2019). 0.045 g each of the gums were dissolved in 30 ml water and 10 ml of 0.1 M calcium acetate was added. After stirring for 1 h the liquid was titrated with 0.01 M NaOH. The carboxyl content was calculated using Equation 5.

$$\text{Carboxyl } \% = \frac{(\text{Vol of sample} - \text{Vol of blank}) \times 0.01 \times 45}{0.045} \times 100\% \qquad (5)$$

where Vol of sample and Vol of blank represent the volume of NaOH solution used for the oxidized gums and native gum respectively and 45 is the molecular weight of the carboxyl group.

Fourier Transformation Infrared Spectroscopy (FTIR)

0.2 g of each gum sample powder and 1.8 g of KBr were place in a mortar and crushed till homogenous. The homogenous powder was put in the pelletizer, closed and pressed to make a pellet which was used for the analysis. The pellet obtained was inserted into the FTIR machine and the analysis was run. The absorbance spectra were acquired over a range of 400 - 4000 cm-1 using detector.

Solubility test

1 g was taken from each sample of unmodified and modified gums and dissolved in 100 ml of acetone for 4 hours. The gum was physically observed for dissolution and reported. The same procedure was repeated for ethanol, chloroform, 5% HCl, 5% KOH, 5% NaCl and 5% H_2SO_4 (Afinjuomo *et al*., 2020).

Inotropic gelation

1 g was taken from each sample of unmodified and modified gums and dispersed in 100 ml of deionized water at room temperature in triplicates. The solutions were heated at 90 ◦C in water bath to aid dissolution. Then 1, 3 and 5 g of $CaCl_2$ were added to the gum solutions above separately and stirred with a glass rod until completely dissolved. The mixtures were cooled and observed for gel formation (Lu *et al*., 2019).

Viscosity of the gums

Viscosity of 0.5 and 1 % gum solutions were determined at room temperature using the Brookefield viscometer (100 RPM, spindle number 4) (Senthil and Sripreethi, 2011). Flowrate of each gum solution was carried out using a 5 ml pipette and a stopwatch. The flowrates were calculated from equation 6.

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$$\text{Flowrate} = \frac{\text{5 mLs of gum solution}}{\text{time taken to empty the pipette}} \qquad (6)$$

Juice preparation and stabilization

The method of Akkarachaneeyakorn and Tinrat, (2015) was adopted with some modifications. Single strength watermelon juice was prepared from Unblemished water melon fruits. The pulp was blended and the juice was strained using a fine muslin cloth. 0.25, 0.50 and 1 % of the gum-juice solutions were prepared for the unmodified and modified gums. These solutions were blended separately for three minutes. The physical characteristics of the solutions were observed while clarity, redispersability and viscosity were measured and recorded. The clarity of the solution was measured over four weeks by measuring the absorbance of the supernatant using a UV-Visible spectrophotometer at 600 nm. Clarity is indicated by low absorbance values (Afolabi and Adekanmi, 2017). Viscosity and flowrates were also measured.

RESULTS AND DISCUSSION

Discussion

The colour of the native African Star apple gum is brown and a yield of 10.25% was obtained on dry weight basis. Oxidation of the gums resulted in brighter shades of brown as the degree of oxidation increased (Figure 1). Oxidation is accompanied by depolymerization which resulted in reduced yield of oxidized gum recovered as the concentration of the oxidant and reaction temperature increased (Wu *et al*., 2017; Lu *et al*., 2019).

Figure 1: Physical appearance of native and modified African Star apple gum

Proximate and physicochemical properties

Pharmacopeia limit for moisture content in natural gums is ≤ 15.0 % (Rowe *et al*. 2006) while 20.0 % is that prescribed by FAO (1990). Both accommodate the moisture contents of the native and modified gums. While high moisture content is not desirable for additives

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used in food formulation, it is a plus when incorporating the gum as a disintegrant or in bioadhesive (Emeje *et al*., 2009). This makes the gums good alternatives in food and bioadhesive formulations. Generally, higher carbonyl contents increase the propensity of gums for trapping of water through hydrogen bonding (Singh *et al*., 2009). Hydrogen peroxide has been used for oxidative degradation of gums of some viscous or insoluble gums (Wu *et al*. 2017; Lu *et al*, 2019). It was observed that the degree of depolymerization in the oxidized gum had a negative impact on intramolecular hydrogen bonding resulting in its lower moisture content (Wu *et al*., 2017).

The inorganic content of gums left after combustion also known as the ash content measures the residual mineral deposit in living systems on consumption (Ohwoavworhua and Adelakun, 2005). The ash contents of the native and oxidized gums are slightly above the limit of 4.0 % specified for Pharmaceutical and food quality acacia gum and gum tragacanth (Mhinzi, 2003; Rowe *et al*., 2006). The high ash content in the oxidized gum was attributed to the oxidant used (Olayinka *et al*., 2015). The high ash value was corroborated by the rich mineral content of the oxidized gum increased as the degree of oxidation increased. The crude fibre reduced as the degree of depolymerization of the gum increased. Carbohydrate rich gums such as the African Star apple gum are useful in preventing flocculation and merger of oil droplets in water-oil systems. (Patridge *et al*., 2019). However, the carbon content of the oxidized gums decreased due to the reduction of the polymer chain length through degradation.

Table 1: Proximate composition of native and oxidized African Star apple

S/N	PARAMETERS	NATIVE	OX 60 5
1.	Moisture content (%)	13.75 ± 0.02	12.76 ± 0.01
2.	Ash content (g/100g)	5.29 ± 0.02	5.89 ± 0.03
3.	Crude fiber (g/100g)	6.21 ± 0.01	6.01 ± 0.02
4.	Ether extract (g/100g)	9.03 ± 0.01	11.01 ± 0.02
5.	Crude protein (g/100g)	12.72 ± 0.04	13.14 ± 0.02
6.	Carbohydrates (g/100g)	53.00 ± 0.07	51.19 ± 0.03

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Table 2: Elemental composition of native and oxidized African Star apple gums

S/N	PARAMETERS	NATIVE	OX 1	OX 3	OX 5
1.	Carbon (%)	39.64	40.30	39.89	39.55
2.	Phosphorus (%)	4.46	4.79	4.70	4.61
3.	Sulphur (%)	4.74	3.68	3.58	3.46
4.	Iron (ppm)	1.9698	3.2318	3.3016	3.4216
5.	Manganese (ppm)	0.1330	0.1500	0.1512	0.1530
6.	Nickel (ppm)	0.1840	0.0858	0.1055	0.1272
7.	Copper (ppm)	0.1206	0.8202	0.5534	0.2468
8.	Zinc (ppm)	0.2024	0.2536	0.2995	0.3656
9.	Potassium (ppm)	260.9970	90.7558	93.2565	93.3984
10.	Sodium (ppm)	6.2986	7.1120	7.2019	7.5080
11.	Calcium (ppm)	28.6170	28.6724	32.4584	37.4172
12.	Magnesium (ppm)	12.7182	12.7688	12.8125	13.1506
13.	Aluminium (ppm)	<1	<1	<1	<1
14.	Lead (ppm)	<1	<1	<1	<1

Carboxyl content of the oxidized gums increased as the concentration of oxidant and the reaction temperature increased (Hongbo *et al*., 2015; Lu *et al*., 2019). Increase in carboxyl content led to a decrease in insoluble gel. The carboxyl groups being bulkier than hydroxyl group prevent close packing of the molecular chains. With this increase in disorder and hydrophilic nature of the carboxyl group, the gums become more soluble (Olayinka *et al*., 2015). Water absorption capacity of gums is vital to their stabilization of solutions and the release of active ingredient of drugs (Adedokun *et al*., 2014). This property is linked to the presence of proteins which have large number of hydrophilic sites (Yeh *et al*., 2005). While Paiva *et al*. (2016) reported swelling culminating in gel formation for oxidized xanthan gum, no gel was formed by the oxidized gums in this study although the oxidized gums showed better water absorption capacity with increase in degree of oxidation.

Table 3: The physicochemical properties of native and oxidized African Star apple gum.

Sample	NATIVE	OX 60 1	OX 60 2	OX 60 3	OX 60 4	OX 60 5	OX RT	OX 70	OX 80
Percentage Yield	10.25 ± 0.12	67.33 ± 0.25	66.05 ± 0.10	64.67 ± 0.15	68.22 ± 0.24	68.01 ± 0.02	58.67 ± 0.05	66.56 ± 0.10	50.66 ± 0.12
Carboxyl content (%)		36.03 ± 0.02	42.35 ± 0.02	49.04 ± 0.04	54.06 ± 0.02	57.06 ± 0.01	48.04 ± 0.05	55.05 ± 0.04	56.05 ± 0.02
Water Binding Capacity (g)	8.58 ± 0.05	9.80 ± 0.01	12.35 ± 0.05	13.82 ± 0.02	14.05 ± 0.03	15.22 ± 0.05	12.54 ± 0.12	13.84 ± 0.02	14.33 ± 0.07
Oil Binding Capacity (g)	6.83 ± 0.03	6.88 ± 0.02	6.91 ± 0.01	6.95 ± 0.01	6.99 ± 0.03	7.05 ± 0.00	6.88 ± 0.12	6.97 ± 0.11	7.01 ± 0.06
Cold water insoluble gel (%)	54.61 ± 0.07	52.04 ± 0.05	51.25 ± 0.07	50.40 ± 0.05	49.77 ± 0.01	48.32 ± 0.02	51.01 ± 0.05	49.05 ± 0.05	49.39 ± 0.00
Hot water insoluble gel (%)	36.70 ± 0.02	34.46 ± 0.03	30.60 ± 0.04	28.87 ± 0.01	25.16 ± 0.01	23.22 ± 0.02	29.55 ± 0.04	26.91 ± 0.09	23.70 ± 0.04

Table 4: Solubilities of the native and modified gums in different media at room temperature.

Media	**Native gum**	**Oxidized gums**
Acetone	Insoluble	Insoluble
Ethanol	Insoluble	Insoluble
Chloroform	Insoluble	Insoluble
5 % HCl	Slightly soluble	More soluble
5 % KOH	Slightly soluble	More soluble
5 % NaCl	Slightly soluble	More soluble
5 % H_2SO_4	Slightly soluble	More soluble

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Table 5: Viscosity and flowrate of native and oxidized 0.5 and 1.0 % gum solution.

Sample	0.5% Flowrate (ml/s)	Viscosity (mPa.s)	1.0% Flowrate (ml/s)	Viscosity (mPa.s)
Distilled Water	1.13 ± 0.00	1.205 ± 0.000	1.13 ± 0.00	1.205 ± 0.000
NATIVE	1.07 ± 0.00	1.839 ± 0.003	1.04 ± 0.01	2.607 ± 0.002
OX 60 1	1.07 ± 0.00	1.807 ± 0.000	1.04 ± 0.00	2.558 ± 0.001
OX 60 2	1.07 ± 0.01	1.757 ± 0.000	1.05 ± 0.00	2.495 ± 0.003
OX 60 3	1.07 ± 0.00	1.701 ± 0.002	1.05 ± 0.01	2.461 ± 0.000
OX 60 4	1.07 ± 0.00	1.667 ± 0.001	1.05 ± 0.00	2.410 ± 0.002
OX 60 5	1.07 ± 0.00	1.600 ± 0.001	1.05 ± 0.01	2.385 ± 0.001
OX RT	1.07 ± 0.01	1.766 ± 0.000	1.05 ± 0.00	2.517 ± 0.000
OX 70	1.07 ± 0.00	1.660 ± 0.001	1.05 ± 0.01	2.451 ± 0.003
OX 80	1.07 ± 0.03	1.640 ± 0.001	1.05 ± 0.00	2.397 ± 0.001

Food formulations require gums that are soluble and solubility of polysaccharides is dependent on their structural conformations and crystallinity (Lu *et al*., 2019). The solubility of the oxidized gums in water increased with increase in carboxyl content owing to the increase in intermolecular space and increase in disorder within the molecular conformations (Adeyanju *et al*., 2016, Paiva *et al*., 2016).

FTIR analysis

The FTIR spectra of the gums had characteristic peaks at 3450, 2929, 1740, 1650 and 1069 cm^{-1}. The spectra of the native gum is similar to that obtained by Bakre and Akinsanya (2019), however the peaks obtained in this study were more intense. This was associated with the wet method used to obtain the gum in comparison with the dry method used by the author.

Gums exhibit broad strong absorption for the OH in the region 3500 – 3300 cm^{-1} (Adeyanju *et al*., 2016; Afolabi and Adekanmi, 2017; Ayorinde *et al*., 2018; Lu *et al*., 2019; Bakre and Akinsanya, 2019). The strong peaks at 3450 cm^{-1} (OH region) indicates the gum has an abundance of hydroxyl group (Adeyanju *et al*., 2016; Lu *et al*., 2019). Absorption at 2929 cm^{-1} is also a typical feature of FTIR spectra for gums (Ayorinde *et al*., 2018; Bakre and Akinsanya, 2019; Lu *et al*., 2019) representing the C-H vibrations. For the oxidized gums the peaks in this region were slightly intense as the degree of oxidation increased due to the formation of terminal $-CH_3$ groups through depolymerization (Wu *et al*., 2017). The oxidized gums showed increase in C=O and C-O at around 1740 cm^{-1} and 1069 cm^{-1} respectively (Lu *et al*., 2019; Wu *et al*., 2017) while sharp peaks at 3770 cm^{-1} found in all the gums indicate the presence of amine (NH_2).

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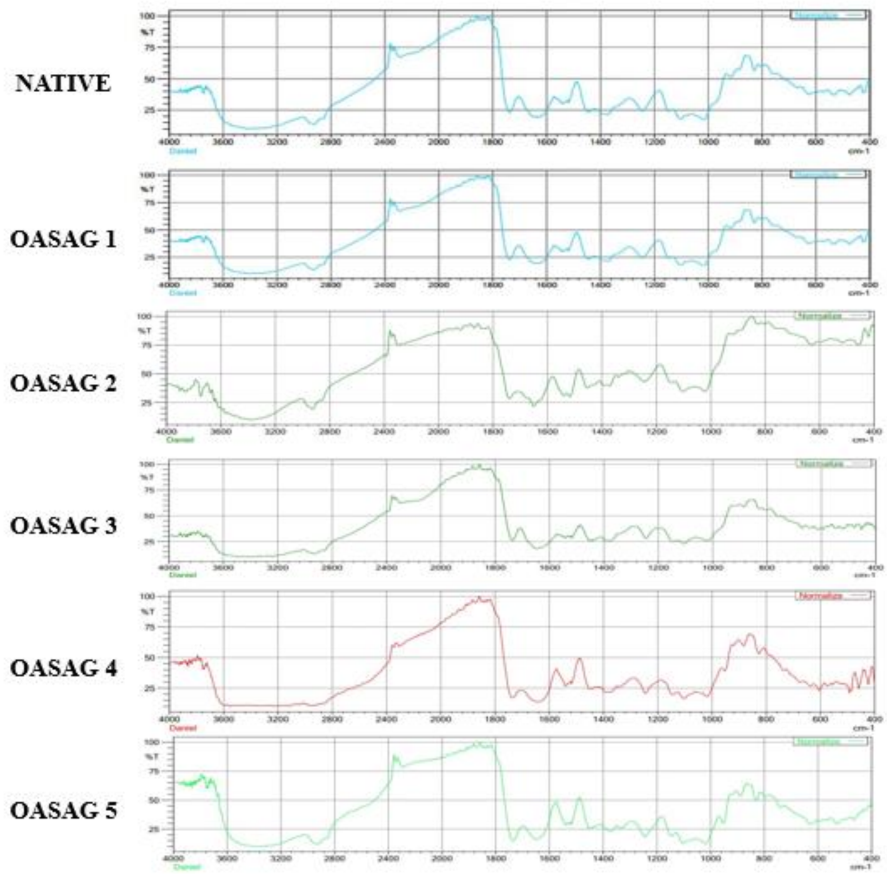

Figure 2: FTIR of the native and oxidized gums.

Viscosity

The viscosity of hydrocolloids is perhaps their most important property. Hydrocolloids exhibit viscosity because of the hydrogen bonding between molecules and within segments of the molecules in solution (Tako *et al*., 2003; Singh *et al*., 2009). The inter twining of the polymer chain sets up a drag resulting in thickness and viscosity. Another factor is branching and pendant groups attached to the backbone of the gum molecules (Akkarachaneeyakorn and Tinrat, 2015). The viscosity of the native gum is lower than that reported for Cashew gum (20.20 mPa.s, Adeyanju *et al*., 2016), *Enterolobium* gum (530.8 mPa.s, Ayorinde *et al*., 2018), Xanthan gum (430 mPa.s, Pinto, 2011) and Gum Arabic (2340 mPa.s, Altuakar *et al*., 2006), but comparable to *Albiza saman* and *Albizia glaberrima* gums (0.78 and 1.11 mPa.s respectively, Afolabi and Adekanmi, 2017). Low viscosity gums are used as emulsifiers in sauces and mayonnaises (Segura-Campos *et al*., 2014). The gums exhibited a non-newtonian behaviour in which the viscosity is directly proportional to the concentration and inversely related to the shear rate. Oxidation of the

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gum resulted in decreased in viscosity due to depolymerization. On the other hand, the flowrate increased as the viscosity of the solution decreased.

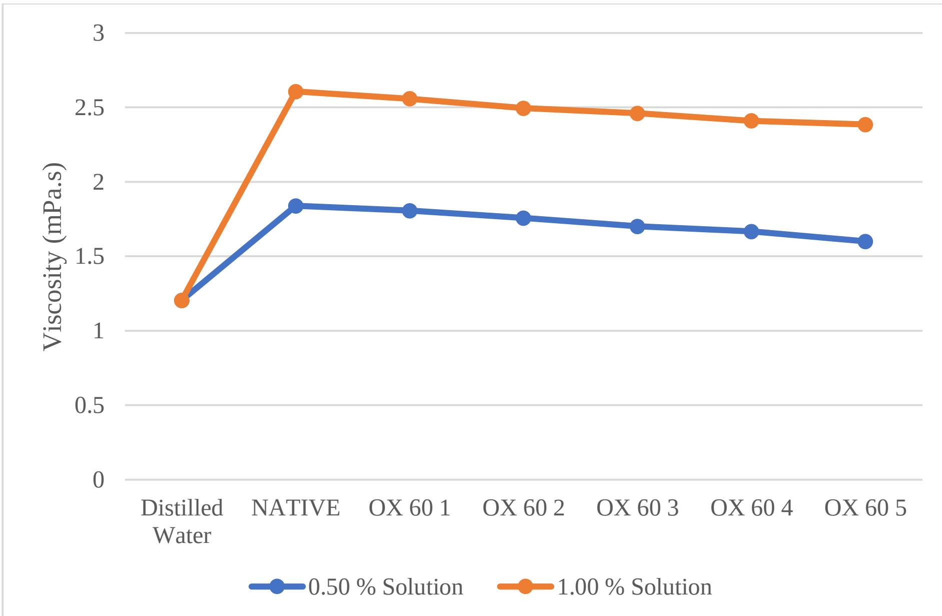

Figure 3: Viscosity of 0.50 and 1.00 % solutions of the native and oxidized gums.

Juice stabilization studies

Popular gums like xanthan gum and gum Arabic have been used to stabilize drinks at up to 0.5% concentration. They are also used as texture modifiers for drinks and other confectionaries at high concentration (Zecher and Van Coillie, 1992). Larson-Powers and Pangborn (2006) and Akkarachaneeyakorn and Tinrat (2015) established increase in viscosity of the juice as gum concentration increased which is in agreement with this study. Viscosity of the juice also decreased as the storage period increased. After six hours of standing, a distinct layer of juice sediments was formed in the pure juice and juice gum solution. While the juice with the native gum had a steady increase in clarity over the storage period (30.23 to 80.05 %), that of the oxidized gums increased with increase in the degree of oxidation due to their coagulating effect.

In the first week, the viscosity and thickening power of the gums increased as the hydration and dissolution of the gums take place. Higher flowability indicated easier pourability. Decrease in juice viscosity was recorded for gums with higher degree of oxidation. At higher concentrations of the gum, the juice had reduced clarity and better stability because of the increase in viscosity which reduced the settling velocity of the juice particles (Akkarachaneeyakorn and Tinrat, 2015). Gums with lower degree of oxidation had stabilizing effect on the juice. The oxidized gums inhibited deterioration in the juice solution which appeared in day 7. This inhibition is attributed to the acidity of the oxidized

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gums (Lu *et al*., 2019). The deterioration reduced clarity in Week 3 and Week 4. No caking was observed for all the gums and the solution was easy to redisperse after the storage period.

Table 6: The effect of various concentration of oxidized African Star Apple gum on the flowrate and viscosity of Water Mellon Juice (Day1).

Sample	0.25 % Flowrate (ml/s)	Viscosity (mPa.s)	0.50 % Flowrate (ml/s)	Viscosity (mPa.s)	1.00 % Flowrate (ml/s)	Viscosity (mPa.s)
WMJ	1.08 ± 0.00	1.319 ± 0.000	1.08 ± 0.00	1.319 ± 0.000	1.08 ± 0.00	1.319 ± 0.000
NATIVE	1.06 ± 0.00	1.962 ± 0.000	1.05 ± 0.01	2.234 ± 0.001	1.03 ± 0.01	2.805 ± 0.001
OX 60 1	1.07 ± 0.02	1.946 ± 0.003	1.06 ± 0.02	2.199 ± 0.002	1.04 ± 0.02	2.790 ± 0.002
OX 60 2	1.07 ± 0.00	1.909 ± 0.000	1.06 ± 0.01	2.169 ± 0.000	1.04 ± 0.00	2.769 ± 0.000
OX 60 3	1.07 ± 0.01	1.864 ± 0.001	1.06 ± 0.01	2.121 ± 0.002	1.04 ± 0.02	2.725 ± 0.003
OX 60 4	1.07 ± 0.00	1.811 ± 0.003	1.06 ± 0.00	2.067 ± 0.000	1.04 ± 0.01	2.695 ± 0.002
OX 60 5	1.07 ± 0.01	1.783 ± 0.002	1.06 ± 0.00	2.015 ± 0.000	1.04 ± 0.01	2.677 ± 0.002
OX RT	1.07 ± 0.00	1.933 ± 0.000	1.06 ± 0.01	2.172 ± 0.000	1.04 ± 0.00	2.775 ± 0.001
OX 70	1.07 ± 0.00	1.802 ± 0.002	1.06 ± 0.00	2.059 ± 0.000	1.04 ± 0.01	2.685 ± 0.001
OX 80	1.07 ± 0.00	1.792 ± 0.001	1.06 ± 0.01	2.025 ± 0.002	1.04 ± 0.01	2.674 ± 0.000

Table 7: The effect of various concentration of oxidized African Star Apple gum on the flowrate and viscosity of Water Mellon Juice (Day7).

Sample	0.25 % Flowrate (ml/s)	Viscosity (mPa.s)	0.50 % Flowrate (ml/s)	Viscosity (mPa.s)	1.00 % Flowrate (ml/s)	Viscosity (mPa.s)
WMJ	1.09 ± 0.00	1.200 ± 0.000	1.09 ± 0.00	1.200 ± 0.000	1.09 ± 0.00	1.200 ± 0.000
NATIVE	1.05 ± 0.00	2.435 ± 0.002	1.05 ± 0.01	2.461 ± 0.001	1.02 ± 0.00	3.115 ± 0.001
OX 60 1	1.05 ± 0.01	2.331 ± 0.002	1.06 ± 0.02	2.389 ± 0.002	1.03 ± 0.01	3.090 ± 0.001
OX 60 2	1.05 ± 0.01	2.295 ± 0.001	1.06 ± 0.01	2.372 ± 0.001	1.03 ± 0.00	3.029 ± 0.000
OX 60 3	1.05 ± 0.01	2.264 ± 0.001	1.06 ± 0.02	2.316 ± 0.002	1.03 ± 0.01	3.005 ± 0.003
OX 60 4	1.05 ± 0.00	2.211 ± 0.001	1.06 ± 0.00	2.278 ± 0.001	1.03 ± 0.00	2.985 ± 0.000
OX 60 5	1.06 ± 0.01	2.190 ± 0.002	1.06 ± 0.01	2.235 ± 0.002	1.03 ± 0.01	2.970 ± 0.002
OX RT	1.05 ± 0.01	2.317 ± 0.000	1.06 ± 0.01	2.372 ± 0.003	1.03 ± 0.02	3.071 ± 0.003
OX 70	1.05 ± 0.00	2.205 ± 0.002	1.06 ± 0.00	2.260 ± 0.000	1.03 ± 0.01	2.977 ± 0.001
OX 80	1.06 ± 0.01	2.199 ± 0.003	1.06 ± 0.01	2.241 ± 0.002	1.03 ± 0.01	2.974 ± 0.002

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Table 8: The effect of various concentration of oxidized African Star Apple gum on the flowrate and viscosity of Water Mellon Juice (Week 2).

Sample	0.25 % Flowrate (ml/s)	Viscosity (mPa.s)	0.50 % Flowrate (ml/s)	Viscosity (mPa.s)	1.00 % Flowrate (ml/s)	Viscosity (mPa.s)
WMJ	1.09 ± 0.00	1.020 ± 0.000	1.09 ± 0.00	1.020 ± 0.000	1.09 ± 0.00	1. 020 ± 0.000
NATIVE	1.05 ± 0.00	2.215 ± 0.002	1.05 ± 0.01	2.300 ± 0.001	1.03 ± 0.00	2.966 ± 0.001
OX 60 1	1.06 ± 0.00	2.144 ± 0.001	1.05 ± 0.01	2.244 ± 0.002	1.03 ± 0.01	2.955 ± 0.002
OX 60 2	1.06 ± 0.00	2.090 ± 0.001	1.05 ± 0.00	2.220 ± 0.001	1.03 ± 0.00	2.869 ± 0.000
OX 60 3	1.06 ± 0.00	2.055 ± 0.001	1.06 ± 0.00	2.176 ± 0.000	1.03 ± 0.01	2.847 ± 0.002
OX 60 4	1.06 ± 0.00	2.033 ± 0.000	1.06 ± 0.001	2.140 ± 0.000	1.03 ± 0.01	2.824 ± 0.002
OX 60 5	1.06 ± 0.01	1.981 ± 0.003	1.06 ± 0.00	2.099 ± 0.001	1.03 ± 0.01	2.809 ± 0.000
OX RT	1.06 ± 0.00	2.110 ± 0.000	1.05 ± 0.01	2.226 ± 0.001	1.03 ± 0.00	2.939 ± 0.001
OX 70	1.06 ± 0.01	2.005 ± 0.001	1.06 ± 0.00	2.115 ± 0.000	1.03 ± 0.01	2.820 ± 0.002
OX 80	1.06 ± 0.00	1.990 ± 0.000	1.06 ± 0.01	2.110 ± 0.002	1.03 ± 0.00	2.813 ± 0.000

Table 9: The effect of various concentration of oxidized African Star Apple gum on the flowrate and viscosity of Water Mellon Juice (Week 3).

Sample	0.25 % Flowrate (ml/s)	Viscosity (mPa.s)	0.50 % Flowrate (ml/s)	Viscosity (mPa.s)	1.00 % Flowrate (ml/s)	Viscosity (mPa.s)
WMJ	1.09 ± 0.00	1.010 ± 0.000	1.09 ± 0.00	1.010 ± 0.000	1.09 ± 0.00	1.010 ± 0.000
NATIVE	1.06 ± 0.00	1.998 ± 0.002	1.06 ± 0.01	2.149 ± 0.001	1.03 ± 0.00	2.826 ± 0.001
OX 60 1	1.06 ± 0.02	1.990 ± 0.001	1.05 ± 0.01	2.100 ± 0.002	1.03 ± 0.01	2.812 ± 0.002
OX 60 2	1.06 ± 0.00	1.965 ± 0.001	1.05 ± 0.00	2.077 ± 0.001	1.03 ± 0.00	2.809 ± 0.000
OX 60 3	1.06 ± 0.01	1.910 ± 0.000	1.06 ± 0.01	2.033 ± 0.002	1.03 ± 0.01	2.739 ± 0.002
OX 60 4	1.06 ± 0.00	1.895 ± 0.000	1.06 ± 0.00	2.000 ± 0.000	1.03 ± 0.01	2.680 ± 0.002
OX 60 5	1.06 ± 0.01	1.841 ± 0.002	1.06 ± 0.00	1.955 ± 0.002	1.03 ± 0.01	2.661 ± 0.001
OX RT	1.06 ± 0.00	1.910 ± 0.000	1.05 ± 0.01	2.076 ± 0.003	1.03 ± 0.01	2.810 ± 0.002
OX 70	1.06 ± 0.01	1.888 ± 0.002	1.06 ± 0.00	1.980 ± 0.000	1.03 ± 0.00	2.675 ± 0.000
OX 80	1.06 ± 0.00	1.820 ± 0.000	1.06 ± 0.01	1.962 ± 0.002	1.03 ± 0.00	2.668 ± 0.001

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Table 10: The effect of various concentration of oxidized African Star Apple gum on the flowrate and viscosity of Water Mellon Juice (Week 4).

Sample	**0.25 % Flowrate (ml/s)**	**Viscosity (mPa.s)**	**0.50 % Flowrate (ml/s)**	**Viscosity (mPa.s)**	**1.00 % Flowrate (ml/s)**	**Viscosity (mPa.s)**
WMJ	1.09 ± 0.00	1.000 ± 0.000	1.09 ± 0.00	1.000 ± 0.000	1.09 ± 0.00	1.000 ± 0.000
NATIVE	1.07 ± 0.00	1.735 ± 0.002	1.06 ± 0.01	2.002 ± 0.001	1.04 ± 0.00	2.633 ± 0.001
OX 60 1	1.07 ± 0.02	1.782 ± 0.001	1.06 ± 0.01	1.938 ± 0.002	1.04 ± 0.01	2.629 ± 0.002
OX 60 2	1.07 ± 0.00	1.771 ± 0.001	1.07 ± 0.01	1.900 ± 0.001	1.04 ± 0.00	2.601 ± 0.000
OX 60 3	1.07 ± 0.01	1.724 ± 0.000	1.07 ± 0.00	1.883 ± 0.002	1.04 ± 0.00	2.549 ± 0.000
OX 60 4	1.07 ± 0.00	1.700 ± 0.000	1.07 ± 0.00	1.850 ± 0.000	1.05 ± 0.00	2.491 ± 0.000
OX 60 5	1.07 ± 0.01	1.656 ± 0.002	1.07 ± 0.00	1.800 ± 0.002	1.05 ± 0.01	2.480 ± 0.001
OX RT	1.07 ± 0.00	1.777 ± 0.000	1.06 ± 0.01	1.919 ± 0.003	1.04 ± 0.01	2.606 ± 0.001
OX 70	1.07 ± 0.01	1.688 ± 0.002	1.07 ± 0.01	1.840 ± 0.000	1.05 ± 0.00	2.477 ± 0.000
OX 80	1.07 ± 0.00	1.662 ± 0.000	1.07 ± 0.01	1.807 ± 0.002	1.05 ± 0.00	2.453 ± 0.001

Table 11: Clarity of Water Mellon Juice supernatant at 1% concentration of oxidized African Star Apple gums.

Sample	**After 6hours**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
WMJ	30.66 ± 0.03	80.90 ± 0.00	81.75 ± 0.00	80.90 ± 0.00	80.05 ± 0.00
NATIVE	30.06 ± 0.01	80.75 ± 0.05	81.45 ± 0.05	79.75 ± 0.05	79.75 ± 0.05
OX 60 1	30.23 ± 0.00	70.44 ± 0.06	72.22 ± 0.06	71.49 ± 0.06	70.00 ± 0.06
OX 60 2	30.97 ± 0.03	70.74 ± 0.11	73.74 ± 0.11	72.74 ± 0.11	70.74 ± 0.11
OX 60 3	50.45 ± 0.01	79.19 ± 0.07	80.30 ± 0.07	80.45 ± 0.07	80.30 ± 0.07
OX 60 4	50.78 ± 0.03	79.26 ± 0.10	80.44 ± 0.10	80.48 ± 0.10	80.26 ± 0.10
OX 60 5	50.86 ± 0.03	79.56 ± 0.10	81.56 ± 0.10	80.56 ± 0.10	80.56 ± 0.10
OX RT	30.65 ± 0.02	70.22 ± 0.01	73.00 ± 0.01	72.02 ± 0.01	72.02 ± 0.01
OX 70	50.81 ± 0.01	79.30 ± 0.05	80.40 ± 0.05	80.25 ± 0.05	80.25 ± 0.05
OX 80	50.83 ± 0.01	79.40 ± 0.07	80.40 ± 0.07	80.25 ± 0.07	80.25 ± 0.07

CONCLUSION

African Star apple (*Chrysophyllum africanum*) gum was extracted from the fruit pulp and oxidized to increase it usability food and drink formulations. Oxidation of African Star apple gum increased its solubility and reduced its viscosity. The percentage yield of the oxidized gum reduced as the degree of oxidation increased. Low degree of oxidation improved the juice stabilizing potentials of the gum. Oxidized African Star apple gum is a mildly viscous soluble gum that can be used in confectionaries and food drinks.

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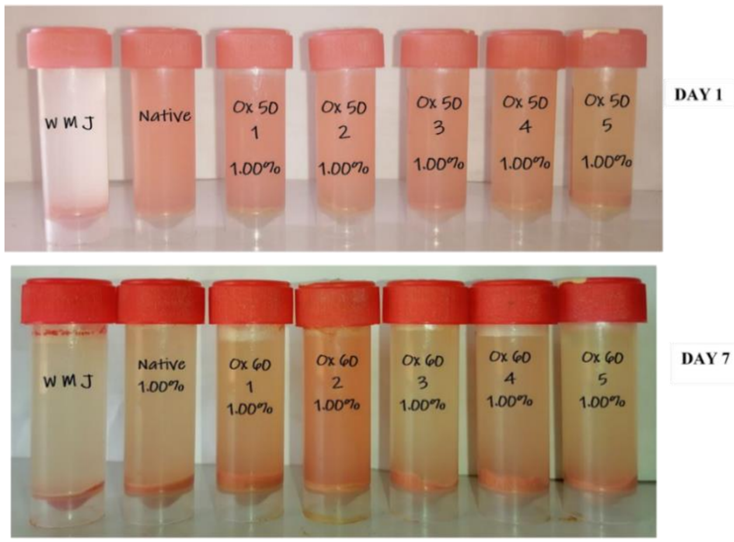

Figure 4: Water Mellon juice test.

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