EXPLORING *IN VITRO* ANTIOXIDANT ACTIVITY AND PHYSICOCHEMICAL PROPERTIES OF SELECTED UNDER-EXPLOITED TROPICAL FRUITS

– Research paper –

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Abstract: *Dacryodes edulis* (DE), *Dalium guineensis* (DG), *Spondias mombin* (SM) and *Irvingia gabonensis* (IG) as notable underexploited tropical wild fruits in Nigeria, were evaluated for quality characteristics, phenolic contents and *in-vitro* antioxidant activity. pH of the fruits ranked thus DE > IG > DG > SM and the reverse order was true for acidity. IG exhibited highest °brix, vitamin C and total sugar content. DE had no detectable reducing sugar compared to 18.84% in IG. Total phenol and flavonoid contents followed the same pattern with DG as the highest (1796.89 ± 71.1 and 860.64 ± 3.7 mg/100g) and IG as the lowest (454.23 ± 13.9 and 304.98 ± 7.5 mg/100g), respectively. Regarding antioxidant activities, SM was significant for ABTS•, DE and IG were similar in FRAP assay, while all the fruits were effective DPPH• radical scavengers. Generally, the fruits demonstrate high food application potentials with possible health benefits if consumed adequately.

Keywords: Underexploited tropical fruits, quality parameters, phenolic contents, *in vitro* antioxidant assays.

INTRODUCTION

Nutritionally, fruit and vegetable occupy the top position of healthy foods and their regular consumption has a range of health benefits. In developing countries, reliance on seasonal availability of fruits due to inadequate storage facilities and postharvest losses lowers adequate consumption of fruit and vegetable (Jolayemi & Adeyeye, 2018). During off-season of most conventional tropical fruits, several undomesticated and agronomically regarded as unexploited wild fruits come handy especially among rural dwellers. These nutrients-packed underutilized fruits are not only known for their nutritional benefits, many of them have been given medicinal status due to their potencies in the treatment of one form of ailment or the other (Ong, Chan, Khoo, Ong, & Sit, 2018). A closer chemical characterization of these fruits showed an array of chemical compounds among which many are capable of inducing nutraceutical effects on consumers

Polyphenols are among several phytonutrients embedded in these wild fruits which explain the links between their consumptions and disease managements. Antioxidant capacity of polyphenol is evidenced in its radical-scavenging ability, reactive-oxygen species quenching and other *in vitro* and *in vivo* redox processes (Pereira et al., 2014). With the new age of “*the natural, the better*”, it becomes noteworthy to explore some of these indigenous fruits for their phenolic contents and *in vitro* antioxidant properties. Among these fruits, *Dacryodes edulis* (african pear), *Dialium guineense* (black velvet tamarind), *Spondias mombin* (hog plum) and *Irvingia gabonensis* (bush mango), are few that are close to being domesticated in Nigeria.

Dacryodes edulis is occasionally referred as to as african bush butter fruits because of the fat content of the fruits. It is native to Central Africa and the Gulf of Guinea (Youmbi, Mbeuyo, Tchinda, & Amougou, 2010). The most economically and nutritionally significant specie under the genus *Dacryodes* is *Dacryodes edulis* meaning “edible”. The main geographical area of this tree is in the south-eastern part of the country where it’s called “ube” and commonly consumed as roasted, boiled

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or an accomplice to roasted corn and other staples. The fruit comes in various shape, texture, size, taste, weight and chemical compositions. The edible portion is made up of 22% oils, 4% protein, 5% carbohydrates and 8.7% dietary fiber. Consumption of decocted part of the *Dacryodes edulis* alone or in conjunction with other locally sourced herbs has been traditionally attributed to several therapeutic effects and some of those assertions were further corroborated with scientific facts. An extract of the leaves and other plant leaves was found to lower blood sugar and hypertension (Erukainure, Mopuri, Oyeboode, & Koorbanally, 2017). Similarly, enough intake of the fruit has been medically implicated in correcting visual impairment in diabetic patients. Other studies have shown *in vivo* and *in vitro* antioxidant and inhibitory effectiveness of the fruit's polyphenols against several digestive enzymes (Oboh, Ademosun, Olasehinde, & Oyeleye, 2014). These functional properties of the plant have been attributed to its polyphenolic compounds. However, there are no studies about individual phenolic distribution in *Dacryodes edulis*. *Dialium guineense* is another highly nutritious underutilized tropical fruits. There are several trees belonging to this genus and the most common ones are *Dialium guineense*; *Dialium indum*, and *Dialium cochinchinense* (Lasekan & See, 2015). *Dialium guineense* is a shrub of the family *Leguminosae* (Olajubu, Akpan, Ojo, & Oluwalana, 2012). Several studies have been devoted to the chemical evaluation and nutritional values of *D. guineense* including its medicinal application and volatile properties (Lasekan & See, 2015). A mature *D. guineense* fruit appears as brownish to black shell. The shell houses a brownish yellow edible pulp with an embedded seed. The pulp and other components of the fruits have found usage in traditional medicine for therapeutic purpose. The fruit is seasonally cherished mainly due to its pleasant organoleptic characteristics. There is an overwhelming upsurge in demand for natural food and other nutritionally driven quest in recent time. However, nutritional and health-related information on *D. guineense* includes antimicrobial properties of its extract (Okeke, Udeani, & Onyebuchi, 2016), partial prevention of drug-induced oxidative stress and anti-plasmodial effects (Ogbe et al., 2019). In addition to a rich source of vitamin C, fibres, sugars, acids, polysaccharides, small amount of protein, lipids, *D. guineense* possess some plant secondary metabolites that are probably responsible for most of the nutraceutical properties associated with the consumption of the fruit.

Spondias mombin among the underexploited tropical fruits, has more information on its nutritional, organoleptic, and nutraceutical properties compare to others. Bioactive compounds in hog plum have been characterized to include phenols, sterols, triterpenes, saponins, essential oils, amino acids and polysaccharides (Sameh, Alsayed, Labib, & Singab, 2018). Among the most abundant phenolic compounds in *S. mombin* are rutin, ellagic acid and quercetin with their intrinsic antiviral capacity and ability to manage chronic gastrointestinal disorders (Brito et al., 2018; Neiens, Geißlitz, & Steinhaus, 2017). Juice extracted from hog plum competed closely with pure vitamin C in antioxidative and hepatoprotective properties (Sabiou et al., 2016). Other competitive benefits of the fruits include an array number of aromatic compounds of butanoate and acetate derivatives, mineral and pigment compounds higher than most commercial tropical fruits such as pineapple and passion fruits.

Irvingia gabonensis is another traditionally essential fruit known as oro or oba in Nigeria, bobo in Sierra Leone, andok in Cameroon, boboru or wanini in Ivory Coast and meba or mueba in Zaire (Olayiwola et al., 2013). Applications of its fleshy mesocarp in the treatment of gastrointestinal disorder and infection have been well documented (Ekpe et al., 2019). Stringy, gum-like and high-flavored soup can be prepared from the dried, milled and oil-rich two-cotyledon seed called dikanuts, ogbono, apon, and kuwing in different regions of Nigeria. Methanolic extract of the fruit has been used in the treatment of bacterial and fungal infections (Arogba & Omede, 2012). In recent years, novel *Irvingia gabonensis* herbal weight loss dietary supplement appeared in the market (Sun & Chen, 2012). The study further identified over 40 phenolic compounds which include ellagic and flavonoid derivatives. *Irvingia gabonensis* seed extract was significant in inhibiting adipogenesis in adipocytes – an enzyme-mediated process of managing obesity (Oben, Ngondi, & Blum, 2008).

Indeed, studies have been done on the nutritional, health benefits and overall food potential of the individual fruit. However, a comparative exploration of these four undomesticated tropical fruits has not been found in literature. This informs the objective of this study, which was to characterize the fruits regarding their quality parameters, total phenolics and *in vitro* antioxidant capacities. This study is an extension of the existing information; that could aid commercial production and eventual domestication of these essential fruits.

MATERIALS AND METHODS

Fresh fruits and pretreatments: *Dacryodes edulis* was collected at National Centre for Genetic Resources and Biotechnology, (NACGRAB) farm, Moore Plantation, Ibadan, Oyo State. Mature *Spondias mombin* were harvested at research farm of the Federal University of Technology, Akure (FUTA). *Dalium guineense* and *Irvingia gabonenses* were purchased in Ketu Market located in Lagos state. Prior to polyphenolic extractions, the fruits were prepared according to the most common way of consumption. Thus, uniformly ripened and approximately homogenous *D. edulis* were thoroughly washed, the seeds were removed, and the pulp vacuum sealed. In the case of *S. mombin*, and *I. gabonenses* the skins and seeds were removed, and pulp vacuum packed. *D. guineense* were carefully cracked, deseeded and the pulp was vacuum sealed. All samples were stored at 4 °C until analyzed.

Analytical reagents: Analytical reagents were of HPLC grades. Commercial phenolic standards - gallic acid, was a product of Fluka (Germany) and quercetin was obtained from Extrasynthese (France). Methanol, ethanol, hexane, ABTS and DPPH radicals were purchased from Riedel-deHaen (Germany) and FRAP was a Sigma-Aldrich (Germany) product. Double distilled was used in the standards preparation.

pH, titratable acidity, and total soluble solid (°Brix): The pH of homogenized fruits pulps was determined with a Digital Handheld Thermal Orion 868 pH meter (Thermo Fisher Scientific, Inc., Massachusetts, USA) at room temperature. A prior calibration of the meter was performed by a differential method in which two buffer solutions at pH 4.0 and 7.0, respectively (Zhou, Wang, Hu, Wu, & Liao, 2009). The acidity of the fruit extracts was determined by titrating 10 mL of the juice against a standard NaOH (0.02 mol/L) using phenolphthalein as indicator. The titre value (volume of NaOH) was expressed in mg citric acid/L extract, while total soluble solid was measured using a hand refractometer (Erma, Japan) at 20 °C (Wang, Hu, Chen, Wu, Zhang, Liao, & Wang, 2006).

Vitamin C contents of the fruits: Standard dye solution of indophenol was used in the quantitative determination of vitamin C contents of the juice extracts following the method described in AOAC (2000). The diluted sample (50 ml) was pipetted into 100 ml volumetric flask and 25 ml of 20 %

metaphosphoric acid was added as stabilizing agent and made up to mark. The solution (10 ml) was dispensed into a small flask and 2.5 ml of acetone was added and titrated with the indophenol solution until a faint pink color persist for 15 s and vitamin C contents of the samples were recorded as mg/100g according to the equation thus.

$$\frac{\text{Ascorbic acid (mg/100g)}}{\frac{\text{Titre value} \times \text{Dye factor} \times \text{volume (100ml)}}{\text{aliquot of extract} \times \text{sample weight}}} \times 100 =$$

Total and reducing sugar quantification: The method of Ranganna (1995) was used to estimate total and reducing sugar content of the fruits. Briefly, 50g of crushed fruit pulp was made up to 250 ml with distilled water, 2 mL lead acetate solution was added, mixed thoroughly, and kept for 10 minutes excess of lead was removed with potassium oxalate and the mixture was filtered. The filtrate was used in total and reducing sugar determination. Initially, Fehling reagents consisting of two solutions A (7% CUSO₄) and B (25% KOH and 35% sodium potassium tartarate) were mixed in equal amounts to obtain a clear blue solution (tartarate soluble complex with copper hydroxide). In addition, milligram of invert sugar was determined by titrating hydrolyzed standard solution of sucrose with Fehling solution using methylene blue as indicator.

Factor for Fehling's solution (mg of invert sugar) = Titre x 2.5

For total sugar, about 50 mL of extract was hydrolyzed overnight at room temperature with 1 mL concentrated HCl. The mixture was neutralized by NaOH and phenolphthalein as indicator, made up to 100 mL with distilled water and titrated against Fehling's A and B mixture. Total sugar was calculated thus:

$$\text{Total sugar (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution factor}}{\text{titre (after inversion)} \times \text{weight of sample}} \times 100$$

Reducing sugar was determined by titrating sugar extract against 10 mL of boiling Fehling's solution using same indicator. Appearance of brick red precipitates marks the end point:

$$\text{Reducing sugar (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution factor}}{\text{titre (after inversion)} \times \text{weight of sample} \times 1000} \times 100$$

Polyphenol extraction: Extraction of polyphenolic compounds from the fruits were carried out according to the liquid-liquid method proposed by (Loizzo et al., 2019.), modified as follows - 10 g of the fruit pulp was homogenized

with 20 mL absolute ethanol for 48 h at room temperature. The mixture was filtered (Whatman filter paper #4) and the residue was re-extracted with 20 mL of absolute ethanol. The filtrates were combined and washed with 10 mL of n-hexane to remove fat residue in the case of *D. edulis* fruit. The mixture was separated in a separating funnel and ethanolic mixture was submitted for vacuum evaporator (Buchi R-300, Milan, Italy) at 45 °C to dryness. The residue was dissolved in 10 mL of methanol/water (70/30) mixture, microfiltered (nylon filters 0.20 µm) into an amber colored vial and kept at 4 °C for phenolic characterization and antioxidant assays.

Total phenol content (TPC) determination:

Total phenol contents of the fruits were determined according to Folin-Ciocalteu reagent as described by (Vernon, Rudolf, & Rosa, 1999). Briefly, absorbances of the blue coloration obtained when methanolic (MeOH/H₂O; 70/30) extract of the sample and Folin-Ciocalteu reagent reacted, was measured spectroscopically (spectrophotometer V-650, Jasco, Easton, Maryland) at 750 nm. TPC results were expressed as mg gallic acid equivalent/100g of fruits.

Total flavonoid content (TFC) determination:

Flavonoid content was determined by mixing appropriate dilution of the extract with equal volume of 2% AlCl₃ in methanol solution (5% acetic acid in methanol). The mixture was incubated for 10 min and the absorbance of resultant solution was taken at 430 nm. TFC results were expressed as mg quercetin equivalent/100g of fruits.

ABTS radical scavenging assay: Antioxidant capacities of the fruits were measured by ABTS (2,2'-azino-bis-[3-ethylbenzothiazoline-6-sulfonic acid]) radical scavenging activities of methanolic extracts, according to a modified method of

Sarabandi, Sadeghi Mahoonak, Hamishekar, Ghorbani, & Jafari, (2018). Ethanolic solution of ABTS+ radical was adjusted to 0.70 ± 0.02 absorbance at 734 nm. When the right absorbance was reached, 1900 µL of this solution were added to 100 µL of fruit extract in plastic tubes, vortexed and equilibrated at 25°C for exactly 8 min. The absorbance of the mixture was read against pure ethanol as blank at 734nm. ABTS+ radical scavenging activities of the samples were expressed as µmol Trolox Equivalent/g of the fruits.

DPPH radical scavenging assay: The assay was performed according to Brand-Williams, Cuvelier, & Berset, (1995). Briefly, methanolic DPPH (1,1-diphenyl-2-picrylhydrazyl radical) solution was prepared and absorbance adjusted to 0.67 ± 0.02 at 517 nm. To the 100 µL of sample phenolic extract, 1900 µL of DPPH solution were added, vortexed and incubated at 25°C for exactly 30 min. The absorbance reaction mixture was read at 517 nm. DPPH radical scavenging activities of the samples were expressed as µmol Trolox equivalent/g of the fruit.

Ferric Reducing Antioxidant Power (FRAP) assay: Freshly prepared FRAP reagent (1900 µl) was mixed with 100 µl fruits extract at incubating temperature of 37 °C according to (Pulido, Bravo, & Saura-calixto, 2000) procedure. After 30 min incubation of the test samples, absorbance readings were taken immediately at 593 nm using a spectrophotometer. The reducing power of the fruits were expressed as µmol Trolox equivalent/g of the fruit.

Statistical Data Analysis: Minitab Statistical Package (Minitab 16.0, Minitab Inc., State College, USA) was used to determine one-way analysis of variance (ANOVA) of the data at 95% confidence level. Three replicates results of each parameter were compared between different fruits by least significance difference (LSD).

RESULTS AND DISCUSSION

Physicochemical properties

Figure 1 shows the physical appearance of the fruits and Table 1; the primary quality properties that could influence the food application potential of the fruits. pH, titratable acidity and total soluble solid (°Brix) constitute intrinsic quality attributes that could influence consumers' acceptability of the fruits (Jolayemi, 2019). There was no significant different between DE and IG with

respect to pH. SM was the most acidic as reflected in the low pH (2.95 ± 0.1) and significantly high percent acidity (1.13 ± 0.1). DG also was very acidic and have statistically similar total soluble solid content with SM. DE exhibited lowest soluble solid (8.87 ± 0.2). A reasonably high total soluble solid may be desirable for aesthetic purpose. IG have fleshier mesocarp than other fruits considered, yet similar soluble solid as DG and SM. Study have shown that the fleshy mesocarp of IG contains considerable amount of dietary fibre (Sun & Chen, 2012), thus lowering its

solubility. Natural physiological differences between these tropical fruits explain to a large extent; the variations in their physicochemical properties. For example, respiration – an important metabolic process which may utilize organic acids and other substrates during fruit ripening, can lead to a change in pH, acidity and total solid content (Wijewardane & Guleria, 2013).

Ascorbic acid is a nutritionally important water-soluble vitamin and one of many parameters that determine the eating quality of fresh fruits and vegetables. The disparity between vitamin C contents of the fruits is more pronounced than other physicochemical properties. IG exhibited significantly more vitamin C than other fruits. The vitamin C content of IG (64.12 ± 2.7 mg/100g) is more than four times that of DE and SM, almost twice of DG. The fruits with the lowest vitamin C contents (DE) can approximately account for close to 80% of the recommended nutrient intake requirement for adults and about 50% that of lactating women. These populations constitute the most vulnerable to vitamin C inadequacy (FAO &

WHO, 2004). Therefore, these underutilized fruits are nutritionally packed enough to sustain basic daily micronutrient demand of human, especially during off-season of most conventional fruits. Similarly, vitamin C contributes to the antioxidant properties of fruits and vegetables and sometimes causes overestimation of phenolic compounds. Sugar is an important feature of table fruits serving as indicator for freshness and market value (Wu, Gao, Guo, Yu, & Wang, 2012). In the present work, total and reducing sugars found in the selected tropical fruits were significantly different from each other. Table 1 shows that IG had the highest total and reducing sugars at 33.37 ± 4 , and 18.84 ± 1.0 , respectively which further corroborates its °brix level. About 50% of the sugar content is composed of reducing sugar. On the other hand, DE has a very low total sugar content (3.88 ± 0.4), and no detectable reducing sugar; as the fruit is not peculiarly known for sweet taste but rather; its buttery mouth feel. DG shows higher total and reducing sugar than SM; which is particularly known for its acidity (Adepoju, 2009).

Figure 1. Physical appearance of the selected tropical wild fruits: *Dacryodes edulis* (A), *Dialium guineense* (B), *Spondias mombin* (C) and *Irvingia gabonensis* (D) fruits

Table 1 Quality characteristics of underutilized tropical fruits

Parameters	DE	DG	SM	IG
pH	6.03 ± 0.07^a	3.45 ± 0.07^b	2.95 ± 0.12^c	5.86 ± 0.20^a
Acidity (%)	0.12 ± 0.01^d	0.46 ± 0.04^b	1.13 ± 0.06^a	0.24 ± 0.02^c
°Brix	8.87 ± 0.23^c	11.49 ± 0.48^b	11.48 ± 1.51^b	20.43 ± 0.39^a
Vitamin C (mg/100g)	14.11 ± 0.34^c	32.48 ± 2.42^b	14.35 ± 0.58^c	64.12 ± 2.69^a
Total sugar (%)	3.88 ± 0.37^d	8.08 ± 0.13^b	5.94 ± 0.28^c	33.37 ± 4.01^a
Reducing sugar (%)	ND	7.64 ± 0.13^b	5.15 ± 0.10^c	18.84 ± 1.02^a

DE: *Dacryodes edulis*; DG: *Dialium guineense*; SM: *Spondias mombin*; IG: *Irvingia gabonensis*.

ND: not detected

^{a-d}Mean $\pm$ standard deviation values having different superscript letters across the row are significantly different ($P < 0.05$).

Total phenolic and flavonoid contents

Figure 2 shows the difference between the fruits with respect to total phenol and total flavonoid contents. *Dacryodes edulis* (DE) had an average of 991 ± 11.07 mg/100g total phenol content, which is about half of the value obtained for *Dialium guineense* (DG) (1796.89 ± 71.11 mg/100g). *Spondias mombin* (SM) exhibited TPC of 595.65 ± 6.22 mg/100g, while *Irvingia gabonensis* (IG) was the lowest among the fruits. Compare to some other tropical fruits, *Spondias mombin* was characterized with low phenolic compounds (249 mg/100g) (de Carvalho et al., 2015). The fruits are genetically different and thus synthesize secondary metabolites at varying degree. Also, solvent polarities relative to the phenolic compounds present in the fruits, affect the quantity of extractable phenols. For instance, DE has significant amounts of oils (value not reported), therefore, in order to recover lipidic phenolic compounds entrapped within the oil matrices, selection of appropriate solvent becomes a necessity. Other factors influencing the total phenol content of the fruit is the presence or absence of non-phenolic antioxidant compounds that can reduce Folin-Ciocalteu thus leading to over or underestimation of TPC. As described by (Ikram et al., 2009), ascorbic acid, and some lipophilic active reducing agents common in fruits and vegetables can lead to overappraisal of total phenol contents. Nevertheless, the recorded TPC for these fruits are comparatively high enough to effect useful physiological benefits when consumed in reasonable amounts. SM and IG exhibited higher TPC contents than those of Olayiwola et al., (2013) who reported 367.36 ± 9.53 and 382.20 ± 24.37 mg/100g, respectively.

Although the total phenol content of SM and IG are less than those of DE and DG, but higher than many other common fruits like guava, strawberry, pineapple, soursop and passion fruits (Kuskoski et al., 2006). In DE fruit, our observed TPC was lower than that those reported by Ononamadu et al., (2019) using different solvent extraction methods on *Dacryodes edulis* leaves ($29.0 \pm 3.00 - 331.0 \pm 13.0$ mg/g). In addition to other intrinsic chemical composition, high phenolic content of DG may be responsible for its medicinal properties. Quantitatively, the phenolic contents of these fruits are high enough to support some of the functional properties attributed to them. Total flavonoid contents (TFC) of the fruits followed the same pattern as TPC. Flavonoid is one of the most potent antioxidant group of phenolic compounds found in fruits and vegetables. In the case of flavonoids content (Fig 2b), DG also ranked highest at 860.63 ± 4.0 mg/100g, followed by DE (661.06 ± 49.1 mg/100g); while SM (350.09 ± 41.6 mg/100g) and IG (304.98 ± 7.5 mg/100g) were the lowest. Among the fourteen underutilized seeds explored by Lamien-Meda et al., (2008), DE was amount those with highest flavonoids and phenolic contents. Being usually ripening-mediated, flavonoid content of fruits is influenced by maturation stage. All the fruits studied were extracted at optimum ripening stage and this is partly responsible for the high recoverability of the phenolic compounds. The registered flavonoid content of african pear is compared to a local 'pear jujube' at an early ripening stage (Wu et al., 2012). Similarly, *Irvingia gabonensis* (bush mango) showed higher flavonoids than common mango (*Mangifera indica*) (Jolayemi, 2019).

Figure 2. TPC (A) and TFC (B) of *Dacryodes edulis* (DE), *Dalium guineense* (DG), *Spondias mombin* (SM) and *Irvingia gabonensis* (IG) fruits

In vitro antioxidant activities

The antioxidant capacities of the fruit extracts were evaluated using ABTS•, DPPH• radical scavenging and FRAP assays. Interestingly, unlike TPC and TFC, antioxidant capacities of the three fruits extracts did not follow regular pattern (Figure 3). In ABTS• assay, SM showed a significantly ($P < 0.05$) higher radical scavenging ability than both DE and DG despite having lower values of TPC and TFC, while DE and IG were statistically similar. All the fruits exhibited promising free radical scavenging effect against DPPH. The study of (Ishola et al., 2019) observed similar antioxidant response in *Spondias mombin* leaves extract, while iron chelating FRAP method best characterized the predominant phenolic compounds in SM according to Silva et al., (2018). Among the fruits, DE is the most consistent with respect to relationship between TPC and *in vitro* antioxidant assays. Usually, these assays measure the ability of the fruits antioxidant to scavenge specific radicals, either to inhibit lipid peroxidation or to chelate metal ions. Therefore, the use of more than two methods allows for a comprehensive assessment of

the fruits' redox potential at physiological level. Having over 50% inhibitions in all the three assays, DE and IG showed remarkable non-specific antioxidant capacity compare to other fruits. Also, the non-linear correlation between the TPC and antioxidant properties of the fruits may be due to the differences in the reaction kinetics of the assays. Considering DPPH• assay results, all the fruits had very close activities that ranged from 0.81 ± 0.02 for DE to 0.97 ± 0.01 $\mu\text{mol TE/g}$ for DG. Other study correlated antioxidant activities of DG leave extract to its protective effect against induced oxidative stress and hepatorenal injuries (Ogbe, Luka & Adoga, 2019). In comparison with some other edible tropical wild fruits such as *Psidium acutangulum*, *Prunus mahaleb*, *Sorbus torminalis*, *Ziziphus mistol*, *Malpighia emarginata* (Li et al., 2016), DE, DG, SM and IG had similar antioxidant effects using ABTS, DPPH and FRAP assays. Different extraction techniques and types of solvent have been known to affect antioxidant activities of horticultural produce (Srisupa & Chaicharoenpong, 2020).

Figure 3. ABTS (A), DPPH (B) and FRAP (C) antioxidant assays of *Dacryodes edulis* (DE), *Dalium guineensis* (DG), *Spondias mombin* (SM), and *Irvngia gabonensis* (IG) fruits

CONCLUSIONS

This study explored the differences in the chemical profiles of four underexploited tropical fruits thus: *Dacryodes edulis*, *Dalium guineensis*, *Spondias mombin* and *Irvingia gabonensis*. High pH, low acidity and reducing sugar characterized *Dacryodes edulis* fruits, while *Irvingia gabonensis* exhibited significantly high total soluble solid, vitamin C and total sugar contents. High total phenol and flavonoid contents were the distinctive properties of *Dalium guineensis*. While the phenolic contents of *Dalium guineensis* were

significantly higher than other fruits, its antioxidant responses according to ABTS•, DPPH• and FRAP assays, did not follow the same pattern. *Spondias mombin* was very responsive in scavenging ABTS• radical while *Dacryodes edulis* and *Irvingia gabonensis* performed similarly in FRAP assay. All the fruits were effective DPPH• radical scavengers. These quality properties of the fruits provide a strong incentive to expand their production and utilization. However, studies should be focused on characterizing the individual phenols and other phytonutrients in the fruits, and their *in vivo* bioavailability at cellular levels.

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