Research Journal of Biological Science

MEDWELL PUBLICATIONS

Biological Activity of Banana (*Musa sapeintum* and *Musa cavandish*) Fruit Peel

[1]A. Abd-Elsamad, [1]Nadia M. Abdelmoein, [2]Amal H. Mahmoud, [2]*Merit Rostom and* [3]*Shaimaa M. Hassan*
[1]*Department of Biochemistry, Faculty of Agriculture, Cairo University, Giza, Egypt*
[2]*Food Technology Research Institute, Agricultural Research Center, Giza, Egypt*
[3]*Academy of Scientific Research and Technology (ASRT), Cairo, Egypt*

Key words: *Musa sapientum* and *Musa cavandish*, proximate analysis, antioxidant, antimicrobial, anti cancer, HPLC

Corresponding Author:
A. Abd-Elsamad
Department of Biochemistry, Faculty of Agriculture, Cairo University, Giza, Egypt

Page No.: 40-52
Volume: 15, Issue 2, 2020
ISSN: 1815-8846
Research Journal of Biological Sciences

Abstract: The chemical composition of banana (*Musa sapeintum* and *Musa cavandish*) peel were studied. The proximate analysis was found to be 89.63 and 86.43 moisture and 12.48 and 7.65 crude protein and 3.86 and 14.05 total lipid and 18.5 and 12.26 ash, 14.61 and 16.36 crude fiber, 50.55 and 49.23 total available carbohydrate in peel of *Musa sapientum* and *Musa cavandish*., respectively. The ash contained (mg/100 g) 96.58 and 60.68 mg and 137.69 and 81.71 Na and 0.75 and 1.48 Zn and 3.80 and 2.11 Fe and 102.25 and 43.12 Ca and 3804.73 and 2882.12 K in peel, respectively, antimicrobial activity of *Musa sapientum* and *Musa cavandish* were found to be the methanolic extract more effective than all other extracts on bacteria and fungi. Oppositethat in anti-cancer activity of *Musa sapientum* and *Musa cavandish* were found to be the methanolic extract not effective compare with all other extracts on Hepatic cell cancer (HEP G2) and colonic cell cancer (HCT). The phenolic compound contents (mg/100 g) were determined of *Musa sapeintum* and *Musa cavandish* peel, methanolic extract The results show the presence of pyrogallol (31.98 and 63.98) catechein (21.55 and 16.33), gallic (58 and 3.22), vanillic (2.94 and 4.46) ellagic (5.57 and 1.48), protocatchoic (1.22 and 3.09) and catechein (21.55 and 16.32), e-vanilic (19.6 and 7.23) salycilic (25.53 and 1.13), respectively.

INTRODUCTION

Different species of Musa genus (Family: Musaceae), commonly known as banana are native to the Asian, Indo-Malaysian and Australian tropics and are now widely found throughout the tropical and subtropical areas[1, 2]. Banana grown in all governorates of Egypt and available throughout the year, banana currently occupies a total area of 72953 Fadden. The productive area of which is 60090 Fadden produces about 1158224 tons with an average production per Fadden 19.28 tons[3]. Significant quantities of banana peels, equivalent to 40% of the total weight of fresh banana are generated as a waste product in industries producing banana based products[4]. Potential applications for banana peel depend on its chemical composition. Banana peel is rich in dietary fiber, proteins, essential amino acids, polyunsaturated fatty acids and potassium[5].

Banana peels are major agricultural wastes which have been used as medicine, animal feeds, blacking of

leathers, soap making, fillers in rubber and so on[6]. Fruit wastes are highly perishable and seasonal and are a problem to the processing industries and pollution monitoring agencies. This problem can be recovered by utilizing its high value compounds including the dietary fiber fraction that has a great potential in the preparation of functional foods[7]. Banana peel, an underutilized source of phenolic compounds is considered as a good source of antioxidants for foods and functional foods against cancer and heart disease[8]. The peel of the fruit contains various antioxidant compounds such as gallocatechin[8] and dopamine[7].

Antifungal and antibiotic principles are found in the peel and pulp of fully ripe bananas[9]. The antibiotic acts against mycobacteria[10]. Norepinephrine, dopamine and serotonin are also, present in the ripe peel and pulp[11]. The first two elevate blood pressure, serotonin inhibits gastric secretion and stimulates the smooth muscle of the intestines[12].

Banana fruit and peel are effective in the treatment of various conditions, from the treatment of simple bruises to reducing the pain in flares of arthritis and even possibly having anti cancer properties[13]. The natural bioactive compounds in fruits such as carotenoids, quercetin derivatives, phenolic acids and saponins are originally found in the peels with higher concentration towards the flesh[14].

Mordi *et al*.[15] the banana peel is simply discarded as rubbish, although, in certain areas, it is used as animal feed. Although, banana peel is biodegradable, its disposal causes unsightly pollution. With this environmental concern in mindand some beneficial uses of banana, it was decided to investigate the usefulness of the peel with the aim of extracting and identifying any useful chemicals that may be available in it.

MATERIALS AND METHODS

Plant material: Fresh banana of two varieties were purchased one from Carrefour market (*Musa cavendish*) and another one from Al Obour market (*Musa sapantium*) in one lot and processed. Banana peel were cleaned using distilled water and dried in an oven at 40±1°C for 72 h. The peels were powdered using lab grinder. Then stored in an air-tight jars maintained at -4°C until extraction.

Preparation of different plant extracts: The powdered air dried of banana peel (600 g) were subjected separately to exhaustive continuous successive extraction using shaker. Different extracts were obtained using the following solvents according to their polarities (in ascending order) hexane, ethyl acetate, methanol and deionized water. The different solvents were completely removed under reduced pressure using rotary evaporator at a temperature not exceeding 50°C. The residue in each case was dried in under vacuumed. The obtained extracts were stored in refrigerator (4°C) till chemical analysis and biological assay.

Chemical composition of the dried peel of *Musa sapeintum* and *Musa cavendish*: Chemical composition such as moisture, ash content, crude protein, crude fiber, total lipid, total carbohydrate (by difference) and mineral content of banana peel (*Musa sapeintum* and *Musa cavandish*) were determined according to the methods of AOAC.[16].

Separation and identification of chemical components of *Musa sapeintum* and *Musa cavendish* and extracts by HPLC: HPLC Agilent 1200 series equipped with quaternary pump, autosampler, column compartments ET at 35°C, malti wavelength detector set at 330 and 280 nm for detection of flavonoid compounds and phenolic compounds, degasser, column used for fractionation Zorbax OD. 4.6×250 mm and the flow rate of mobile phase during run was 1 mL min^{-1}.

Chromatographic analysis of phenolic compounds: The phenolic compounds of black mulberry methanolic extract were fractionated and identified by HPLC according to the method described by Goupy *et al*.[17].

Chromatographic analysis of flavonoid compounds: Flavonoid compounds of black mulberry methanolic extract according to the method described by Mattila *et al*.[18].

Determination of fatty acids

Separation of fatty acids: Lipid was saponified with ethanolic KOH (20% w/v) for 24 h at room temperature. The aqueous layer was acidified by HCL (20% w/v) and the liberated fatty acids were extracted with diethyl ether[19].

Preparation of fatty acid methyl ester: Fatty acids of standards and samples were converted to methyl esters using ethereal solution of diazomethane. Fatty acids were dissolved in 0.5 mL anhydrous diethyl ether and methylated by dropwise addition of diazomethane solution until the yellow color persisted[20]. The mixture was then left at room temperature for 15 min and the solvent was evaporated on a water bath maintained at 60°C. Finally, the fatty acid methyl esters were dissolved in pure chloroform and aliquots of this solution were subjected to GLC analysis.

Fractionation of *Musa sapeintum* and *Musa cavendish* fatty acid by GLC method: The methyl esters of *Musa sapeintum* and *Musa cavendish* fatty acid and standard compounds were analyzed by using HP 6890

GC capillary column gas liquid chromatography with a dual flame ionization were carried out on (30 m×0.32 mm×0.25 μm) DB-225 capillary column, stationary phase (50% cyan propyl phenyl+50% dimethyl polysiloxane). Column temperature; initial temperature was 150°C, the temperature was programmed by increasing the temperature from 150-170°C at the rate of 10°C min^{-1}, then increased from 170-192°C at the rate of 5°C min^{-1}, holding for five min and then increased from 192-220°C during 10 min, holding three min. The injector and detector temperature were 230 and 250°C, respectively. Carrier gas, hydrogen flow rate 40 mL min^{-1} and air flow rate was 450 mL min^{-1}. Peak identification was established by comparing the retention times obtained with standard methyl esters. The area under the chromatographic peak were measured with electronic integrator[16].

***In vitro* antioxidant study**

Determination of radical scavenging activity in banana peel: The free radical scavenging effect of each extract was assessed by the discoloration of a methanolic solution of 2, 2-diphenyl-1-picryl hydrazyl (DPPH) radical (violet color) according to the method of Brand-williams *et al*.[21].

Determination of total phenolic compounds in banana peel: The concentration of total phenolic compounds in the methanolic extract (1:10) was determined by using folin-ciocalteu's reagent according to Singleton and Rossi[22]. Calibration curve was prepared using gallic acid as standard for TPC which was measured as mg Gallic Acid Equivalents (GAE) per milliliter of the sample (μg/mL).

Determination of total flavonoid of banana peel: The colorimetrically method as described by Hoslattmann and Hoslattmann[23] was used to determine total flavonoids contents.Calibration curve was prepared using quercetin as standard for total falvonoid which was measured as mg Quercetin Equivalents (QE) per milliliter of the sample (μg/mL).

Antimicrobial activity The antimicrobial activity of black mulberry extracts was determined by the disk diffusion methods[24]. The Minimum Inhibitory Concentrations (MIC) were determined according to Cheesbrough[25].

Bacterial strain: Four bacterial strains of significant importance were used to test the antibacterial properties of the essential oils. Two of them were Gram positive (*Bacillus cereus* ATCC6538 and *Staphylococcus aureus* ATCC25923) and the others were Gram negative (*E. coli* ATCC25922 and *Salmonella typhimurium* ATCC9027). The cultures of strains used in this study were obtained from Microbiological Resources Centre (MIRCEN), Faculty of Agriculture, Ain Shams University and Cairo, Egypt. Bacterial strains were inoculated into Mueller Hinton Broth (Difco) and incubated at 37°C for 24 h. The cultures were subjected to three successive 24 h. transfers before use. All cultures were adjusted to 106 CFU per mL prior to use 2.

Disk diffusion assay: About 20 mL of Muller Hinton agar was placed into 10 mL petri dishes and 0.1 mL of the active cultures was spread over the plate using a sterile glass spreader in order to get a uniform microbial growth for all plates[26].

Anticancer activity

Measurement of potential cytotoxicity by SRB assay: Potential cytotoxicity of the compounds were tested using the method of Skehan *et al*.[26]. Cells were plated in 96-multiwell plate (104 cells/well) for 24 h. Before treatment with the components to allow attachment of cell to the well of the plate. Concentration of the compound under test (12.5, 25, 50, 100 g mL^{-1}) was added to the cell monolayer triplicate wells were prepared for each individual dose. Monolayer cells were incubated with the compounds for 48 h at 37°C and inatomosphere of 5% CO_2. After 48 h, Cells were fixed, washed and stained with Sulfo rhodamine-B stain. Excess stain was washed with acetic acid and attached stain wise recovered with Tris EDTA buffer. Color intensity was measured in an ELISA reader. The relation between surviving fraction and drug conc is plotted to get the survival curve of each tumor cell line after the specified compound.

Statistical analysis: Data were subjected to the convenient statistical analysis methods. Where mean and standard error was calculated. Data were analyzed using two way-classifications ANOVA as described by Snedecor and Cochran followed by Duncans multiple comparison tests to find the statistical significant difference between the ten treated groups. Mean separation was done according to the Least Significant Differences ($L.S.D_{5\%}$) Duncans multiple range tests according to Waller and Duncan[27].

RESULTS AND DISCUSSION

Chemical composition of banana peel of *Musa sapientum* and *Musa cavendish*

Proximate analysis: Data in Table 1 show the proximate analysis of banana peel *Musa sapientum* and *Musa cavendish*. The moisture content was found to be 89.62^{a}±0.4 and 86.43^{b}±0.7% in *Musa sapientum* and *Musa cavendish* peel, respectively. These results are nearly the same to those of Waller and Duncan[27] who found that 90.7% in *Musa cavendishii* species.

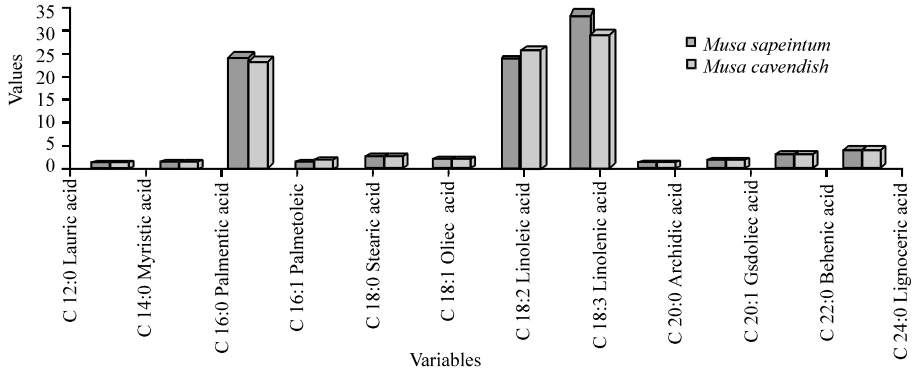

Fig. 1: Fatty acid content of banana peel

Table 1: Proximate analysis of *Musa sapeintum* and *Musa cavendish* (% dry wt.)

Chemical composition (%)	*Musa sapientum*	*Musa cavendish*
Moisture	89.62±0.4[a]	86.43±0.7[b]
Protein	12.48±0.68[a]	7.65±0.28[b]
Total lipid	3.86±0.31[a]	14.05±0.58[b]
Ash	18.5±0.28[a]	12.26±0.49[b]
Crude fiber	14.61±0.62[a]	16.36±0.40[b]
Total available carbohydrate	49.83±0.35[a]	48.76± 0.25[b]

[a, b]Siguificut values

The protein content was found to be 12.48±0.68[a] and 7.65±0.28[b] in *Musa sapientum* and *Musa cavendish* peel, respectively. These results are slightly lower than those of Schmid *et al*.[28] who found 15.8%. While our results are nearly the same to that found by Yan *et al*.[31] who found it from 6.59-7.37 in different ripening stages on *Musa cavendish* peel[30, 31]. The total lipid content was found to be 3.86±0.31[a] and 14.05±0.58[b], ash 18.5±0.28[a] and 12.26±0.49[b], total available carbohydrate by difference was 49.83±0.35[a] and 48.76±0.25[b] in *Musa sapientum* and *Musa cavendish* peel, respectively. According to Anhwange[32], the ash content in banana peel was 8.5% which was lower than what hasbeen found in this study. The banana species *Musa sapientum* which were grown in Africa was studied by Anhwange[32]. Zafar *et al*.[33] tested the chemical composition of peels from three varieties of *Musa paradaisica* (varieties were Pachabale, Yelakkibale and Nendranbale) grown in Indiaand found that the ash content ranged from 8.9-12.96%. However, samples in this study were Egyptian-grown *Musa sapeintum*, Ecuador-grown *Musa cavendish*. The variation in banana species and growing area could lead to the difference of chemical composition. The percentage of crude fiber of banana peel in this study was approximately 14.61±0.62[a] and 16.36±0.40[b]% in *Musa sapientum* and *Musa cavendish* peel, respectively. These results are nearly the same to those of[28] who found that 14% in *Musa cavendishii* species. However, Anhwange[32] reported crude fiber contents of 31.7% in *Musa sapientum*. Such differences could be due to the differences in farming conditions and species; the bananas studied by Anhwange[32] were *Musa sapientum* from Zafar *et al*. (2011) found that the crude fiber content in banana peel fluctuated through the different maturation stages.

Table 2: Fatty acid contents in *Musa sapeintum* and *Musa cavendish*

Variables	*Musa sapeintum*	*Musa cavendish*
C12:0 Lauric acid	0.411	0.37
C14:0 Myristic acid	0.844	0.77
C16:0 Palmetic acid	24.49	23.50
C16:1 Palmetoleic acid	0.7	1.20
C18:0 Stearic acid	2.5	2.50
C18:1 Oliec acid	1.4	1.20
C18:2 Linoleic acid	23.7	26.10
C18:3 Linolenic acid	34.16	29.70
C20:0 Arachidic acid	0.66	0.80
C20:1 Gadoliec acid	1.05	1.04
C22:0 Behenic acid	2.6	2.90
C24:0 Lignoceric acid	3.4	3.90
Total saturated FA	31.5	34.74
Total unsaturated FA	61.01	59.24

The yield of *Musa sapeintum* and *Musa cavendish* in different fractions: It is clear that the yield percentage of *Musa sapeintum* and *Musa cavendish* 5.52 and 3.39%, 1.06 and 1.084%, 14.68 and 12.71% and 17.3 and 11.99% in hexane fraction, ethyl acetate fraction, methanol fraction and aqueous extract fraction, respectively. These results are in agreement with Arawande and Komolafe[6] who found that the yield percent of methanol extracts was next to acetic acid. The percent yield of extract in banana peel was higher than that of plantain peel in all the solvents used. According to the rule of thumb, natural antioxidants are polar (phenolic) compounds and they are best extracted using polar solvents[34]. Ethylacetate, acetone and chloroform yielded about 20-25% (Fig. 1).

Fatty acid contents of *Musa sapeintum* and *musa cavendish*: Fatty acid contents of *Musa sapeintum* and *Musa cavandish* were shown in Table 2. The results show linolenic represent the major content (34.16 and 29.7%) followed by linoleic (23.7 and 26.1%) and palmitic (24.49 and 23.5%) in *Musa sapeintum* and *Musa cavandish* peel, respectively. These results indicate that the peel have

Table 3: Mineral contents in *Musa sapeintum* and *Musa cavendish*

Mineral as (mg/100 g)	Fe	Zn	Ca	Na	Mg	K
Musa sapeintum	3.87±0.05[a]	0.8±0.05[b]	106.9±4.04[a]	134.69±3.6[a]	95.25±4.1[a]	3804.73±40.09[a]
Musa cavendish	2.11±0.2[b]	1.63±0.2[a]	45.12±2.5[b]	81.71±4.6[b]	66.68±4.9[b]	2883.78±7.6[b]

Table 4: Radical scavenging activity in *Musa sapeintum*

Concentration (%)	Hexane extract	Ethyl acetate extract	Methanol extract	Water extract	Ascorbic acid (st)
20	18.99±3.5[e]	13.63±2.3[d]	21.92±0.5[e]	12.06±1.3[e]	92.05±2.2[ab]
40	32.8±2.9[d]	21.6±3.2[c]	45.31±3[d]	18.22±1.8[d]	92.21±2.7[b]
60	48.3±5.6[c]	37.89±1[b]	62.55[c]±1.4	23.58±2[c]	95.36±2.3[ab]
80	71.1±4.3[b]	40.71±3.6[b]	74.8[b]±1.2	34.84±2.3[b]	97.34±2.1[ab]
100	82.02±2[a]	47.91±5.3[a]	87.36[a]±0	46.07±1[a]	98.16±3.5[a]
LSD 0.05	5.5	6.22	2.86	3.12	4.82

Table 5: Radical scavenging activity in *Musa cavandish*

Concentration (%)	Hexane extract	Ethyl acetate extract	Methanol extract	water extract	Ascorbic acid as (st)
20	10.22±1.7[e]	14.08±2.1[e]	19.42±5.4[e]	10.63±2.4[c]	92.05±2.2[ab]
40	24.7±3.5[d]	22.1±3.22[d]	35.21±2.2[d]	22.31±2.7[b]	92.21±2.7[b]
60	33.6±3.5[c]	30.94±2.9[c]	55.03±7.1[bc]	39.17±4[a]	95.36±2.3[ab]
80	49.5±4.1[b]	41.71±3.5[b]	69.52±3.2[b]	41.92±3.5[a]	97.34±2.1[ab]
100	68.3±5[a]	50.52±6.7[a]	85.97±4.6[a]	44.52±4.9[a]	98.16±3.5[a]
LSD 0.05	6.58	5.7	6.2	6.4	4.82

[a-d]Siguificut values

high concentration of essential fatty acids. The peel contains 31.5% saturated acids (24.49% palmitic, 2.5% stearic, 0.66% arashidic) and 61.01% unsaturated acids (34.16% linolenic acid, 23.7% linoleic and 1.4% oleic) in *Musa sapeintum* 34.74% saturated acids (23.5% palmitic, 2.5% stearic, 0.8% arashidic) and 59.24% unsaturated acids (29.7% linolenic acid, 26.1% linoleic and 1.2% oleic) in *Musa cavandish*. These results are agreement with[35] who found that the fatty acid content palmitoleic acids (0.92, 2.79 and 4.6%, respectivily), palmitic acid (29.18, 30.57 and 43.17%, respectivily), linoleic acid 14.36, 36.10 and 21.82%, respectivily), linolenic acid (35.93, 30.46 and 39.68%, respectivily) and stearic acid (3.76, 3.34 and 3.32%, respectivily). In three varieties of banana and higher than[36] who found that myristic acid (0.5%), palmetoleic acid (1.2%), palmeticacid (11.6%), linoleic acid (9.6%), linolenic acid (11.78%), stearic acid (1.45%) arachidic acid (0.399%) and behenic acid (1.43%).

Minerral content of *Musa sapeintum* and *Musa cavendish*: Table 3 show that the ash mineral content of *Musa sapeintum* and *Musa cavendish* (as mg/100 g). It is clear that potassium represents the high content of *Musa sapeintum* and *Musa cavendish* (3804.73 mg/100 g) and (2882.12 mg/100 g) respectively., followed by sodium (137.69 mg/100 g) and (81.71 mg/100 g) and calcium in *Musa sapeintum* (102.26 mg/100 g). The high ash (minerals) content in banana peel indicates its potential in food applications. Anhwange[31] found that banana peels contained high potassium (78.10 mg g^{-1}) and manganese (76.20 mg g^{-1}). Emaga *et al*.[5] concluded that the potassium was the most important mineral in banana peels.

Data in Table 4 and 5 and Fig. 2 and 3 illustrate the DPPH free radical scavenging effect of different successive extracts of *Musa sapeintum* and *Musa*

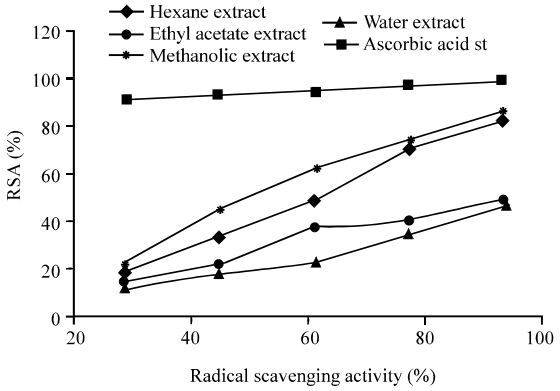

Fig. 2: Radical scavenging activity of different *Musa sapeintum* peel extracts

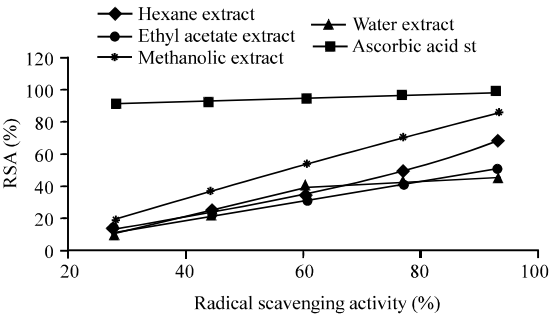

Fig. 3: Radical scavenging activity of different *Musa cavendish* peel extracts

cavendish all the tested extracts show appreciable free radical scavenging activities. The antioxidant activity of the extracts obtained in this study was determined using DPPH method because it is one of the most effective methods for evaluating radical-scavengers. Ascorbic acid

Table 6: The total phenolic compounds and total flavonoid compounds of *Musa sapeintum* and *Musa cavendish*

Variables	Total phenol mg g^{-1} gallic acid	Total flavonoid mg g^{-1} quercetine
Powder *Musa sapeintum*	15.40±5.7[e]	14.33±1.6[e]
Powder *Musa cavendish*	27.76±2.8[d]	40.61±6.26[c]
Ethyl acetate *Musa sapeintum*	56.16±6.5[c]	52.73±8.49[b]
Ethyl acetate *Musa cavendish*	39.46±2.39[d]	83.59±9.7[a]
Methanol *Musa sapeintum*	80.95±6.38[a]	77.71±5.47[a]
Methanol ex *Musa cavendish*	71.15±7.18[b]	77.41±10.4[a]
Water ex *Musa sapeintum*	27.37±2.77[d]	27.8±2.3[d]
Water ex *Musa cavendish*	42.98±5.5[d]	36.58±2.7[cd]

[a-d]Siguificut values

was chosen as the reference antioxidant in this study. The DPPH radical contains an odd electron which is responsible for the absorbance at 517 nm and also for a visible deep purple color. The decolourisation of the purple reaction solution is stoichiometric with respect to number of electrons donated by antioxidant compounds[37]. Ascorbic acid as standard test has strongest radical scavenging activity (98.16[a]±3.5) but in extracts methanolic extract has the strongest radical scavenging activity (87.36±0[a] and 85.97±4.6[a]%) in *Musa sapeintum* and *Musa cavandish* peel compared to other successive extracts followed by Hexane extract and ethyl acetate, aqueous extract. These results are in agreement with[38] who found the extracts prepared from ethanol had the most potent antioxidant activity whereas the extracts prepared from the solvent hexane displayed poor or moderate DPPH and FRAP scavenging activity. Among the tested extracts, peels extracted with ethanol exhibited potent antioxidant activity on DPPH with the lowest IC50 value calculated forthe ethanol extract (19.10 µg mL^{-1})[39] who found that the banana peel extracts extracted with methanol demonstrated the highest percentage of DPPH radical scavenging.

Values represent mean±SD of 3 replicates; Total phenols was expressed as mg gallic acid equivalents/g for successive extract and dry tissue, flavonoids was expressed as mg querectine equivalents/g for successive extract and dry tissue; Mean followed by a common letter are not significantly different at the 5% level by CoStat.

Data in Table 6 Shown the total phenolic and total flavonoids effect of different successive extracts of Banana peel *Musa sapeintum* and *Musa cavandish* methanolic extract have higher total phenol (80.95±6.38[a] and 71.15±7.18[b]), Total flavonoid (77.71±5.47[a] and 77.41 ±10.4[a]). The ethyl acetate extract has high concentration of flavonoid in *Musa cavandish* 83.59±9.7[a] mg g^{-1}[39] who found thatin banana peel, TF varied from 467-756 mg of catechin/100 g dw. Someya *et al*.[38] reported that the main flavonoid compound in banana peel is gallocatechin (158 mg/100 g dw), although, TF values are less than that obtained in the present study, there are other flavonoids in banana peel such as catechin and epicatechin that could increase,

Table 7: Phenolic compound contents in *Musa sapeintum* and *Musa cavendish*

Phenolic compound (mg/100 g)	*Musa sapeintum*	*Musa cavandish*
Pyrogallo	31.98	63.98
Gallic acid	0.58	3.32
4-amino-benzoic	0.44	0.98
Protocatchoic acid	1.22	3.09
Catechein	21.55	16.32
Catechol	0.32	2.32
Chlorogenic	1.05	5.24
Epicatechein	1.38	1.40
P-OH-benzoic	4.65	4.37
Caffeic acid	0.49	0.31
Vanillic	2.94	4.46
P-coumaric	0.44	0.85
Ferulic	2.17	1.89
Iso-ferulic	0.48	0.88
E-vanilic	19.60	7.23
Ellagic	5.57	1.48
Benzoic	1.62	1.58
3, 4, 5-methoxy-cinnamic	2.16	0.42
Coumarin	1.82	0.40
Salycilic	25.53	1.13
Cinnamic	2.95	0.06
Caffeine		1.10
Alpha-coumaric		0.32

Also that, the flavonoid content showed higher content in methanolic extracts (as mg g^{-1} Quercetine). Similar to the totalphenolic content, antioxidant activity of the extracts also varied with polarities of solvents. Similar findings were reported by Sulaiman *et al*.[40] that found that the antioxidant activity exhibited by banana extracts is significantly affected by the solvents used for extraction.

Phenolic compound contents (mg/100 g) of *Musa sapeintum* and *Musa cavandish* peel, methanolic extract are shown in Table 7. The results show the presence of pyrogallol (31.98 and 63.98) catechein (21.55 and 16.33), gallic (0.58 and 3.22), vanillic (2.94 and 4.46) ellagic (5.57 and 1.48), protocatchoic (1.22 and 3.09) and catechein (21.55 and 16.32), E-vanilic (19.6 and 7.23) salycilic (25.53 and 1.13) in *Musa sapeintum* and *Musa cavandish* peel methanolic extract, respectively.

The total phenol and flavonoid content of different banana peels extracts are shown in Table 8 and 9. From the results, it is inferred that methanolic extract showed higher phenol content compared to other extracts which could be related to its antioxidant potential. content of *Musa sapeintum* and *Musa cavendish* (as mg g^{-1} gallic acid). It is clear that methanolic extract represents the high content of *Musa sapeintum* and *Musa cavendish* (80.95±6.38[a] mg g^{-1}) and (71.15±7.18b mg g^{-1}) respectively., followed by ethyl acetate extract (56.16±6.5[c] mg g^{-1}) and (39.46±2.39[d] mg g^{-1}) and water extract (27.37±2.77[d] mg g^{-1}) and (42.98±5.5[d] mg g^{-1}) in *Musa sapeintum* and *Musa cavendish*, respectively (Table 10).

Antimicrobial

In case antibacterial: Various extracts were selected according to polarization and efeect of this extracts

Table 8: Phenolic compound contents in *Musa sapeintum* and *Musa cavendish* extracts

Phenolic compound	Hexane 1	Ethyl acetate 1	Methanol 1	Water 1	Hexane 2	Ethyl acetate 2	Methanol 2	Water 2
Pyrogallo	9.69	36.79	584.67	209.77	15.48	139.32	739.42	98.41
Gallic acid	0.27	9.63	21.62	4.23	0.7	29.01	32.19	9.04
4-amino-benzoic	0.07	5.65	2.8	2.44	0.33	2.5	2.4	1.39
Protocatchoic acid	0.56	13.04	17.68	16.94	3.45	28.55	51.55	7.74
Catechein	0.45	61	23.99	20.39	2.16	49.81	36.95	13.41
Catechol	1.03	135.83	56.56	82.89	6.73	17.58	84.2	61.7
Chlorogenic	-	6.55	-	41.73	-	-	-	7
Epicatechein	0.96	3.71	9.24	73.23	7.33	11.46	9.77	10.44
P-OH-benzoic	0.88	4.87	43.59		4.84	35.21	22.13	4.05
Caffeic acid	0.66	7.06	5.45	4.74		37.55	3.79	0.95
Vanillic	1.97	5.9			6.42	-	26.13	3.45
P-coumaric	0.15	8.46	6.22	8.97	0.84	14.72	5.1	1.04
Ferulic	0.39	12.5	5.22	14.44	1.01	29.34	2.76	2.42
Iso-ferulic	-	3.54	0.55		0.84	2.69	2.35	1.48
E-vanilic	31.18	186.13	227.55	597.62	71.02	970.96	201.84	214.24
Ellagic	21.13	238.14	-	-	120.51	998.94	296.52	61.38
Benzoic	3.58	27.39	44.92	-	16.1	-	39.33	17.19
3,4,5-methoxy-cinnamic	1.67	7.13	9.4	19.52	3.98	39.83	14.71	3.63
Coumarin	0.35	2.4	1.98		2.06	7.45	2.21	1.29
Salycilic	1.7	15.56	7.27	10.07	10.58	22.47	60.75	2.67
Cinnamic	0.08	1.23	0.48	1.48	0.22	2.49	0.27	0.23
Caffeine	-	3.67	-	-	-	22.22	5.1	1.81
Alpha-coumaric	0.37	-	1.65	4.32	-	-	2.59	-

Table 9: Flavonoid compound contents in *Musa* spp

Flavonoid compound (mg/100 g)	*Musa sapeintum*	*Musa cavandish*
Naringin	1.039	2.750
Hespirdin	2.051	13.688
Rutin	0.380	0.916
		0.051
Rosmarinic	0.019	2.528
Quercetrin	0.900	1.339
Quercetine	6.218	1.030
Hespirtin	1.200	1.836
Kampferol	0.348	0.589
Apigenin	0.128	0.436

Table 10: Flavonoid compound contents in *Musa sapeintum* and *Musa cavendish* extracts

Flavonoid (mg/100 g)	Hexane 1	Ethyl acetate 1	Methanol 1	Water 1	Hexane 2	Ethyl acetate 2	Methanol 2	Water 2
Naringin	1.679	28.355	17.887	152.289	3.318	15.757	54.131	18.529
Hespirdin	3.586	61.817	56.655	121.286	24.330	82.298	142.373	71.706
Rutin	1.467	8.579	69.154	59.291	14.392	18.446	35.334	9.388
Rosmarinic	0.082	0.441	1.280	4.051	0.282	0.630	1.837	0.859
Quercetrin	1.758	23.251	38.652	19.237	0.408	73.928	37.751	5.879
Quercetine	0.273	1.002	6.026	9.696	0.451	3.537	6.528	5.502
Hespirtin	1.280	4.875	15.850	42.222	5.432	8.025	8.573	14.652
Kampferol	0.335	2.523	5.121	5.258	0.375	1.071	10.882	1.386
Apigenin	0.166	1.373	1.044	3.091	0.490	1.053	3.688	1.694
Naringenin	0.152	8.201	5.506	9.175	0.660	1.914	3.510	2.236

on two species of banana peel *Musa sapeintum* and *Musa cavandish* two of them were given a stronger effect and two were given a lower effect with two banana species. The extracts that are given as a strong ereffect are them ethanolic and ethyl acetate extract. Since, the methanolic extract contains effective ingredients that dissolve completely in the mixture, the lower concentration of this extract is given a higher positive result. While the opposite is the case with the use of ethyl acetate extract (Fig. 4-7).

Where, the methanolic extract is given a positive result in the four strains higher result with bacillus cereus followed by *E. coli* followed by *Salmonella typhimurium* and *Staphylococcus aureus*. And low effect in *E. coli* when compared with other bacteria. Methanolic extract has higher effect on fungi (*Asprgilus niger* and *Fusarium oxysporum*) While in the case of ethyl acetate extract, it is given a positive result with the positive bacteria of gram and the negative bacteria of the gram and the positive bacteria of gram there is a difference between them where *Bacillus cereus* is given with the lowest concentrations while *Staphylococcus aureus* given with the highest concentration and *Salmonella typhimurium* given effect with lower concentration and *E. coli* not give any effect with ethyl acetate extract. Ethyl acetate extract has higher effect on fungi (*Asprgilus niger* and *Fusarium*

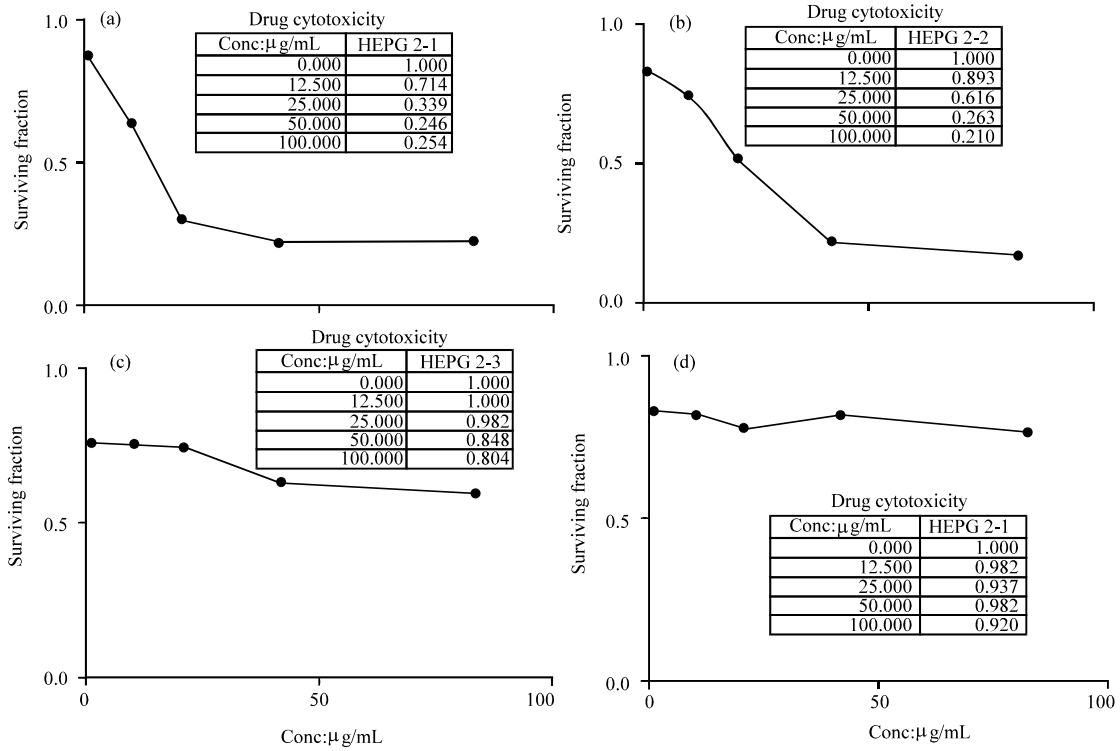

Fig. 4(a-d): Anti Hepatic cancer (HEP G2) of *Musa sapentum*: a) HEP G2-1; b) HEP G2-2; c) HEP G2-3 and d) HEP G2-4

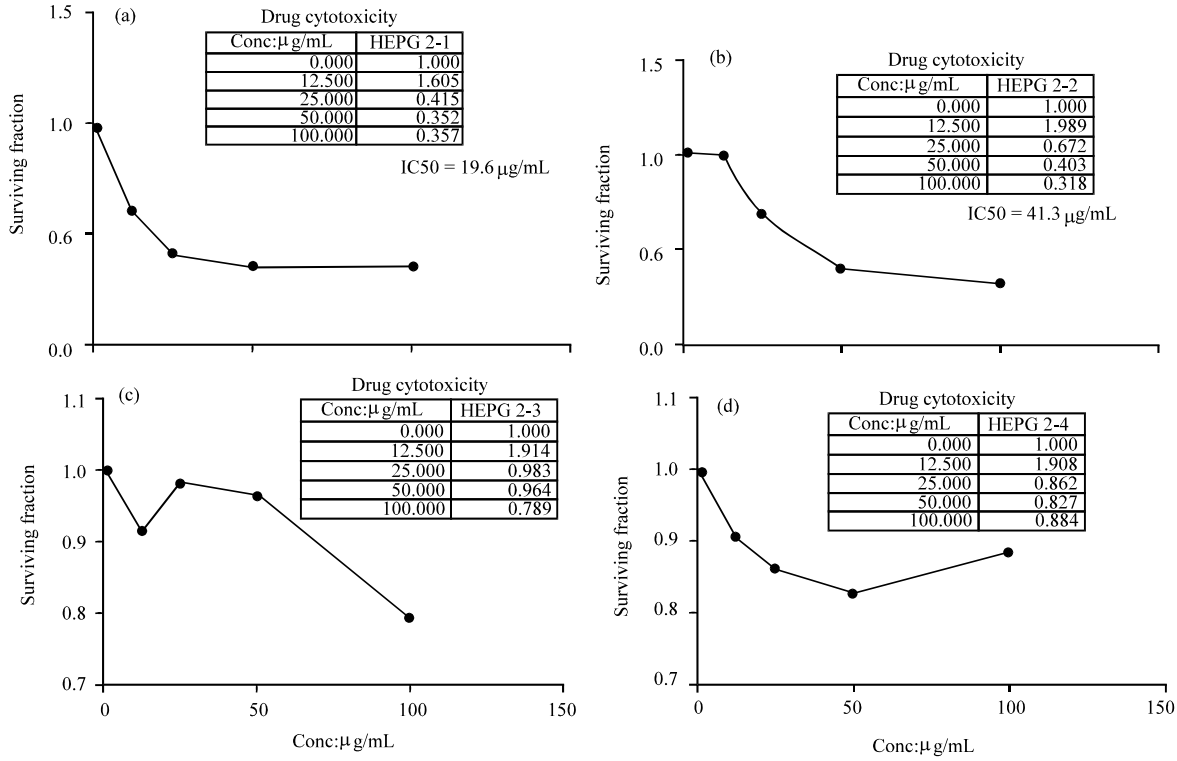

Fig. 5(a-d): Anti colonic cancer (HCT) of *Musa sapentum*: a) HCT-1; b) HCT; c) HCT-3 and d) HCT-4

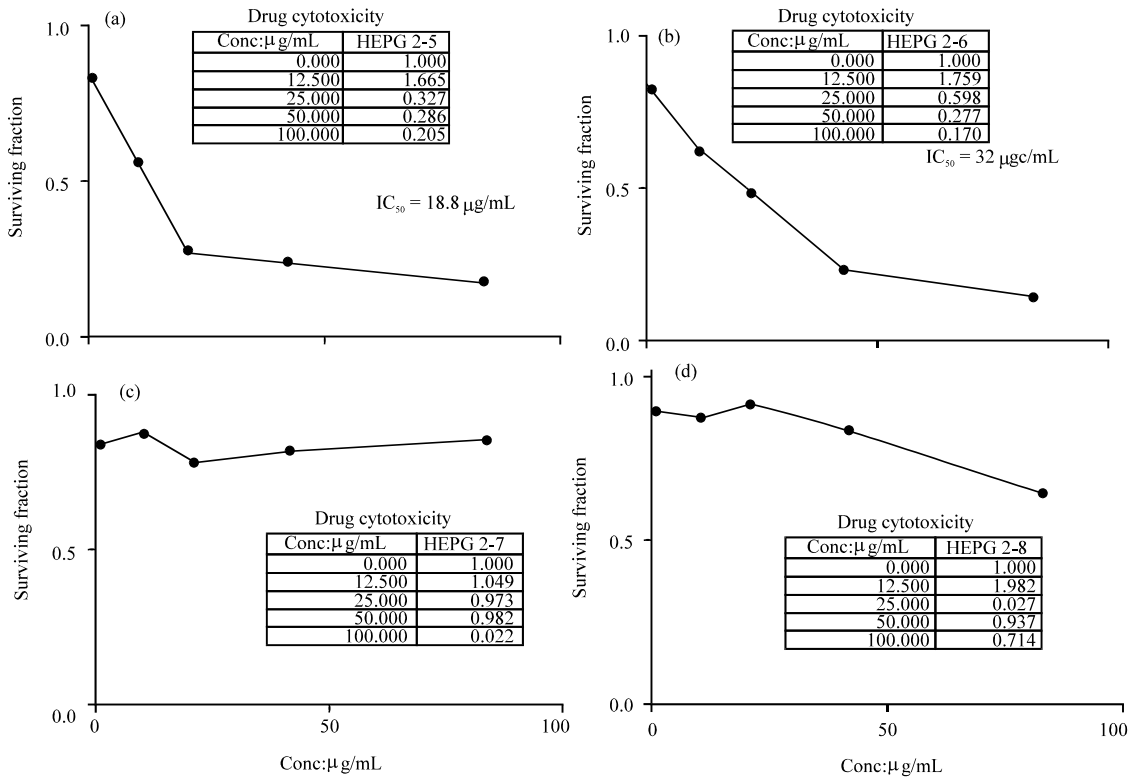

Fig. 6(a-d): Anti cancer (HEP G2) of *Musa cavendish*: a) HEP G2-5; b) HEP G2-6; c) HEP G2-7 and d) HEP G2-8

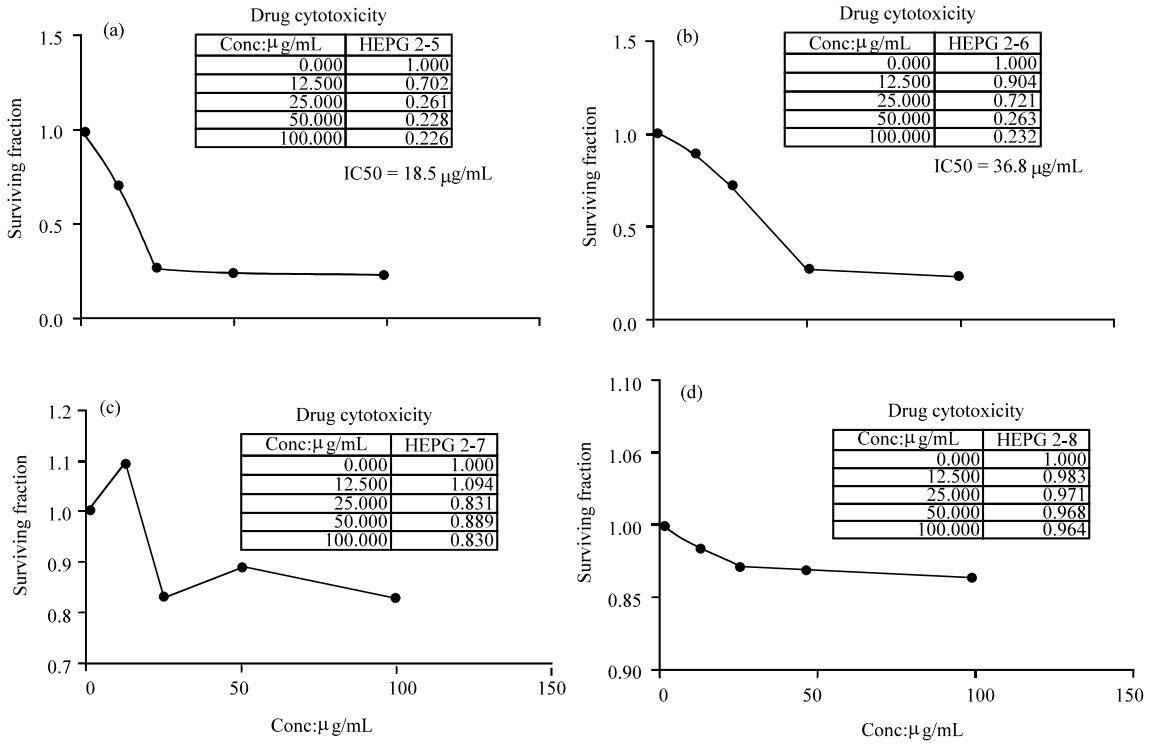

Fig. 7(a-d): Anti colonic cancer (HCT) of *Musa cavendish*: a) HCT-5; b) HCT-6; c) HCT-7 and d) HCT-8

oxysporum). Hexane extract and water extract have moderate effect with high concentration (256 and 512 mg mL^{-1}) in positive gram and fungi but have not detected with negative gram bacteria. This result in agreement with[41] who found the banana inflorescence extracted with 80 and 100% methanol gave the strongest antibacterial activity against all tested bacteria. The addition of water increase the polarity of the extracting solvent makes it more selective and more antibacterial compounds from the samples becoming soluble[42]. However, the addition of more water to alcohol ratio also, increases the retention of highly polar non-bioactive polysaccharides which explain the reduction of antibacterial activity on Gram negative bacteria[43]. Ethyl acetate extract showed higher activity than the ethanolic extract both in case of peel as well as pulp 24 mm of clear inhibition zone against Gram positive bacteria *S. aureus*. In fact, high antibacterial activity against all test organisms was observed with ethyl acetate extract of peel and pulp and zone diameters ranged from 12.5-24 mm antibacterial activity obtained in this study varied with solvents used for extraction. Ethyl acetate extracts showed best antibacterial activity against both Gram positive and Gram negative bacteria with Gram positive slightly more susceptible to the extracts than Gram negative bacteria. Hexane extract of either part did not show any antibacterial activity against any of the bacteria. Some studies have reported similar findings[44] and this difference in sensitivity could be attributed to different morphological[44]. Jalani *et al*.[45] found that the antibacterial activity of different extracts of banana pulps were analyzed *in vitro* against Gram positive and negative bacteria by disc diffusion method. The aqueous extract of all types of banana pulp displayed no zone of inhibition indicating no antibacterial activity. Acetone and methanol extracts of all banana pulps exhibited antibacterial activity only against *P. aeruginosa* and *E. coli* at 10 mg/disc. The highest antibacterial activity was observed with methanol extract of banana pulps against *E. coli* with 8.5 mm zone of inhibition. Mokbel and Hashinaga[46] found that EtoAc extract of green banana peel recorded significant antimicrobial activities while yellow peel extracts recorded low activity and no activity was recorded to $CHCl_3$ and water extracts as measured by paper disk methods. Ehiowemwenguan *et al*.[47] can be conclude that ethanol extract of *Musa sapientum* peels had significant in vitro broad spectrum antimicrobial activity. Thus, extracts from the plant can be used to control infections caused by *Salmonella typhi*, *Escherichia coli*, *Klebsiella pneumoniae* and *Staphylococcus aureus*. Opportunistic infections such as bronchopneumonia, bacterial endocarditis and meningitis caused by *Micrococcus* spp. and *Pseudomonas aeruginosa* will also, find treatment with the extracts of this medicinal peel. El Zawawy[48] banana extracts, high antibacterial activity was recorded for *S. aureus*.

Cytotoxicity effects: Banana extracts were tested for the irability to inhibit the growth of HCT and HEP-G_2, tumorcell lines (Table 11-13). The extracts showing >80%

Table 11: Antimicrobial activity of *Musa sapeintum* peel extracts using various extraction solvents

		Diameter of inhibition zone (mm)					
EEP concentration (mg/mL)	Solvent	BC	SA	ST	*E. coli*	AN	FO
From 2-16	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	ND	ND	ND	ND	ND	ND
	MeOH	ND	ND	ND	ND	ND	ND
	H_2O	ND	ND	ND	ND	ND	ND
32	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	3.39±0.26^a	ND	ND	ND	ND	ND
	MeOH	7.21±0.4^a	ND	6.12±0.5^a	ND	5.63±0.4^b	ND
	H_2O	ND	6.78±0.54^a	ND	ND	ND	ND
64	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	5.22±0.24^a	ND	ND	ND	5.39±0.26^a	ND
	MeOH	12.53±0.2^a	ND	10.63±0.33^a	ND	8.18±0.23^b	6.63±0.22^b
	H_2O	ND	ND	ND	ND	ND	ND
128	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	8.86±0.16^a	ND	6.39±0.26^b	ND	8.53±0.62^a	7.73±0.82^a
	MeOH	20.53±0.3^c	5.53±0.62^b	18.53±0.62^d	3.83±0.19^b	13.13±0.12^b	10.63±0.8^a
	H_2O	3.43±0.25^a	ND	4.34±0.86^a	ND	5.04±0.16^a	ND
256	Hexane	6.52±0.24^b	6.38±0.25^b	ND	ND	7.53±0.62^a	6.45±0.45^b
	EtoAc	10.24±0.236^a	6.47±0.72^a	10.39±0.26^a	8.31±0.22^a	16.83±0.52^a	12.44±0.72^a
	MeOH	26.31±0.37^a	8.53±0.42^a	25.43±0.82a	6.13±0.12^b	22.53±0.18^a	15.23±0.4^a
	H_2O	7.76±0.36^d	ND	8.34±0.65^a	ND	8.93±0.7^a	4.76±0.86^a
512	Hexane	11.72±0.24^b	8.38±0.25^b	ND	ND	11.53±0.62^c	10.45±0.45^b
	EtoAc	17.64±0.36^b	9.47±0.72^a	17.53±0.62^a	ND	26.23±0.43^a	22.83±0.52^a
	MeOH	35.31±0.37^a	8.53±0.62^a	33.23±0.26^a	9.11±0.36^c	27.58±0.3a	19.53±0.3^a
	H_2O	12.44±0.2^a	ND	14.53±0.3^d	ND	14.93±0.6bc	9.22±0.5bc

Data represent the means±SD (n = 3) including the well diameter, $^{a\text{-}c}$Subscripts represent significance differences between extraction solvents at $p<0.05$ 'ND' Not Detected. H_2O: Deionized water, MeOH: Methanol, EtoAc: Ethyl Acetate, SA: *Staphylococcus aureus* (gram+), BC: *Bacillus cereus* (gram+), ST: *Salmonella typhimurium* (gram-), *E coli*: *Escherichia coli* (gram-), Fo: *Fusarium oxysporum* (Fungi), AN: *Asprgilus niger* (Fungi).

Table 12: Antimicrobial activity of *Musa sapeintum* peel extracts using various extraction solvents

		Diameter of inhibition zone (mm)					
EEP concentration (mg/mL)	Solvent	BC	SA	ST	*E. coli*	AN	FO
From 2-16	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	ND	ND	ND	ND	ND	ND
	MeOH	ND	ND	ND	ND	ND	ND
	H_2O	ND	ND	ND	ND	ND	ND
32	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	3.39±0.26[a]	ND	ND	ND	ND	ND
	MeOH	8.21±0.4[a]	5.63±0.7[a]	6.12±0.5[a]	ND	5.63±0.4[b]	ND
	H_2O	ND	6.78±0.54[a]	ND	ND	ND	ND
64	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	4.22±0.24[a]	ND	ND	ND	ND	ND
	MeOH	13.53±0.2[a]	9.43±0.82[a]	10.63±0.33[a]	ND	8.18±0.23[b]	6.63±0.22[b]
	H_2O	ND	ND	ND	ND	ND	ND
128	Hexane	ND	ND	ND	ND	ND	ND
	EtoAc	7.86±0.16[a]	ND	5.59±0.96[a]	ND	5.95±0.54[a]	3.73±0.82[a]
	MeOH	20.53±0.3[c]	12.63±0.72[b]	22.56±0.42[d]	3.33±0.59[b]	13.13±0.12[b]	8.66±0.8[a]
	H_2O	ND	ND	5.32±0.96[a]	ND	5.04±0.16[a]	ND
256	Hexane	7.82±0.88[c]	ND	ND	ND	5.53±0.62[c]	3.72±0.65[b]
	EtoAc	10.24±0.236[a]	4.67±0.55[a]	10.39±0.263[a]	5.71±0.66[a]	9.73±0.43[b]	6.44±0.72[a]
	MeOH	25.61±0.39[a]	17.63±067[a]	0.53±0.92[a]	7.18±0.32[b]	20.13±0.68[d]	12.26±0.8[a]
	H_2O	6.76±0.36[d]	ND	9.38±0.66[a]	ND	10.83±0.7[a]	5.76±0.46[a]
512	Hexane	10.55±0.34[a]	5.38±0.25[b]	ND	ND	9.43±0.22[d]	6.43±0.94[b]
	EtoAc	13.33±0.32[b]	8.56±0.42[a]	12.73±0.62[d]	9.48±0.65[c]	6.43±0.94[b]	11.73±0.82[c]
	MeOH	33.21±0.45[a]	21.58±0.97[a]	36.27±0.67[a]		25.52±0.34a	16.83±0.34[a]
	H_2O	11.46±0.33[a]	ND	13.34±0.5[d]	ND	14.93±0.6[bc]	10.29±0.4[d]

Data represent the means±SD (n = 3) including the well diameter, [a-c]subscripts represent significance differences between extraction solvents at $p<0.05$ 'ND' Not Detected. H_2O: Deionized water, MeOH: Methanol, EtoAc: Ethyl Acetate, SA: *Staphylococcus aureus* (gram+), BC: *Bacillus cereus* (gram+), ST: *Salmonella typhimurium* (gram-), *E coli*: *Escherichia coli* (gram-), Fo: *Fusarium oxysporum* (Fungi), AN: *Asprgilus niger* (Fungi)

Table 13: Cytotoxic effects of *Musa sapientum* and *Musa cavendish* extracts

IC_{50}			
Banana verities	Solvent	HCT	HEP-G2
Musa sapeintum	Hexane	19.6	19.7
	EtoAc	41.3	33
	MeOH	ND	ND
	H_2O	ND	ND
Musa cavendish	Hexane	18.8	18.5
	EtoAc	32	36.8
	MeOH	ND	ND
	H_2O	ND	ND

inhibition of cell proliferation were considered to be active extracts. Hexane extracts of banana peel exhibited the highest cytotoxicity to wards HCT and HEP-G_2 with inhibition of 80.4 and 80.3, respectively, IC_{50}19.6 and 19.7, respectively in Musas ape in tum, ethyl acetate extract have inhibition of 58.70 and 67, respectively, IC_{50}41.3 and 33, respectively in *Musa sapeintum*. Hexane extracts have (81.5 and 81.2, respectively), IC_{50} 18.5 and 18.8, respectively in *Musa cavendish*. Followed by ethyl acetate extracts have inhibition of (63.2 and 68, respectively), IC_{50} 36.8 and 32, respectively in *Musa cavendish*. On other hand the water and methanolic extracts showed no antiproliferative effects against HCT and HEP-G_2. Most importantly, all banana extracts showed poor cytotoxicity against the normal cellline. The morphological alteration of the treated cancercells presented clear evidence of significant cytotoxicity of hexane banana extracts. Followed by ethyl acetate extract.

CONCLUSION

This result in agreement with Dahham *et al*.[38] who found the cytotoxicity assay showed that the highly non-polar solvent extract (i.e., n-hexane extracts) had the highest cytotoxic activity among the extract stested. Among the 6 extracts, the hexane extract of banana peel had a strong cytotoxic effect on tested cancer cell lines. Our findings In contrast, all banana extracts were not cytotoxic to the normal cell line (HUVEC). However, the results of the antiangiogenic study showed that out of the six extracts from banana, only two showed a strong inhibitory effect (>60%).

REFERENCES

01. Rahman, M.M. and S.M.H. Kabir, 2003. Banglapedia. 1st Edn., Asiatic Society of Bangladesh, Dhaka, Bangladesh, Pages: 403.
02. Alkarkhi, A.F.M., R. Saifullah, Y. Yong and M.E. Azhar, 2010. Physicochemical properties of banana peel flour as influenced by variety and stage of ripeness: Multivariate statistical analysis. Asian J. Food Agro Ind., 3: 349-362.

03. Anonymous, 2015. Ministry of agriculture and land reclamation. American Refugee Committee, Minneapolis, Minnesota, USA.
04. Tchobanoglous, G., H. Theisen and S. Vigil, 1993. Integrated Solid Waste Management: Engineering Principles and Management Issues. 2nd Edn., McGraw-Hill, New York, ISBN-10: 0070632375, Pages: 992.
05. Emaga, T.H., R.H. Andrianaivo, B. Wathelet, J.T. Tchango and M. Paquot, 2007. Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. Food Chem., 103: 590-600.
06. Arawande, J.O. and E.A. Komolafe, 2010. Antioxidative potentials of banana and plantain peel extracts on crude palm oil. Ethnobotanical Leafl., 14: 559-569.
07. Kanazawa, K. and H. Sakakibara, 2000. High content of dopamine, a strong antioxidant in cavendish banana. J. Agric. Food Chem., 48: 844-848.
08. Someya, S., Y. Yoshiki and K. Okubo, 2002. Antioxidant compounds from bananas (*Musa cavendish*). Food Chem., 79: 351-354.
09. Brooks, A.A., 2008. Ethanol production potential of local yeast strains isolated from ripe banana peels. Afr. J. Biotechnol., 7: 3749-3752.
10. Omojasola, P.F. and O.P. Jilani, 2009. Cellulase production by *Trichoderma longi, Aspergillus niger and Saccharomyces cerevisae* cultured on plantain peel. Res. J. Microbiol., 4: 64-74.
11. Ratule M.T., A. Osman, N. Saari and S.H. Ahmad, 2007. Microstructure of peel cell wall and selected physic-chemical characteristics of Berangan banana (Musacv. Berangan [AAA]) ripened at high temperature. Asia Pacific J. Mol. Biol. and Biotech., 15: 8-13.
12. Anhwange, B.A., T.J. Ugye and T.D. Nyiaatagher, 2009. Chemical composition of *Musa sapientum* (banana) peels. Electron. J. Environ. Agric. Food Chem., 8: 437-442.
13. Ghani, A., 2003. Medicinal Plants of Bangladesh with Chemical Constituents and Uses. 2nd Edn., Asiatic Society of Bangladesh, Dhaka, Bangladesh, Pages: 603.
14. Goulas, V. and G.A. Manganaris, 2012. Exploring the phytochemical content and the antioxidant potential of Citrus fruits grown in Cyprus. Food Chem., 131: 39-47.
15. Mordi, R.C., A.E. Fadiaro, T.F. Owoeye, I.O. Olanrewaju and G.C. Uzoamaka *et al*., 2016. Identification by GC-MS of the components of oils of banana peels extract, phytochemical and antimicrobial analyses. Res. J. Phytochem., 10: 39-44.
16. AOAC., 2005. Official Methods of Analysis of the Association of Official Analytical Chemist. 18th Edn., Horwitz William Publication, Washington, DC., USA.
17. Goupy, P., M. Hugues, P. Boivin and M.J. Amiot, 1999. Antioxidant composition and activity of barley (*Hordeum vulgare*) and malt extracts and of isolated phenolic compounds. J. Agric. Food Chem., 79: 1625-1634.
18. Mattila, P., J. Astola and J. Kumpulainen, 2000. Determination of flavonoids in plant material by HPLC with diode-array and electro-array detections. J. Agric. Food Chem., 48: 5834-5841.
19. AOAC., 2000. Official Methods of Analysis of AOAC International. 17th Edn., AOAC International, Gaitherburg, MD., USA., ISBN-13: 9780935584677, Pages: 2200.
20. Vogel, A.I., 1975. A Text Book of Practical Organic Chemistry. 3rd Edn., ELBS Publisher, Londan, UK., Pages: 721.
21. Brand-Williams, W., M.E. Cuvelier and C. Berset, 1995. Use of a free radical method to evaluate antioxidant activity. LWT-Food Sci. Technol., 28: 25-30.
22. Singleton, V.L. and J.A. Rossi, 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am. J. Enol. Viticult., 16: 144-158.
23. Hoslattmann, K. and M. Hoslattmann, 1982. Isolation Techniques for Flavonoid in the Flavonoid: Advances in Research. In: The Flavonoids Advances in Research, Haboran, J.B. and T.J. Mabry (Eds.). Springer, Berlin, Germany, ISBN:978-1-4899-2915-0, pp: 1-18.
24. Bauer, A.W., W.M. Kirby, J.C. Sherris and M. Turck, 1966. Antibiotic susceptibility testing by a standardized single disk method. Am. J. Clin. Pathol., 45: 493-496.
25. Cheesbrough, M., 2000. District Laboratory Practice in Tropical Countries Part 2. 1st Edn., Cambridge University Press, Cambridge, London, ISBN-13: 978-0521665452, pp: 434.
26. Skehan, P., R. Storeng, D. Scudiero, A. Monks and J. McMahon *et al*., 1990. New colorimetric cytotoxicity assay for anticancer-drug screening. J. Natl. Cancer Inst., 82: 1107-1112.
27. Waller, R.A. and D.B. Duncan, 1969. A bayes rule for the symmetric multiple comparisons problem. J. Am. Stat. Assoc., 64: 1484-1503.
28. Schmidt, M.M., R.C. Prestes, E.H. Kubota, G. Scapin and M.A. Mazutti, 2015. Evaluation of antioxidant activity of extracts of banana in florescences (*Musa cavendishii*). CyTA. J. Food, 13: 498-505.

29. Yan, L., W.M. Fernando, M. Brennan, C.S. Brennan and V. Jayasena *et al*., 2016. Effect of extraction method and ripening stage on banana peel pigments. Intl. J. Food Sci. Technol., 51: 1449-1456.
30. Nagarajaiah, S.B. and J. Prakash, 2011. Chemical composition and antioxidant potential of peels from three varieties of banana. Asian J. Food Agro-Ind., 4: 31-46.
31. Gulizar, K. and Y. Sibel, 2011. Extracts using different extraction method-research gate. J. Agr. Food Chem., 47: 4638-4644.
32. Anhwange, B.A., 2008. Chemical composition of *Musa sapientum* (banana) peels. J. Food Technol., 6: 263-266.
33. Zafar, I.M., A. Saleha, M.M.E. Hoque and R.M. Sohel, 2011. Antimicrobial and cytotoxic properties of different extracts of *Musa sapientum* L. subsp. sylvestris. Int. Res. J. Pharm., 2: 62-65.
34. Goli, A.H., M. Barzegar and M.A. Sahari, 2005. Antioxidant activity and total phenolic compounds of pistachio (*Pistachia vera*) hull extracts. Food Chem., 92: 521-525.
35. Blois, M.S., 1958. Antioxidant determinations by the use of a stable free radical. Nat., 181: 1199-1200.
36. Orhan, I., S. Kusmenoglu and B. Sener, 2002. Fatty acid profile of fresh and dried banana (*Musa sapientum* L. var. *cavendishii* Lamb.) Peel Oils. J. Fac. Pharm. Ankara, 31: 13-19.
37. Norshazila, S., I.S. Zahir, K.M. Suleiman, M.R. Aisyah and K.K. Rahim, 2010. Antioxidant levels and activities of selected seeds of Malaysian tropical fruits. Malaysian J. Nutr., 16: 149-159.
38. Dahham, S.S., M.T. Agha, Y.M. Tabana and A.M.S.A. Majid, 2015. Antioxidant activities and anticancer screening of extracts from banana fruit (*Musa sapientum*). Acad. J. Cancer Res., 8: 28-34.
39. Hernandez-carranza, P., R. Avila-Sosa, J.A. Guerrero-Beltran, A.R. Navarro-Cruz and E. Corona-Jimenezi *et al*., 2015. Optimization of antioxidant compounds extraction from fruit by-products: Apple Pomace, Orange and Banana peel. J. Food Process. Preserv., 40: 103-115.
40. Sulaiman, S.F., N.A.M. Yusoff, I.M. Eldeen, E.M. Seow, A.A.B. Sajak, Supriatno and K.L. Ooi, 2011. Correlation between total phenolic and mineral contents with antioxidant activity of eight Malaysian bananas (*Musa* sp.). J. Food Compos. Anal., 24: 1-10.
41. Hoe, S.T., B.S. Padam, C.S. Vairappan, M.I. Abdullah and Y.C. Fook, 2015. Effect of preparation and extraction parameters of Banana (*Musa balbisiana* cv. Saba) inflorescence on their antibacterial activities. Sains Malaysiana, 44: 1301-1307.
42. Kim, J.M., S.M. Chang, I.H. Kim, Y.E. Kim and J.H. Hwang *et al*., 2007. Design of optimal solvent for extraction of bio-active ingredients from mulberry leaves. Biochem. Eng. J., 37: 271-278.
43. Koh, G.Y., G.X. Chou and Z.J. Liu, 2009. Purification of a water extract of Chinese sweet tea plant (*Rubus suavissimus* S. Lee) by alcohol precipitation. J. Agric. Food Chem., 57: 5000-5006.
44. Chan, E.W.C., Y.Y. Lim and M. Omar, 2007. Antioxidant and antibacterial activity of leaves of Etlingera species (*Zingi beraceae*) in Peninsular Malaysia. Food Chem., 104: 1586-1593.
45. Jalani, F.F.M., S. Mohamad and W.N.S. Shahidan, 2014. Antibacterial effects of banana pulp extracts based on different extraction methods against selected microorganisms. Asian J. Biomed. Pharm. Sci., 4: 14-19.
46. Mokbel, M.S. and F. Hashinaga 2005. Antibacterial and antioxidant activities of banana (*Musa*, AAA cv. *Cavendish*) fruits peel. Am. J. Biochem. Biotechnol., 1: 125-131.
47. Ehiowemwenguan, G., A.O. Emoghene and J.E. Inetianbor, 2014. Antibacterial and phytochemical analysis of banana fruit peel. IOSR. J. Pharm., 4: 18-25.
48. El Zawawy, N.A., 2015. Antioxidant, antitumor, antimicrobial studies and quantitative phytochemical estimation of ethanolic extracts of selected fruit peels. Intl. J. Curr. Microbioogyl Apl. Sci., 4: 298-309.