Journal of Applied Biosciences 191: 20203 - 20218
ISSN 1997-5902

Comparative studies of phytonutrients content and therapeutic potential of fruits parts of *Dialium guineense* Willd (Fabaceae) and *Ziziphus mauritiana* Lam. (Rhamnaceae) used in traditional pediatric in Burkina Faso

Alphonsine RAMDE-TIENDREBEOGO[1, 4*], David BADO[2], Jules YODA[1], Samson GUENNE[2], Martin KIENDREBEOGO[2], Innocent Pierre GUISSOU[3], Aliou GUISSE[4]
1 Research and Development of Phytomedicines and Medicines Laboratory /Health Sciences Research Institute / National Center for Scientific and Technological Research (L-RD/PM / IRSS)/ CNRST), 03 BP 7047 Ouagadougou 03, Burkina Faso.
2 Laboratory of Applied Biochemistry and Chemistry/ Joseph KI-ZERBO University, 03 BP 7021 Ouagadougou 03, Burkina Faso.
3 St Thomas d'Aquin University/ Faculty of Health Sciences, 06 BP 10212 Ouagadougou 06 Burkina Faso.
4International Research Laboratory IRL 3189 Environment, Health, Societies (CNRST/USTTB/ UCAD/UGB/ CNRS).
* Corresponding author. E-mail: ramdalphonsine@gmail.com Tel: +226 74 49 43 55

Submission 14th September 2023. Published online at https://www.m.elewa.org/Journals/ on 30th November 2023. https://doi.org/10.35759/JABs.191.3

ABSTRACT
Objective: The objective of the present study was to determine the phytonutrients content and selected biological activities of fruit parts of *Dialium guineense* commonly known as velvet tamarind and *Ziziphus mauritiana* called jujube tree used in the management of childhood diseases.
Methodology and Results: Phytochemical components were determined by specific reagents and biological activities by antiradical and antibacterial test. The fruit pulp of *Ziziphus mauritiana* had the best antioxidant activity (IC_{50} = 0.27 mg/mL) due to its high contents ($p < 0.05$) of total phenolic compounds (31.18 ± 0.06 mg GAE/g), flavonoids (0.73 ± 0.50 mg RE /g), hydrolysable tannins (11.37 ± 0.05 mg TAE/g) and condensed tannins (9.86 ± 0.30 mg CE/g). It also exhibited the highest contents of β-carotene (72 ± 0.01 mg/100g) and macroelements Na (12 ± 0.00 mg/100g), K (605 ± 0.20 mg/100g). On the other hand, the fruit pulp of *Dialium guineense* had the best contents of vitamin C (36 ± 0.07 mg/100g), vitamin E (0.109 ± 0.07 mg/100g) and microelements (Fe, Zn) with 8.00 ± 0.01 mg/100g and 1.10 ± 0.02 mg/100g respectively. The fruits pulp of these two species showed antibacterial activity against *E. coli* with the best minimum inhibitory concentration (MIC) of 3.12 mg/mL
Conclusions and application of results: Recommendations of enhancement and promotion of these two fruit species could constitute important sources for the development of new nutraceuticals and phytomedicines in the prevention and treatment of childhood diseases.
Keywords: Childhood diseases, *Dialium guineense, Ziziphus mauritiana,* Nutraceuticals.

INTRODUCTION

Sub-Saharan Africa is the region with the highest infant mortality rate in the world, where one in thirteen children dies before the age of five (Rao, 2017). In Burkina Faso, the main lethal pathologies of children aged 0-5 are made up of malaria (23.8%), acute respiratory infections (13.4%) and diarrhoea (11.5%). A third of these deaths occur on malnourished land. In fact, about 30.2%, representing one third of children under the age of 5 years, still suffer from malnutrition in Burkina Faso, with a higher prevalence among boys (34%) than among girls (29%) (Ndamobissi, 2018). It is on record, that less than 40% of young children with malnutrition-related diseases have access to modern treatments in sub-Saharan Africa (Diaby, 2014). The World Health Organization estimates that between 2030 and 2050 climate change will cause about 250 000 additional deaths every year, among which 95 000 cases due to undernourishment of children (WHO, 2014). In fact, previous authors have reported an alteration of the antioxidant system with high oxidative stress and decreased antioxidant defences in malnourished children compared to those in good health (Black *et al.*, 2003; Sharda, 2006). For reasons that include both economic and cultural preferences, nearly 80% of African populations use traditional medicine for health care according to World Health Organization. The use of medicinal plants as the first aid for infants and young children is a practice that exists in many African communities. Indeed, herbal decoctions, purging and even force-feeding with herbal tea are recipes used in traditional paediatrics. However, the poor quality of certain preparations, non-standardized dosages and limited scientific evidence to validate most herbs can have harmful or even dangerous effects on the health of this vulnerable user. Hence the need for a scientific basis to ensure the identity, purity and quality of the medicinal plants used. *Dialium guineense* (*D. guineense*) commonly known as velvet tamarind, and *Ziziphus mauritiana* (*Z. mauritiana*) popularly called 'jujube tree' or respectively 'Mag pussa' and 'Mugunuga' in local Moore language are two very well-known fruit species in Burkina Faso. The fruit pulp of *D. guineense* is incorporated into infant foods to improve appetite and address nutritional deficiencies. Whereas the powdered leave of *D. guineense* is eaten as mineral supplements. The fruits of *Z. mauritiana* are consumed fresh, in the form of juice or are transformed into flour, that are nutritional supplements with various food including dough, cakes, drinks, porridge (Lucien, 2012). In addition, the fruit seed or fruit nut of these species are used in many recipes in traditional medicine to treat stomach aches, malaria, diarrheal, measles, fever, teething, mycosis, scurvy or to improve on the general body build of children (Mishra and Bhatia, 2014). However, there are not enough reliable data that scientifically explain the traditional use of the different parts of these fruits in the management of childhood diseases. It is therefore important to promote alternative and local therapy based on food plants claiming virtues for health. The objective of this study was to compare the phytochemical profile and biological activities of different parts of fruits of *Z. mauritiana* and *D. guineense* in order to provide scientific prerequisites for the development of new functional foods and phytomedicines in the management of childhood diseases.

MATERIAL AND METHODS

Material

Plant material: The ripe fruits of *Z. mauritiana*. were collected in December 2020 in the village of Dapelogo, located about 35 km north of the capital Ouagadougou of Burkina Faso. After identification by the botany team of Joseph Ki-Zerbo University, a specimen voucher code 18007 was deposited in the herbarium of the Training and Research Unit of Life and Earth Sciences (UFR/SVT). The fruits of *Z. mauritiana* were dried under laboratory conditions and then lightly pulverized to separate the pulp from the seed. After drying, the seeds were crushed mechanically using a mortar to release the nuts. The latter were pulverized using a grinder and a 2 mm diameter sieve. The powders obtained from pulp and nut were packaged in transparent sachets, labelled and then stored at room temperature for further use. Figure 1 presents the fruits of *Z. mauritiana* and its different parts.

a. Whole fruits b. Pulps c. Nuts

Figure 1. Whole fruits, pulps and nuts of *Z. mauritiana* (photo David Bado., 2020)

The fruits of *D. guineense* were purchased from dried fruit sellers in the city of Ouagadougou, Burkina Faso. They were identified by the botany team of Joseph Ki-Zerbo University. The fruits were stripped of their velvet shells by hand. Then, by light pulverization, the fruit pulps were separated from seeds. The powders obtained from pulps and seeds using a mechanical grinder and a sieve with 2 mm diameter pores were packaged in transparent sachets, labelled and then stored at room temperature for further use. Figure 2 presents the fruit of *D. guineense* and its different parts.

a. Whole fruits b. Pulverized pulp c. Seeds

Figure 2: Whole fruits, pulverized pulp and seeds of *D. guineense* (photo David Bado., 2020)

Test microorganisms: The test organisms consisted of American Type Culture Collection (ATCC) reference strains of *Escherichia coli* (*E. coli* ATCC 25922) and *Staphylococcus aureus* (*S. aureus* ATCC 43300) obtained from the bacteriology laboratory of the Muraz Center in Bobo Dioulasso, which is a public health research institute in Burkina Faso.

Chemical material: All chemicals used were of analytical grade and included: 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Sigma, St Louis, MO, USA), 6-hydroxy 2,5, 7, 8-tetramethylchroman-2-carboxylic acid (Trolox) and Folin-Ciocalteu Reagent (Sigma Chemical Company, Steinheim, Germany), NEU Reagent (Natural Products - Poly Ethylene Glycol), NaOH, Na_2CO_3, HPLC grade methanol (VWR, France), methanol, dichloromethane, ethyl acetate, absolute ethanol (Carlo Erba, France). Sulfuric acid, aluminium trichloride, acetic acid (Labosi, France), n-hexane (SDS, France), phosphoric acid, gallic acid, rutin, tannic acid, catechin, p-iodonitrotetrazolium (INT) (Sigma-Aldrich, Germany) and $AlCl_3$ (Fluka Chemika, Switzerland).

Methods

Fruit extraction and phytochemical screening: Five (5) g of the powder pulp, nut and seed were extracted by maceration at low temperature (4°C) with 50 mL of dichloromethane for 24 hours. After filtration, a second maceration was carried out on the residual marc for 24 hours using a 70% hydroethanolic solution, then filtration. The two extracts obtained were separately concentrated to half under reduced pressure using a rotary evaporator (Buchi Heating bath B-490, Cambridge Scientific ID*:* 16082). The dichloromethane extract was used to target lipophilic compounds while the hydroalcoholic extract was used to target polar phytochemicals from the three analytes (pulp, nut and seed). Phytochemical screening of extracts was carried out using the HPTLC analytical technique described by Kavit *et al.* (2013) with slight modifications. Plates with aluminum support Silica Gel 60 F_{254} (Merck, Darmstadt, Germany) were used. Sample solutions were applied on the HPTLC plates using a Linomat 5 applicator (CAMAG, Muttenz, Switzerland). The mobile phase consisting of ethyl acetate: formic acid: water (80: 10: 10, v/v/v) was used for the development 70% ethanolic extract, to resolve the flavonoids and phenolic acids and other polar components in the extract. Eluent system of hexane: ethyl acetate (20:4, v/v) was used for the development of the plate that was spotted with the dichloromethane extract believed to be riched in sterols and triterpenes. A third solvent system ethyl acetate: methanol: water: trichloromethane, 18: 2, 4: 2, 1: 6, v/v/v/v) was used as mobile phase capable of resolving tannins from the polar extract. Flavonoids and phenolic acids were visualized on the TLC plates revealed with Neu's reagent in the presence of UV light (366 nm), while sterols, triterpenes were revealed by 3% H_2SO_4 in EtOH (96%) and tannins by 2% $FeCl_3$. The frontal reference (Rf) and fluorescence at wavelengths were compared to those of controls including rutin for flavonoids and caffeic acid for phenol acids.

Determination of total phenolic content: Total phenolic content of each part of the fruit was estimated using the Folin-Ciocalteu Reagent (FCR) as described by Singleton *et al.* (1999) and used by Koala *et al.* (2021) with slight modifications. So, 1.0 mL of extract and gallic acid solutions were mixed with 1.0 mL of Folin-Ciocalteu Reagent previously diluted ten times with distilled water. After vortexing, the mixture was incubated for 8.0 min at room temperature, and 2.0 mL of 7.5% saturated sodium carbonate solution was added. The combinations were placed at 37 °C for 30 min in the dark. The absorbance of the resulting blue colour solution were read at 760 nm with

a spectrophotometer (Shimadzu UV-1280, ALT, USA). Calculation was based on a calibration curve obtained with increasing concentration of gallic acid solution ($y=10.459x + 0.0335$; $R^2 = 0.9993$) following the same procedure. Total phenolic content was expressed as milligrams of Gallic Acid Equivalents per gram of dry material (mg GAE/g). All determinations were performed in triplicate (n=3).

Determination of flavonoids content: Total flavonoid of the extracts was determined according to the method described by Ouédraogo *et al.* (2018) with slight modifications. In a tube containing 1.0 mL of extract; 2.4 mL of double distilled water and 0.3 mL of $NaNO_2$ (0.05 g/mL in water) were introduced. After 5.0 mins of incubation, 0.3 mL of $AlCl_3$ was added. Then 6 mins later, 2.0 mL of NaOH was added. The resulting mixture was incubated at room temperature for 30 min. 2.0 mL of this mixture were introduced into cuvettes for reading the absorbance at 510 nm against a blank made up of distilled water. Calculation was based on a calibration curve obtained with increasing concentration of rutin solution ($y = 2.5608x + 0.0034$, $R^2 = 0.9995$) following the same procedure. The total flavonoid content was expressed in milligrams of Rutin Equivalents per gram of dry material (mg RE/g). All determinations were performed in triplicate (n=3).

Determination of hydrolysable tannins content: The hydrolysable tannins content of each analyte was determined according to the method described by Çam and Hışıl (2010) with minor modifications. 5.0 mL of $NaIO_3$ were introduced into a tube containing 1.0 mL of each extract. The mixture was vortexed for 10 seconds and incubated for 2.0 min. Then 2 mL of the mixture were separately introduced into cuvette for reading the absorbance at 550 nm against a blank made up of distilled water. Calculation was based on a calibration curve obtained with increasing concentration of tannic acid solution ($y = 0.4158x + 0.0235$; $R^2 = 0.9981$) following the same procedure. The hydrolysable tannins content was expressed as milligrams of Tannic Acid Equivalents per gram of dry material (mg TAE/g). All determinations were performed in triplicate (n=3).

Determination of condensed tannins content: Condensed tannins content of each analyte was determined according to the method described by Broadhurst and Jones (1978) and used by Heimler *et al.* (2006) with minor modifications. In a tube containing 0.4 mL of the extract, 3.0 mL of the 4% vanillin solution in methanol and 1.5 mL of concentrated HCl were added. The resulting mixture was incubated at 37°C for 20 min. Then, 2.0 mL of this mixture were introduced into cuvette for reading the absorbance at 500 nm. Calculation was based on a calibration curve obtained with increasing concentration of catechin solution ($y = 2.9549x - 0.007$; $R^2 = 0.999$) following the same procedure. The condensed tannins content was expressed as milligrams of Catechin Equivalent per gram of dry material (mg CE/g). All determinations were performed in triplicate (n=3)

Determination of fat-soluble vitamins content: The fat-soluble vitamins content was determined according to the method described by Jedlička and Klimeš (2005) used by Kini *et al.* (2008). 10 mL of 10% KOH solution in methanol-water (1:1 v/v) was added to 0.5 g of the sample (pulp, nut or seed). The mixture was then brought to reflux in a water bath at 70° C for 30 min. After allowing it to cool, the mixture was extracted with 3 x 5 mL of hexane. The hexane phases were combined and dried over anhydrous sodium sulphate then evaporated to dryness. The residue obtained was taken up in methanol for HPLC analysis. The evaluation of fat-soluble vitamins content was made by HPLC coupled to a UV-Visible detector. The analysis was done in isocratic mode on an Alumina-C18 column. The mobile phase was an acetonitrile/methanol mixture (80:20 v/v) with a flow rate of 1 mL/min. The

detection of β-carotene (provitamin A) was done at λ = 455 nm and that of vitamin E at λ = 295 nm.

Determination of water-soluble vitamins content: The water-soluble vitamin content (vitamin C) was determined according to the method described by Noba *et al.* (2020). Five (5) g of the sample (pulp, nut or seed) was extracted with 15 mL of 5% metaphosphoric acid solution for 15 min at room temperature. After filtration, the residue was mixed with 10 mL of 5% metaphosphoric acid solution for two successive extractions. The three filtrates were combined and centrifuged for 10 min at 4,000g and 5°C. The supernatant was collected and made up to 40 mL and then filtered with a 0.2 mm Advantec filter for HPLC analysis. The mobile phase was acidified with 0.1% phosphoric acid in distilled water (solvent A) and acetonitrile (solvent B), performed at the ratio 25:75. The flow rate was 1 mL/min, and the injection volume was 20 µL. HPLC-Diode Array Detector (HPLC-DAD) was used, and L-ascorbic acid was detected at 245 nm by High-Performance Liquid Chromatography (Shimadzu LC 20A, ALT, USA) with the Shodex Asahipark NH2-NP column (5 µm, 250 × 4.6 nm from Showa Denko K.K. USA) at 40°C.

Determination of minerals content: The minerals were determined by wet way using an atomic absorption spectrophotometer (Perkin-Elmer Model 3110, Connecticut, USA) according to the method descried by Pinta (1973) used by Makalao *et al.* (2015) with slight modifications. For mineralization 0.2g of each sample was dissolved in a test tube containing 5.0 mL of concentrated nitric acid (HNO_3). The solution thus obtained was placed in a mineralizer integrated in the absorption spectrophotometer for 2h30 min to ensure digestion. After cooling, the content of the tube was inverted into a 25 mL volumetric flask, then topped up with distilled water to the gauge mark. This mixture was filtered through a 0.45 µm Wattman filter paper. Each mineral was dosed according to its wavelength and the content was expressed using the equation:

T= CxVxFD/Pe

Where

T = Mineral content; C = Concentration; V = Volume; DF = Dilution factor; Pe =Test portion.

Antiradical activity by the 1, 1-diphenyl-2-picrylhydrazyl (DPPH) test: The antioxidant activity of the samples was determined by the DPPH antiradical test according to the method described by Kim *et al.* (2003) and used by Yabalak *et al.* (2020) with slight modifications. Ten tubes (1-10) were prepared. The DPPH radical was dissolved in methanol (2 mg/50 mL). Then 0.5 mL of the extract was put in tube 1 to which 2 mL of methanolic solution of the DPPH radical (0.04 mg/mL) was added. The range of extract concentrations was prepared by cascade dilution. After 10 min of incubation at 37°C in the dark, the residual DPPH absorbance was read at 490 nm using a spectrophotometer (Bio-Rad Model 680, Laboratories, B. V. Netherlands). The antiradical activity of each sample was evaluated by determining the concentration (mg/mL) necessary to reduce the DPPH radical by 50% (IC_{50}).

Antibacterial activity: The antibacterial activity was determined according to the method described by Marmonier (1990) and used by Okou *et al.* (2018) with minor modifications.

Preparation of extracts and inoculum: Two hundred and Fifty (250) mg of each fruit sample was dissolved in 0.5 mL of 10% DMSO in centrifuge tubes. The resulting solution was homogenized using the sonicator. Each tube was properly labelled and stored in the refrigerator at a temperature of 4°C. After preparing the test solutions, the inoculum was prepared under sterile conditions. Thus, 2.0 mL of liquid Luria-Bertani (LB) medium (composed of Tryptone, yeast extract and NaCL) was inoculated with 0.4 mL of bacterial

strain in sterile tubes at 37°C with continuous stirring (100 rpm) for 18 hours. Then, the bacterial culture was centrifuged at 3200 G and 24°C for 5 minutes. The supernatant was removed and the bacterial pellet was washed twice as follows: first the pellet was taken up in 2.0 mL of liquid LB medium, and the bacterial suspension was gently homogenized using a micropipette of 1.0 mL then centrifuged at 3200 G at 20 °C for 5.0 minutes. The bacterial pellet obtained was taken up in 1 mL of liquid LB. The concentration was obtained by diluting 5.0 mL of the bacterial solution so that the optical density at 600 nm of 100 µL of this dilution + 1900 µL of liquid LB medium was between 0.02 and 0.03.

Determination of the Minimum Inhibitory Concentration (MIC) and the Minimum Bactericidal Concentration (MBC): In a 96-well plate, were introduced 120 µL of LB medium and 130 µL of extracts diluted in 10% DMSO. Cascade dilutions in the wells made it possible to have the concentration series in each column of the plate. A 10 µL aliquot of bacterial suspension was added to each well of the plate. After incubation at 37ºC for 18 hours with stirring at 150 rpm, 50 µL of p-iodonitrotetrazolium (INT) 0.2 mg/mL were added to each well. The plate was again incubated for 30 min. The appearance of a pink colour indicates the presence of microbial growth in the wells while creamy coloration indicated microbial inhibition. The Minimum Inhibitory Concentration (MIC) of each extract was determined from the wells having no pink or with creamy coloration. For the determination of the Minimum Bactericidal Concentration (MBC), 100 µL of extract were taken from the well which made it possible to determine the MIC, then inoculated onto a plate of LB-agar. This operation was repeated with the other wells showing no pink coloration in the presence of INT. Petri dishes were incubated for 18 h at 37°C. The MBC corresponds to the lowest concentration that does not allow the development of bacteria. Two reference substances Gentamicin (10µg/disk) and Ampicillin (10µg/disk) were tested alongside extracts

Statistical analysis: The results were expressed as mean ± SEM (n = 3). Data were analyzed using analysis of variance (ANOVA) with XLSTAT software. Differences were considered statistically significant for a p-value < 0.05.

RESULTS

Phytochemical profile of pulp, nuts and seeds of *Dialium guineense* and *Ziziphus mauritiana*

The determination of constituents by HPTLC and the revelation of the spots are presented in Figure 3.

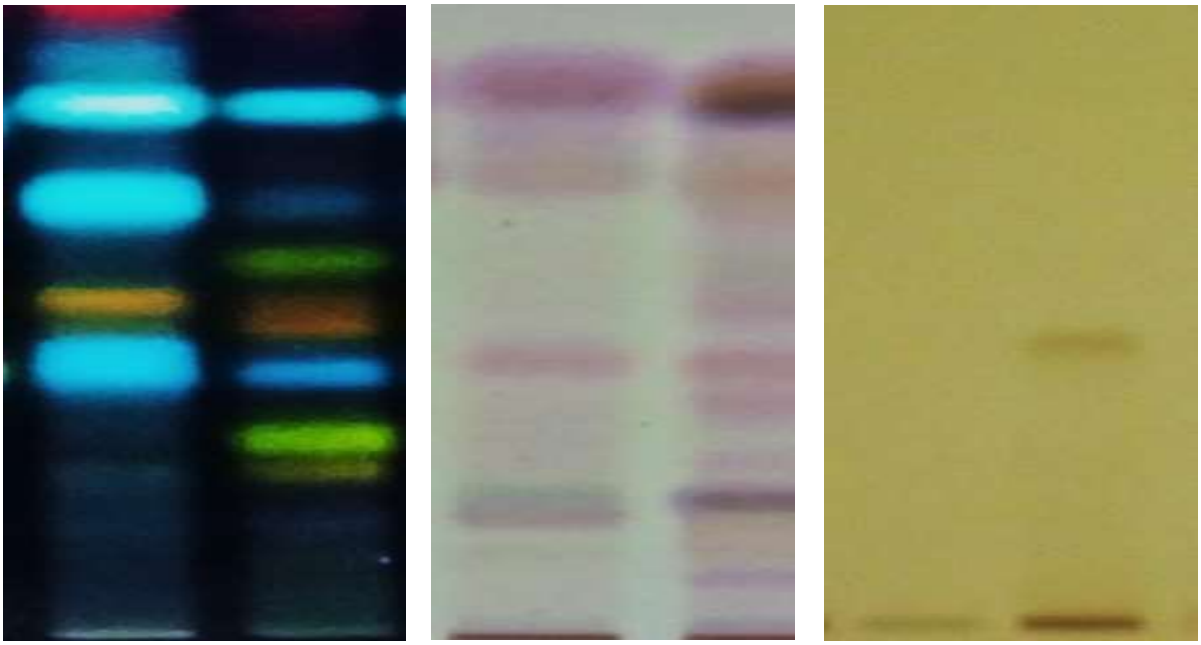

Figure 3: Determination of chemical compounds in the different parts of the two fruits by HPTLC
PZm, *Z. mauritiana* pulp; PDg, *D. guineense* pulp; NZm, *Z. mauritiana* nut; SDg, *D. guineense* seed.
a, revelation of flavonoids by Neu reagent in the presence of UV light (366 nm);
b, revelation of sterols and triterpenes in hydroethanolic (70%) extracts;
c, revelation of tannins by $FeCl_3$ 2%.

Flavonoids react positively to Neu reagent and were yellow-orange in colour while phenolic acids were blue. Sterols and terpenes react to 3% H_2SO_4 in EtOH (96%). Terpenes were purple while sterols were brown .The presence of tannins was confirmed by the reactivity to 2% $FeCl_3$ to afford dark brown colors. Previous authors indicated the presence of these secondary metabolites in the leaf and stem-bark extracts of these plants (Abdallah *et al.*, 2016; Onah *et al.*, 2022)

Phenolic contents and antiradical activity: The contents of phenolic compounds and the concentration inhibiting 50% of DPPH are displayed in Table 1.

Table 1: Phenolic contents and antiradical activity by the DPPH test

Plants	***D. guineense***		***Z. mauritiana***		**Reference**
Samples	**Pulp**	**Seed**	**Pulp**	**Nut**	**Trolox**
Total phenolics (mg GAE/g)	7.15 ± 0.04[a]	2.16±0.08	31.18±0.06	2.75±0.05	
Flavonoids (mg RE/g)	0.15±0.05	0.08±0.05	0.73±0.5	0.075±0.05	
Hydrolysable tannins (mg TAE/g)	1.08± 2.35	0.75±0.2	11.37±0.5	1.12±0.02	
Condensed tannins (mg CE/g)	5.33±0.15	1.31±0.5	9.86±0.3	0.08±0.04	
Antiradical activity IC_{50} (mg/mL)	3.01	9.60	0.27 [b]	2.87	0.012

Values are mean ±SEM (n = 3); [a] $p < 0.05$ against *Z. mauritiana*. pulp; [b] $p<0.05$ against Trolox, GAE, Gallic Acid Equivalents ; RE, Rutin Equivalents; TAE, Tannic Acid Equivalents; CE, Catechin Equivalents.

Z. mauritiana pulp had the best antioxidant activity (IC_{50} = 0.27 mg/mL) due to its high contents ($p < 0.05$) of total phenolic compounds (31.18 ± 0.06 mg GAE/g), flavonoids (0.73 ± 0.5 mg RE /g), hydrolysable tannins (11.37 ± 0.5 mg TAE/ g) and condensed tannins (9.86 ± 0.3 mg CE / g). Our results corroborate the work of Lamien-Meda *et al.* (2008) regarding the content of total phenolic and flavonoids.

Water and fat soluble vitamins content: The contents of water and fat soluble vitamins are presented in Table 2.

Table 2: Water and fat soluble vitamin content (mg/100g)

Plants	***D. guineense***		***Z. mauritiana***	
Samples	**Pulp**	**Seed**	**Pulp**	**Nut**
Vitamin C	36 ± 0.07	7±0.01± 0.07	22. 160± 0.03 [a]	11.760 ±0.03
β-carotene	0.008± 0.07	0.001± 0.07	72 ± 0.01	20.15±0.01 [b]
Vitamin E	0.109 ± 0.07	0.048± 0.07	0.102± 0.01	0.08± 0.01

Values are mean ±SEM (n = 3); [a] $p < 0.05$ against *D. guineense* pulp; [b] $p < 0.05$ against *Z. mauritiana* pulp.

D. guineense pulp had the best ($p < 0.05$) vitamin C content (36 ± 0.07 mg/100g) while *Z. mauritiana* pulp had the best contents of β-carotene. Our results corroborate the work of Achoba *et al.* (1992) regarding the vitamin C content in the pulp and seed of *D. guineense.* The vitamin E content in *Z. mauritiana* pulp was comparable to that obtained by Kini *et al.* (2008).

Mineral contents: Mineral elements contents are presented in table 3.

Table 3: Mineral content (mg/100 g) of the different parts of fruits

Plants	***D. guineense***		***Z.mauritiana***	
Samples	**Pulp**	**Seed**	**Pulp**	**Nut**
Fe	8.0 ± 0.1	2.8 ± 0.1	4.3± 0.1[a]	0.30 ± 0.0
Zn	1.1 ± 0.2	0.03±0.0	0.1 ± 0.1	0.01 ± 0.0
K	401 ± 0.3[b]	0.0 ± 0.0	605±0.2	201 ± 0.3
Na	33 ±0.15	0.0 ± 0.0	138 ± 0.6	30 ± 0.0
Ca	0.4 ±0.1	0.01± 00	51 ± 0.0	12 ± 0.0
Mg	89 ± 0.5	29 ± 0.1	100 ± 0.0	25 ± 0.0

Fe, Iron ; Zn, Zinc ; K, Potassium ; Na, Sodium ; Ca, Calcium ; Mg, Magnesium, values are mean± SEM (n = 3), [a] $p < 0.05$ against *D. guineense* pulp. ; [b] $p < 0.05$ against *Z. mauritiana* pulp.

D. guineense pulp had the best contents of microelements (Fe, Zn) while the best contents of macroelements (K, Na, Ca, Mg) were obtained in the pulp of *Z. mauritiana.* Our results corroborate those of Makalao *et al.* (2015) regarding to the macroelement contents (Na and Ca). However, the K content (401 ± 0.3mg/100g) expressed in *D. guineense* pulp was clearly higher to that obtained by previous authors (Airaodion *et al.*, 2021a).

Antibacterial activity: The results of antibacterial assay of the different parts of fruits are presented in Table 4.

Table 4: Antibacterial activity of the different parts of fruits on bacterial strains

Plants	***D. guineense***				***Z. mauritiana***			
Bacterial strains	***E.coli***		***S. aureus***		***E.coli***		***S. aureus***	
Samples	Pulp	Seed	Pulp	Seed	Pulp	Nut	Pulp	Nut
MIC (mg/mL)	3.15	25	12.5	12.5	3.12	25	12.5	25
MBC (mg/mL)	12.5	50	25	50	6.25	50	25	50
MBC/MIC	3.9	2.0	2.0	4.0	2.0	2.0	2.0	2.0

Escherichia coli, E. coli; Staphylococcus aureus, S. aureus. Controls: Ampicillin (10µg/disk) and Gentamicin (10 µg/disk)

All the CMB/CMI ratios as indicated in Table 4 were less than or equal to 4. Previous authors have shown that *D. guineense* and *Z. mauritiana* fruits exhibited bactericide activities against *S. aureus* and *E. coli* (Airaodion *et al.*, 2021b; Beg *et al.*, 2016). In our studies, it is the pulp of both species which showed important antibacterial activity on *E. coli* with the best minimum inhibitory concentration (MIC of 3.12 mg/mL).

DISCUSSION

Burkina Faso is exposed to an increase in extreme weather events such as droughts and floods, due to climate change. Local and regional food systems, which are the main source of nutrition, income and employment, are strongly affected by these factors. The great challenge for this country of the Sahel is therefore to ensure, in a context of variability and climate change, the food and health security of a growing population. The growing awareness of better nutrition means that a majority of people now establish a direct link between healthy nutrition and good health or conversely, between malnutrition and the appearance of certain diseases (Yeung *et al.*, 2021). The promotion of infant and young child feeding is part of the interventions implemented at the national level in favor of child health. Indeed, strengthening the immune system of children through better quality food would reduce infant and child mortality and prevent acute and chronic malnutrition (Zongo *et al.*, 2013). Oxidative stress is involved in malnutrition through a decrease in antioxidant protection factors and a deterioration of the digestive flora (Houssaini *et al.*, 1997). Other work showed that increasing the dose of antioxidant in the diet of children suffering from malnutrition leads to a reduction of oxidative stress and an improvement in the state of health (Ece *et al.*, 2007; Tatli *et al.*, 2000). In this study, the antiradical test with DPPH showed that the different extracts of the two fruits have an antioxidant property due to their ability to trap free radical DPPH. But *Z. mauritiana* pulp had the best antioxidant activity due to its high contents of total phenolic compounds. Our results are in agreement with the work of previous authors who showed that plants with best antioxidant activity contain high levels of phenolic compounds (Abdel-Hameed, 2009; Adedapo *et al.*, 2008). Compared to the antiradical activity of the reference control Trolox (IC_{50} = 0.012± 0.00 mg/mL,), this result obtained with a raw extract of *Z. mauritiana* pulp shows significant antiradical activity of the active principle contained in this plant. Other previous studies have proven the antioxidant activity of the fruits of these two species by the reduction of the DPPH radical and by the reduction of the ferrous ion (Ajiboye *et al.*, 2015; Lamien-Meda *et al.*, 2008). The antioxidant property of fruit parts is associated with the presence of several phytoconstituents including phenolic compounds such as tannins and flavonoids which would be responsible for the antiradical activity (Cimanga *et al.*, 2001;

Santi *et al.,* 2018). Indeed, flavonoids are recognized as being powerful antioxidants against free radicals due to their property of donating hydrogen atoms available in the hydroxyl substituents of their phenolic groups (Sandhar *et al.,* 2011). Their protective effects in biological systems are linked to their ability to transfer electrons to free radicals, to chelate metals, to activate antioxidant enzymes, or to inhibit oxidases (Bruneton, 2009). Flavonoids in plants are recognized for their effectiveness against fever, edema and inflammation of the mucous membranes in children (Allcarz and Jimenez, 1988; Cody *et al.,* 1986).

All the CMB/CMI ratios as indicated in Table 4 were less than or equal to 4. Indeed, according to some authors (Okou *et al.,* 2018) if the CMB/CMI ratio ≤ 4, the substance tested is bactericidal, and if the CMB/CMI ratio is >4, the substance tested is bacteriostatic. Which would mean that the different parts of fruits of these species are effective against infections caused by *E. coli* and *S. aureus*. But the pulp of *D. guineense* and that of *Z. mauritiana* showed antibacterial activity against *E. coli* with the best minimum inhibitory concentration. Which is an advantage when we know that *E. coli* is the pathogen most often responsible for pediatric infections (Okarska-Napierała *et al.,* 2017). The presence of tannins in extracts could explain the antibacterial activity of the different parts of fruits. In fact, tannins are astringent, antibacterial, antidiarrheal. They have the property to precipitate proteins. Hydrolysable or condensed tannins have antiradical and antioxidant properties expressed by their inhibiting effect on lipid peroxidation and radical scavenging ability on DPPH radical (Bouchet *et al.,* 1998).

Iron and vitamin A deficiencies are among the most common micronutrient deficiencies in Burkina Faso. The control strategies implemented at the national level in favor of child health and against micronutrient deficiencies should take into account the nutritional properties of *Z. mauritiana* and *D. guineense* pulps. Indeed, the results of the study showed that *Z. mauritiana* pulp had a good β-carotene content. Considered as provitamin A, β-carotene contributes to the maintenance of tissues, epidermis and mucous membranes. *Z. mauritiana* pulp also had a good content of Ca, a mineral essential for the constitution of bones and teeth. The presence of Mg in the pulp of this fruit is also an advantage of its use in food. Indeed, Mg plays an important role in energy metabolism and muscle contraction.

D. guineense pulp had the best contents of vitamin C and E. This could explain the fact that the powder of the pulp is preferentially used to treat scurvy and teething problems in children. Indeed, vitamin C is necessary for the maintenance of teeth, gums, bones and blood vessels and is involved in the absorption of iron, while vitamin E is necessary for the maintenance of muscle functions. It stabilizes unsaturated fatty acids and cell membranes. *D. guineense* pulp also had a good Fe content. This mineral is necessary for the synthesis of hemoglobin and the transport of oxygen in the tissues for the production of energy. Most of these micronutrients act as antioxidants and can scavenge free radicals. In addition, the sterols and triterpenes present in the extracts are recognized for their anti-inflammatory and analgesic properties and would allow good growth of child (Ebajo Jr *et al.,* 2015).

CONCLUSION AND APPLICATION OF FINDINGS

The objective of this study was to determine the phytonutrients content and selected biological activities of fruit parts of *Dialium guineense* and *Ziziphus mauritiana* used in the management of childhood diseases. The results obtained showed that *Ziziphus mauritiana* pulp had the best antioxidant activity due to its high contents of total phenolic compounds,

flavonoids, hydrolysable and condensed tannins. It had also the better contents of β-carotene and macroelements while *Dialium guineense* pulp had the best contents of vitamin C and microelements. The pulp of the two fruits showed important antibacterial activity against germ responsible for pediatric infections. *Ziziphus mauritiana* and *Dialium guineense* are widely distributed and adapted to the drought of Sahelian countries. Recommendations of enhancement and promotion of these fruits could constitute important sources for the development of new nutraceuticals and phytomedicines in the prevention and treatment of childhood diseases.

ACKNOWLEDGMENTS

This work has benefited from a government grant managed by the Labex DRIIHM, French program "Investissements d'avenir" ANR-11-LABX-0010, which is managed by the ANR and a grant from the TotalEnergies corporate foundation.

REFERENCES

Abdallah EM, Elsharkawy ER, Ed-dra A, 2016. Biological activities of methanolic leaf extract of Ziziphus mauritiana. *Bioscience Biotechnology Research Communications* 9, 605-614.

Abdel-Hameed E-S, 2009. Total phenolic contents and free radical scavenging activity of certain Egyptian Ficus species leaf samples. *Food Chemistry* 114, 1271-1277. https://www.sciencedirect.com/science/article/pii/S0308814608013083

Achoba I, Lori J, Elegbede J, Kagbu J, 1992. Nutrient composition of black (African) velvet tamarind (Dialium guineense Wild) seed and pulp from Nigeria. *Journal of Food Biochemistry* **16**, 229-233. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1745-4514.1992.tb00448.x

Adedapo AA, Jimoh FO, Afolayan AJ, Masika PJ, 2008. Antioxidant activities and phenolic contents of the methanol extracts of the stems of Acokanthera oppositifolia and Adenia gummifera. *BMC Complementary and Alternative Medicine* 8, 54. https://bmccomplementalternmed.biomedcentral.com/articles/10.1186/1472-6882-8-54

Airaodion AI, Ayita EB, Oluba SO, Emaleku SA., Osunmuyiwa OJ, Megwas AU, 2021a. Chemical Composition and Nutraceutical Potential of Velvet Tamarind (Dialium guineense wild) Fruit Pulp. *Asian Journal of Biochemistry, Genetics and Molecular Biology* 9, 8-19.

Airaodion AI, Oluba SO, Adedeji AA., Emaleku SA, Osunmuyiwa OJ, Megwas AU, Ayita EB, 2021b. Velvet Tamarind (Dialium guineense Wild) Fruit is Potent against Gram-Positive and Gram-Negative Bacteria. *Asian Journal of Medical Principles and Clinical Practice* 4, 83-88.

Ajiboye AE, Ameen MT, Adedayo MR, 2015. Antimicrobial activity and phytochemical screening of the fruit pulp of Dialium guineense (Velvet Tamarind) on some microbial isolates. *Journal of Microbiology and Antimicrobials* 7, 33-41. https://academicjournals.org/journal/JMA/article-full-text/CB2850055191

Allcarz M and Jimenez M, 1988. Flavonoids as anti-inflammatory agents. *Fitoterapia* 59, 25-38. https://ci.nii.ac.jp/naid/10007369526/

Beg MA, Teotia U, Farooq S, 2016. In vitro antibacterial and anticancer activity of

Ziziphus. *J. Med. Plants Stud* 4, 230-233. https://www.plantsjournal.com/archives/2016/vol4issue5/PartD/4-5-14-917.pdf

Black R E, Morris SS, Bryce J, 2003. Where and why are 10 million children dying every year? *The lancet* 361, 2226-2234. https://www.sciencedirect.com/science/article/pii/S0140673603137798

Bouchet N, Barrier L, Fauconneau B, 1998. Radical scavenging activity and antioxidant properties of tannins from Guiera senegalensis (Combretaceae). *Phytotherapy Research* 12, 159-162. https://doi.org/10.1002/(SICI)1099-1573(199805)12:3%3C159::AID-PTR209%3E3.0.CO;2-C

Broadhurst RB and Jones WT, 1978. Analysis of condensed tannins using acidified vanillin. *Journal of the Science of Food and Agriculture* 29, 788-794. https://onlinelibrary.wiley.com/doi/abs/10.1002/jsfa.2740290908

Bruneton J, 2009. "Pharmacognosie-Phytochimie, plantes médicinales, 4e éd., revue et augmentée, Paris, Tec & Doc-Éditions médicales internationales, 2009, 1288 p." ISBN 978-2-7430-1188-8.

Çam M and Hışıl Y, 2010. Pressurised water extraction of polyphenols from pomegranate peels. *Food chemistry* 123, 878-885. https://www.sciencedirect.com/science/article/pii/S0308814610005716

Cimanga K, Ying L, De Bruyne T, Apers S, Cos P, Hermans N, Bakana P, Tona L, Kambu K, Kalenda, D, 2001. Radical scavenging and xanthine oxidase inhibitory activity of phenolic compounds from Bridelia ferruginea stem bark. *Journal of Pharmacy and Pharmacology* 53, 757-761. https://onlinelibrary.wiley.com/doi/abs/10.1211/0022357011775893

Cody V, Middleton E, Harborne JB, 1986. Plant flavonoids in biology and medicine: biochemical, pharmacological, and structure-activity relationships: proceedings of a symposium held in Buffalo, New York, July 22-26, 1985. *Progress in clinical and biological research (USA)*. http://agris.fao.org/agrissearch/search.do?recordID=US881902

Diaby A, 2014. Connaissances, attitudes et pratiques des bénéficiaires et des prestataires de soins dans la prise en charge de la diarrhée avec SRO à faible osmolaritée et le zinc dans les districts pilotes de Joal, Kolda et Fatick Au Sénégal. *Revue Africaine et Malgache de Recherche Scientifique/Sciences de la Santé* 2. http://publication.lecames.org/index.php/sante/article/view/388

Ebajo Jr V D, Shen C-C, Ragasa CY, 2015. Terpenoids and sterols from Hoya multiflora Blume. *Journal of applied pharmaceutical science* 5, 033-039. https://japsonline.com/admin/php/uploads/1472_pdf.pdf

Ece A, Gürkan F, Çelik F, Boşnak M, Yel S, Balık H, Erel Ö, 2007. Paraoxonase, total antioxidant activity and peroxide levels in marasmic children: relationships with leptin. *Clinical biochemistry* 40, 634-639. https://www.sciencedirect.com/science/article/pii/S0009912007001233

Heimler D, Vignolini P., Dini MG, Vincieri FF, Romani A, 2006. Antiradical activity and polyphenol composition of local Brassicaceae edible vareties. *Food chemistry* 99, 464-469. https://www.sciencedirect.com/science/article/pii/S0308814605006758

Houssaini FZS, Arnaud J, Richard M-J, Renversez J-C, Favier A, 1997. Evaluation du stress oxydant et des défenses antioxydantes chez l'enfant

malnutri marocain. *Annals of nutrition and metabolism* 41, 149-159. https://www.karger.com/Article/Abstract/177990

Jedlička A and Klimeš J, 2005. Determination of water-and fat-soluble vitamins in different matrices using high-performance liquid chromatography. *name Chemical Papers* 59, 202. http://fez.schk.sk/view/changeme:5319

Kavit M, Patel B, Jain B, 2013.Phytochemical analysis of leaf extract of Phyllanthus fraternus. *Research Journal of Recent Sciences, ISSN* 2277, 2502.

Kim KS, Lee S, Lee YS, Jung SH, Park Y, Shin KH, Kim BK, 2003. Anti-oxidant activities of the extracts from the herbs of Artemisia apiacea. *Journal of Ethnopharmacology* 85, 69-72. https://www.sciencedirect.com/science/article/pii/S0378874102003380

Kini F, Saba A, Ouedraogo S, Tingueri B, Sanou G, Guissou I, 2008. Potentiel nutritionnel et thérapeutique de quelques espèces fruitières «sauvages» du Burkina Faso. *Pharmacopée et médecine traditionnelle africaine* 15. http://publication.lecames.org/index.php/pharm/article/viewFile/10/9

Koala M, Ramde-Tiendrebeogo A, Ouedraogo N, Ilboudo S, Kaboré B, Kini FB, Ouedraogo S, 2021. HPTLC Phytochemical Screening and Hydrophilic Antioxidant Activities of Apium graveolens L., Cleome gynandra L., and Hibiscus sabdariffa L. Used for Diabetes Management. *American Journal of Analytical Chemistry* 12, 15. DOI:10.4236/ajac.2021.121002

Lamien-Meda A, Lamien C, Compaoré M, Meda R, Kiendrebeogo M, Zeba B, Millogo J, Nacoulma O, 2008. Polyphenol content and antioxidant activity of fourteen wild edible fruits from Burkina Faso. *Molecules* 13, 581-594. https://www.mdpi.com/2712

Lucien JM, 2012. Etude de la transformation du fruit du jujubier (Ziziphus mauritiana Lam.) en galettes: Impact de la cuisson sur la qualité nutritionnelle, Montpellier SupAgro. https://agritrop.cirad.fr/570288/

Makalao MM, Savadogo A, Zongo C, Traore AS, 2015. Composition nutritionnelle de 10 fruits sauvages consommés dans trois départements du Tchad. *International Journal of Biological and Chemical Sciences* 9, 2385-2400. https://doi.org/10.4314/ijbcs.v9i5.11

Marmonier A, 1990. Technique de diffusion en gélose: Méthode des disques. *Bactériologie Médicale, Techniques usuelles*, 237-244.

Mishra T and Bhatia A, 2014. Antiplasmodial effects of the aqueous ethanolic seed extract of *Ziziphus mauritiana* against Plasmodium berghei in Swiss albino mice. *International Journal of Pharmacological Research* 4, 111-116. DOI:107439/ijpr

Ndamobissi R, 2018. La malnutrition des enfants dans les pays du Sahel et de la Corne de l'Afrique: défis sociodémographiques et politiques (Burkina Faso, Niger, Sénégal, Ethiopie, Ghana). *La malnutrition des enfants dans les pays du Sahel et de la Corne de l'Afrique*, 1-256.

Noba A, Koala M, Hema A, Bationo R K, DabirÃ CM, PalÃ E, Nacro M, 2020. Carotenoids identification by HPTLC-MS and vitamin C content of fruits of Saba senegalensis (A. DC) Pichon. *African Journal of Pure and Applied Chemistry* **14,** 60-68. https://academicjournals.org/journal/AJPAC/article-full-text/51A8F5864371

Okarska-Napierała M, Wasilewska A, Kuchar E, 2017. Urinary tract infection in children: Diagnosis, treatment,

imaging–Comparison of current guidelines. *Journal of pediatric urology* 13, 567-573. https://www.sciencedirect.com/science/article/pii/S1477513117303534

Okou OC, Yapo SES, Kporou K E, Baibo GL, Monthaut S, Djaman AJ, 2018. Évaluation de l'activité antibactérienne des extraits de feuilles de Solanum torvum Swartz (Solanaceae) sur la croissance in vitro de 3 souches d'entérobactéries. *Journal of Applied Biosciences* 122, 12287-12295. https://www.ajol.info/index.php/jab/article/view/176730

Onah GT, Ajaegbu EE, Enweani IB, 2022. Proximate, phytochemical and micronutrient compositions of Dialium guineense and Napoleona imperialis plant parts. *GSC Biological and Pharmaceutical Sciences* 18, 193-205. https://gsconlinepress.com/journals/gscbps/content/proximate-phytochemical-and-micronutrient-compositions-dialium-guineense-and-napoleona

Ouédraogo JCW, Dicko C, Kini FB, Bonzi-Coulibaly YL, Dey ES, 2018. Enhanced extraction of flavonoids from Odontonema strictum leaves with antioxidant activity using supercritical carbon dioxide fluid combined with ethanol. *The Journal of Supercritical Fluids* 131, 66-71. https://www.sciencedirect.com/science/article/pii/S0896844617304473

Pinta M, 1973. Méthodes de référence pour la détermination des éléments minéraux dans les végétaux. Détermination des éléments Ca, Mg, Fe, Mn, Zn et Cu par absorption atomique. https://pascalfrancis.inist.fr/vibad/index.php?action=getRecordDetail&idt=PASCAL7332012073

Rao P, 2017. Afrique numérique: Portable à ultrasons pour enrayer la mortalité infantile. *Afrique Renouveau* 30, 38-38. https://doi.org/10.18356/3f470b75-fr

Sandhar HK, Kumar B, Prasher S, Tiwari P, Salhan M, Sharma P, 2011. A review of phytochemistry and pharmacology of flavonoids. *Internationale Pharmaceutica Sciencia* 1, 25-41.

Santi MD, Zunini MP, Vera B, Bouzidi C, Dumontet V, Abin-Carriquiry A, Grougnet R, Ortega MG, 2018. Xanthine oxidase inhibitory activity of natural and hemisynthetic flavonoids from Gardenia oudiepe (Rubiaceae) in vitro and molecular docking studies. *European journal of medicinal chemistry* 143, 577-582. https://www.sciencedirect.com/science/article/pii/S0223523417309741

Sharda B, 2006. Free radicals: emerging challenge in environmental health research in childhood and neonatal disorders. *International journal of environmental research and public health* 3, 286-291. https://www.mdpi.com/1660-4601/3/3/286

Singleton VL, Orthofer R, Lamuela-Raventos RM, 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. *Methods in enzymology*, 152-178. https://www.sciencedirect.com/science/article/pii/S0076687999990171

Tatli MM, Vural H, Koc A, Kosecik M, 2000. Altered anti-oxidant status and increased lipid peroxidation in marasmic children. *Pediatrics International* 42, 289-292. https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1442-200x.2000.01217.x

WHO, 2014. Quantitative risk assessment of the effects of climate change on

selected causes of death, 2030s and 2050s. https://apps.who.in/iris/bitstream/handle/10665/134014/9789241507691_eng.pd

Yabalak E, Emire Z, Adıgüzel AO, Könen Adıgüzel S, Gizir AM, 2020. Wide-scale evaluation of Origanum munzurense Kit Tan & Sorger using different extraction techniques: Antioxidant capacity, chemical compounds, trace element content, total phenolic content, antibacterial activity and genotoxic effect. *Flavour and fragrance journal* 35, 394-410. https://onlinelibrary.wiley.com/doi/abs/10.1002/ffj.3574

Yeung SS, Kwan M, Woo J, 2021. Healthy diet for healthy aging. *Nutrients* **13**, 4310. https://www.mdpi.com/2072-6643/13/12/4310

Zongo U, Zoungrana SL, Savadogo A, Traoré AS, 2013. Nutritional and clinical rehabilitation of severely malnourished children with Moringa oleifera Lam. leaf powder in Ouagadougou (Burkina Faso). https://www.scirp.org/html/15-2700848_36451.htm