



Ethanol and aqueous extracts characterization from guava (*Psidium guajava* L.) and avocado (*Persea americana* Mill.) residues

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Abstract

In Mexico, avocado and guava production generate agronomic residues that contain bioactive compounds as secondary metabolites produced in plants. Their consumption offer favourable health effects; therefore, the objective of the present research was to characterize the bioactive compounds and antioxidant properties in guava (*Psidium guajava* L.) and avocado (*Persea americana* Mill.) residues (pulp or epicarp and leaves) at different ethanol concentrations (T1 100%, T2 75%, T3 50% and T4 25%, v/v) and in aqueous extracts (T5). Avocado epicarp (56.17 mg of EAG g⁻¹ dm) and guava leaves 50% extracts (45.13 mg of EAG g⁻¹ dm) presented the highest total phenol content; consequently, as it was expected avocado epicarp (328.95 TEAC/g dm) and guava leaves 25% extracts (320.01 TEAC/g dm) shown the highest antioxidant capacity. On the other hand, the highest saponins values were at avocado (100.60 mg g⁻¹ dm) and guava leaves (76.96 mg g⁻¹ dm) 25% extracts. Then avocado epicarp and guava leaves extracts are suggested as a high potential for agro-industrial, pharmacological and chemical uses.

Keywords: ethanol extracts; aqueous extracts; total phenols; saponins; antioxidant.

Practical Application: Use of bioactive compounds in Agroindustrial residues to be used to active ingredient in biofilms in order to increase shelf life in fresh meat and fish. On the other hand, to be used of help to efficient ruminal metabolism, reducing methane production and the effect of global warming.

1 Introduction

Now a days there is a functional food tendency, which composition containing bioactive compounds is obtained from plant secondary metabolites as a mechanism defense from anabolism and catabolism from primary metabolites. Their constantly consumption offer favorable health effects (Callejas & Pablo, 2002). These substances are a chemical compounds heterogeneous family of and their presence is related to the species, families or morphological plant part studied (Shahidi & Ambigaipalan, 2015).

Mexican avocado and guava productions occupies the first and fifth, correspondent places in worldwide production (México, 2017; Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria, 2017). Commonly, these crops during harvest, industrial processing, use or consumption generate agronomic residues (endocarp seeds, epicarp and leaves) that could be very important as bioactive compounds in foods by their metabolites presented (Food and Agriculture Organization, 2014).

Several research have reported chlorophylls, carotenoids, flavonoids and saponins found in avocado (Wojdyło et al., 2013; Sharma et al., 2011; Wang et al., 2010) and ascorbic acid, carotenoids, flavonoids, saponins and tannins (Medina & Valdés-Infante Herrero, 2015; Pineda, 2005) in guava as an alternative medicine for stomach diseases, healings, hypoglycemic, among others treatment pathologies (Henao & Márquez, 2018). However, their

use in different industries (pharmaceutical, chemical and food) is be determined by solvent used during the extraction procedure (Ringuelet & Viña, 2013; Beltrán-Delgado et al., 2013; Bucic' -Kojic' et al., 2007).

Water as universal solvent and ethanol low toxicity are the most important solvents that have been found (Xavier et al., 2015). Their polarity is linked not only to the type of interatomic junctions (ionic or covalent type), but also to the presence of polar functional groups (hydroxyl, amino) and because of the form hydrogen bridge ability (Ringuelet & Viña, 2013). Therefore, the objective of the present research was to characterize the bioactive compounds with antioxidant properties in guava (*Psidium guajava* L.) and avocado (*Persea americana* Mill.) residues (pulp or epicarp and leaves) at different ethanol concentrations (T1 100%, T2 75%, T3 50% and T4 25%, v/v) and in aqueous extracts (T5).

2 Materials and methods

Experimental part was carried out at the Agricultural Sciences Faculty, Autonomous University of Mexico State, Toluca, Mexico. Leaves, fruit or fruit parts (epicarp or mesocarp) were obtained from young trees randomly compound mixtures from a rural production area during 2018 winter. Guava (*Indium guajava* L.) variety was Calvillo and avocado (*Persea americana* Mill) variety

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was Hass that were sample from Benito Juarez and Uruapan, Michoacan State, respectably.

Plant material was disinfected with 1% sodium hypochlorite and air forced dried in an oven (Felisa mod. F313A). Leaves and epicarp were dried at 50 °C, 48 h and avocado pulp for 96 h. Finally, dried material was ground until a less 1 mm size was reached (Salem et al., 2011).

2.1 Obtaining extracts by maceration

Ethanol and aqueous extracts were made following Salem et al. (2011) methodology with modifications. Ethanol extracts were performed using it at different concentrations (T1 100%, T2 75%, T3 50% and T4 25%, v/v) and aqueous (T5) extracts were done. Plant extracts were prepared at 125 mg/mL and macerated in darkness for 72 h. Finally, they were placed in a 39 °C water bath, 30min in order to facilitate their filtration, which was carried out in No. 41 (Quantitative 240 nm) Filter Paper and placed in amber bottles. Samples were in refrigeration for 24h.

2.2 Total phenol determination total (TP)

Folin Ciocalteu spectrophotometric determination followed the Arizmendi et al. (2015) and Spizzirri et al. (2009) methodology. 100 uL of each sample were mix with Folin-Ciocalteu reagent 47.8 uL and incubated for 15 min. 0.1% Na₂CO₃ 300 uL were added to 1080 uL distilled water followed of 2 h darkness incubation. Subsequently, 760 nm absorbance was measured in a spectrometer (GENESYS UV-VIS) and expressed in acid gallic (EAG) per g dry matter (dm) equivalence.

2.3 Saponins by solvent separation method determination (Salem et al., 2011).

Saponins quantification started with a secondary metabolites separation using a phase separation funnel. 10mL sample extract were weighed are poured into a funnel with 20mL ethyl acetate (99.7/100, analytical grade, Fermont®) for 30 min. Phase separation was performed with phenols upper phase part that were removed. Lower part (various compounds) were returned to the funnel and 20 mL of n-butanol (99.9/100, analytical grade, Fermont®, Monterrey, Mexico) were added to separate saponins (SP) phase. Subsequently, quantitation was performed by solvent evaporation and results were registered as dried matter (dm) mg g⁻¹ (Makkar et al., 1998; Salem et al., 2011).

2.4 Antioxidant Capacity (AC) (ABTS⁺) determination

Antioxidant capacity was quantified using the ABTS method [2.20-azinobis-(3-ethylbenzothiazoline-6-acid)] by Mehta et al. (2014) and Archundia et al. (2019). Radical formation was performed by 7 mM ABTS solution and 140 mM potassium persulfate reaction dark incubated at 25 °C, 16 h. Fresh radical solution was diluted in ethanol analytical grade to achieve a 0.7 ± 0.02 absorbance at 734 nm. 10 mL plant extract was diluted in ethanol 100 mL; due to, 30 mL of this plant extract solution was mixed with ABTS radical solution 3 mL. Absorbance was measured at 734 nm after 6 min of reaction and results were

expressed in antioxidant capacity of (TEAC) mmol/g dry matter (dm) Trolox equivalence.

2.5 pH determination

pH determination was carried out following Ramírez et al. (2013) methodology. Potential hydrogen (pH) measure was done with a potentiometer (Thermo Scientific Orion STAR A215).

2.6 Experimental design

A randomized multifactorial experimental design (5x3x2) was performed. Five ethanol concentrations treatments T1 100%, T2 75%, T3 50% and T4 25%, (v/v) and aqueous extract (T5) were considered. Three vegetative parts (epicarp, leaves and fruit or mesocarp) and two plant species guava (*Psidium guajava* L.) Calvillo variety and avocado (*Persea americana* Mill) Hass variety were used with three repetitions. Significant differences found ($P \leq 0.05$) were analyzed using a Tukey means test 95%. Stat graphics Plus Version 5.0. Statistical program was used.

3 Results and discussion

3.1 Total Phenol determination

Total phenol (TP) avocado and guava results (Table 1) by solvent concentration or solvent type had shown significant differences between treatments ($P \leq 0.05$) for both species. Highest values concentration was observed for 50% (v/v) ethanol extracts (26.40 mg of EAG g⁻¹ for avocado and 32.08 mg of EAG g⁻¹ dm for guava). Similar results were reported by Monroy-Vázquez et al. (2007) with higher concentrations (2578 mg/mL) from Mexican chile ancho (*Capsicum annum* L. *grossum sendt*) 50% ethanol extracts. Differences were suggested due to solvent polarity. Ethanol is a medium polarity as water is high polarity solvent; in addition to, their allowed to combine and as a result a higher attracting phenols effectiveness were achieved (Archundia et al., 2019).

For avocado vegetative part results (Table 1), epicarp avocado extracts presented the highest total phenol (44.00 EAG g⁻¹ dm). These results are similar to Wang et al. (2010) (12.60 EAG g⁻¹ dm) for Hass variety; besides, it was concluded that avocado seeds and epicarp as a bioactive compounds such as chlorophylls, carotenoids and phenolic compounds (B and A procyanidins) source. TP for guava extracts presented the highest values (29.57 mg of EAG g⁻¹ dm) especially in leaves extracts (Table 1). Guava leaves have been reported with polyphenols (flavonoids, especially quercetin) content (Vargas-Alvarez et al., 2006).

For solvent type or concentration-avocado vegetative part interaction (Table 2). Epicarp 50% ethanol extracts presented the highest TP quantification (56.17 mg of EAG g⁻¹ dm). Similar results were reported by Salmerón (2014) (53.67 mg GAE g⁻¹ dm) from Hass epicarp 80% methanol extracts; nevertheless, methanol extracts are not allowed as food additives. Highest TP guava quantification (45.13 mg of EAG g⁻¹ dm) was found in 50% ethanol-leaves extract interaction (Table 3). Pérez et al. (2014) found lower TP values (9.071 mg of GAE g⁻¹ dm) in young leaves 80% methanol extracts from the same guava variety. Then, total

Table 1. Total phenols, saponins, pH and antioxidant capacity results from the different ethanol concentration and aqueous extracts from avocado and guava residues.

Species	Avocado (<i>Persea americana</i> Mill.)				Guava (<i>Psidium guajava</i> L.)			
Variable	Total Phenols (mg EAG g ⁻¹ dm)	Saponins (mg g ⁻¹ dm)	TEAC (mmol g ⁻¹ dm)	pH	Total Phenols (mg EAG g ⁻¹ dm)	Saponins (mg g ⁻¹ dm)	TEAC (mmol g ⁻¹ dm)	pH
	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}
Concentration (ethanol)								
1) 100%	14.88a	3.81a	173.93a	5.81a	7.61a	1.18a	219.20a	4.56b
2) 75%	22.43b	20.23a	190.28c	6.35b	15.18b	2.89a	237.75b	4.90b
3) 50%	26.40c	19.21a	180.76b	6.41b	32.08d	28.10c	311.55d	5.07c
4) 25%	24.05b	47.18b	196.62d	5.96a	24.17c	44.71d	314.57d	4.61b
5) Aqueous extracts	23.54b	18.45a	192.40c	5.61a	14.13b	9.33b	282.16c	4.20a
Vegetative part or fruit								
Pulp	10.04a	----	1.05a	6.25b	6.95a	----	220.39a	4.36b
Epicarp	44.00b	19.00a	315.95c	6.03a	19.38b	22.48a	284.43b	4.12a
Leaves	12.74a	46.22b	243.40b	5.80a	29.57c	29.14b	314.32c	5.52c

Note: Different letters in the columns indicated significant differences between means ($P \leq 0.05$) and the equal letters indicated that there were no significant differences between means ($P \leq 0.05$). \bar{X} = Medium. EAG g⁻¹ dm = Equivalent of acid Gallic per g in dm, dm = dry matter. TEAC g⁻¹ of dm equivalent of antioxidant capacity in Trolox. ---- = Samples not analysed.

phenol polarity could suggested as higher for the present solvent and guava variety studied (Archundia et al., 2019).

3.2 Saponins by solvent separation method determination (Salem et al., 2011)

Saponins results for both species (avocado and guava) show significant differences between solvents treatments ($P \leq 0.05$) (Table 1). Highest saponins concentration was found in 25% ethanol extracts (v/v) (47.18 mg g⁻¹ and 44.54 mg g⁻¹, avocado and guava, respectively). Koomson et al. (2018) presented similar saponins results in *Solanum torvum* (53.50 mg g⁻¹) 20% ethanol extracts. Saponins are glycosides chemical compounds with a steroidal or triterpenoid type skeleton, where water solubility is facilitated by its high molecular weight, monosaccharide residues presence and aglycone polar groups. Lower saponins solubility has reported from an 80% ethanol solutions concentration; rather than, lower ethanol concentrations performed higher saponins solubility (Donald et al., 2017). Avocado vegetative part extracts with the highest saponins content (46.22 mg g⁻¹ dm) were leaves extracts; likewise, guava leaves extracts presented the highest saponins results (29.14 mg g⁻¹ dm) (Table 1). It has been suggested that this is due to leaves saponins synthesis emerged as plant defense mechanism for their survival against predators (Acamovic & Brooker, 2005).

Avocado saponins solvent concentration-part vegetative interaction results had significant differences ($P \leq 0.05$) (Table 2). 25% ethanol-leaves extracts interaction presented the highest saponins quantification (100.60 mg g⁻¹ dm) that resulted higher than Arukwe et al. (2012) results in avocado ethyl acetate extracts (1.29 mg/100g dm). For guava, the highest saponins quantification was found for the 25% ethanol concentration-leaves extracts interaction (76.96 mg g⁻¹ dm) (Table 3). This value resulted

higher than that Anbuselvi & Jeyanthi (2017) for guava leaves (3.2 mg/g dm) in 70% methanol extracts.

3.3 Antioxidant Capacity (AC)

Avocado and guava 25% ethanol extracts presented the highest AC values (196.62 TEAC/g dm avocado and 314.57 TEAC/g dm for guava) (Table 1). These results agree with Alvis et al. (2012) in AC Curcuma (*Curcuma longa*) 75% ethanol extracts (2649 mg of Trolox/L). For vegetative part results; further, AC in avocado extracts was found (315.95 TEAC/g dm) in epicarp. It has been suggested because of avocado antioxidants reported such as C, E, B₂ and B₆, vitamins, pantothenic acid, potassium, and dietary fiber (Kagawa, 2001) specifically in epicarp (epicatechin) (Nose & Fujino, 1982) and catechin (Terasawa et al., 2006), high antioxidant capacity chemical compounds. AC 314.32 TEAC/g dm guava leaves extracts (Table 1) were the highest values found. It has been suggested due to its vitamin E, C, carotenes, monounsaturated fatty acids, sterols and polyphenols, phenolic acids, such as ferulic acid content; hence, they were attributed as antioxidant fruit capacity causes (Chen & Yen, 2007; Wang et al., 2010; Gutiérrez et al., 2006).

Regarding the avocado type or solvent concentration-vegetative part interaction (Table 2) the AC highest quantification (328.95 TEAC/g dm) was obtained in 25% ethanol epicarp extracts. Present results are higher than Hernández-Ruiz et al. (2015) (165.18 mmol Trolox /g dm) report with the highest AC in avocado peel methanol extracts. For guava extracts the highest AC was found (320.01 TEAC/g dm) (Table 3) in 25% ethanol leaves extracts. Comparable results were presented by Tachakittirungrod et al. (2007) (4.91 mM equivalent trolox/mg dm) in ethanol leaves extracts. Nonetheless, 25% ethanol extracts are more reliable for food industry uses (Archundia et al., 2019).

Table 2. Avocado vegetative part-solvent type or concentration interaction results.

Concentration (ethanol)	Pulp	Epicarp	Leaves	P
	$\bar{X} \pm DS$	$\bar{X} \pm DS$	$\bar{X} \pm DS$	
Total Phenols (mg EAG g ⁻¹ dm)				
1) 100%	7.83 ± 0.08bx	19.66 ± 0.40by	5.06 ± 0.08az	0.0001
2) 75%	7.94 ± 0.07ay	45.45 ± 0.80cx	13.39 ± 2.04by	0.0001
3) 50%	18.92 ± 0.11ay	56.17 ± 0.83cv	19.76 ± 0.07bx	0.0001
4) 25%	5.35 ± 0.87az	5.35 ± 0.87az	15.19 ± 2.25by	0.0002
5) Aqueous extracts	9.17 ± 0.79ay	50.65 ± 0.36bw	10.79 ± 1.10ay	0.0001
<i>p</i>	0.0001	0.0001	0.0008	
Saponins (mg g ⁻¹ dm)				
1) 100%	----	3.88 ± 0.44az	7.44 ± 0.16by	0.0001
2) 75%	----	7.36 ± 0.24ay	53.24 ± 0.44bw	0.0001
3) 50%	----	4.88 ± 0.48az	4.88 ± 0.48az	0.0001
4) 25%	----	40.84 ± 0.52aw	100.60 ± 0.36bv	0.0001
5) Aqueous extracts	----	38.04 ± 0.04bx	17.2 ± 0.16ax	0.0001
<i>p</i>	----	0.0001	0.0001	
TEAC (mmol g ⁻¹ dm)				
1) 100%	0.22 ± 0.03az	301.13 ± 1.88cz	202.63 ± 0.01bz	0.0001
2) 75%	1.10 ± 0.18ay	317.07 ± 7.51cy	252.66 ± 1.08bx	0.0001
3) 50%	1.01 ± 0.01ay	317.07 ± 3.76cy	224.20 ± 0.94by	0.0001
4) 25%	1.69 ± 0.14ax	328.95 ± 2.82cy	274.86 ± 2.81bv	0.0001
5) Aqueous extracts	1.21 ± 0.07ay	325.52 ± 2.82cy	262.66 ± 1.88bw	0.0001
<i>p</i>	0.0001	0.0005	0.0001	
pH extracts values				
1) 100%	6.24 ± 0.34ay	5.75 ± 0.49az	5.43 ± 0.34az	0.1163
2) 75%	6.70 ± 0.15ay	6.20 ± 0.14bz	6.11 ± 0.26cz	0.0298
3) 50%	6.71 ± 0.24by	6.40 ± 0.11az	6.14 ± 0.16az	0.0149
4) 25%	6.26 ± 0.40ay	5.84 ± 0.15az	5.77 ± 0.42az	0.2506
5) Aqueous extracts	5.33 ± 0.03az	5.94 ± 0.39az	5.55 ± 0.47az	0.1821
<i>p</i>	0.0005	0.125	0.1055	

Note: $p \leq 0.05$. Different letters (a, b and c) in the columns indicated significant differences between vegetative part-solvent type or concentration interaction and different letters (v, w, x, y and z) indicated significant differences between treatments or ethanol concentration (T1 100%, T2 75%, T3 50% and T4 25%, v/v) and in aqueous extracts (T5). \bar{X} = Medium. DS = Standard deviation. EAG g⁻¹ dm = Equivalent of acid Gallic per g in dm, dm = dry matter. TEAC g⁻¹ of dm equivalent of antioxidant capacity in Trolox. ---- = Samples not analysed.

3.4 pH

pH results (Table 1) for avocado and guava presented significant differences ($P \leq 0.05$). Avocado range extracts was 5.61 to 6.41, while guava extracts remained in a range of 4.20 to 5.07. Both species presented the same behavior for ethanol or water extracts obtaining pH acids; comparable, ethanol at different concentrations extracts became more basic pH. The most basic pH was 50% ethanol concentration. It was suggested due to the 7.0 water and 6.0 ethanol initial pH; together with, samples pH (around 6.0), maceration hours and temperatures used for extracts isolation. Escribano-Bailón & Santos-Buelga (2003) mentioned that pH determines the phenol solubility degree in the extraction solvent, because it influences the

extraction of the compounds that are potentially water soluble; as a result, absolute ethanol or aqueous extracts exposed to the conditions described above presented lower phenols solubility than ethanol at different concentrations extracts and higher phenolic compounds were found in 50% ethanol solutions as a polarity balance consequence suggestion.

For the vegetative or fruit part factor for both species significant difference ($P \leq 0.05$) were observed. Avocado extracts were from 5.80 to 6.25 pH. Leaves extracts presented more acidic pH than pulp extracts (Table 1). Guava extracts shown 4.12 to 5.52 pH values, which the most acidic pH was epicarp extract (Table 1). Guava leaves extracts presented higher pH values similar to 6.0 pH. It could be suggested because of

Table 3. Guava vegetative part-solvent type or concentration interaction results.

Concentration (ethanol)	Pulp	Epicarp	Leaves	P
	$\bar{X} \pm DS$	$\bar{X} \pm DS$	$\bar{X} \pm DS$	
Total Phenols (mg EAG g ⁻¹ dm)				
1) 100%	1.56 ± 0.33az	8.84 ± 1.77bz	12.42 ± 1.32cz	0.0001
2) 75%	6.21 ± 0.72ay	13.39 ± 0.98by	25.94 ± 0.11cx	0.0001
3) 50%	12.60 ± 0.26aw	38.53 ± 0.15bw	45.13 ± 0.04cv	0.0001
4) 25%	9.10 ± 0.80ax	20.25 ± 1.66bx	43.15 ± 0.08cw	0.0001
5) Aqueous extracts	5.30 ± 0.30ay	15.88 ± 0.57by	21.22 ± 1.52cy	0.0001
<i>p</i>	0.0001	0.0001	0.0001	
Saponins (mg g ⁻¹ dm)				
1) 100%	----	0.56 ± 0.01az	2.88 ± 0.4bz	0.0001
2) 75%	----	6.36 ± 0.84bz	2.2 ± 0.04az	0.0001
3) 50%	----	57.08 ± 4.36bx	22.68 ± 2.96ax	0.0001
4) 25%	----	61.52 ± 4.36bw	76.96 ± 2.36bw	0.0001
5) Aqueous extracts	----	20.2 ± 0.6by	7.68 ± 0.32ay	0.0001
<i>p</i>	----	0.0001	0.0001	
TEAC (mmol g ⁻¹ de dm)				
1) 100%	140.71 ± 1.88ay	212.95 ± 6.57az	303.94 ± 1.88cz	0.0001
2) 75%	76.92 ± 15.92az	318.09 ± 0.94cx	315.45 ± 1.08by	0.0001
3) 50%	301.44 ± 2.87av	318.07 ± 1.88cx	316.14 ± 2.82by	0.0005
4) 25%	309.57 ± 9.38av	319.89 ± 0.08bx	320.07 ± 0.01cx	0.2374
5) Aqueous extracts	273.3 ± 2.17bx	255.16 ± 3.75ay	318.01 ± 2.82cy	0.0001
<i>p</i>	0.0001	0.0001	0.0001	
pH extracts values				
1) 100%	4.28 ± 0.06by	4.25 ± 0.06ay	5.15 ± 0.16cz	0.0018
2) 75%	4.80 ± 0.03aw	4.63 ± 0.05ax	5.78 ± 0.13by	0.0001
3) 50%	4.51 ± 0.07ax	4.33 ± 0.06ay	5.84 ± 0.10by	0.0001
4) 25%	4.14 ± 0.03az	4.05 ± 0.06ay	5.65 ± 0.28by	0.0001
5) Aqueous extracts	4.08 ± 0.02bz	3.35 ± 0.11az	5.16 ± 0.17cz	0.0001
<i>p</i>	0.0001	0.0001	0.0029	

Note: $p \leq 0.05$. Different letters (a, b and c) in the columns indicated significant differences between vegetative part-solvent type or concentration interaction and different letters (v, w, x, y and z) indicated significant differences between treatments or ethanol concentration (T1 100%, T2 75%, T3 50% and T4 25%, v/v) and in aqueous extracts (T5). \bar{X} = Medium. DS = Standard deviation. EAG g⁻¹ dm = Equivalent of acid Gallic per g in dm, dm = dry matter. TEAC g⁻¹ of dm equivalent of antioxidant capacity in Trolox. ---- = Samples not analysed.

different conditions agroclimatic and natural agents during the plant growth until harvesting or sampling time influence; therefore, H⁺ ions concentration in the vacuole from substrates such as sucrose and glucose, causing a putative decrease with slight pH changes and acidity reduction (García et al., 2015; Sánchez et al., 2014).

Vegetative part or fruit-type and solvent type or concentration interaction for avocado extracts included 5.43-6.71 pH values (Table 2). 50% ethanol extract-pulp

extracts interaction were the most alkaline pH (6.71). Guava extracts resulted from 3.35 to 5.84 pH values, where the most alkaline pH value obtained was 50% ethanol-leaves extracts interaction. pH value has a significant effect over phenol extraction as more basic (even approaching 8.0) is it as higher phenol extraction concentration is presented (Sepúlveda et al., 2016). Therefore, it pH solvent extraction and samples, whether vegetative part or fruit used, is suggested relevant for bioactive compounds extraction.

4 Conclusion

Bioactive compounds with antioxidant quantification were achieved in guava (*Psidium guajava* L.) and avocado (*Persea americana* Mill.) residues (pulp or epicarp and leaves) at different ethanol concentrations, where the best concentrations were 50 and 25% ethanol extracts for total phenol and saponins determinations with AC, respectively. Avocado epicarp with guava leaves and both species leaves under the analyzed conditions presented the highest bioactive compounds studied (total phenol and saponins, respectively). Antioxidant capacity was proportional to total phenols amount obtained. Avocado epicarp or guava leaves-25% ethanol interaction presented the best AC. Finally, according to previous reports avocado epicarp and guava leaves 25 or 50% ethanol extracts are putative potential options for human and animal food supplements food; in addition, present extracts studied are suggested as agro-industrial, pharmaceutical and chemical products active ingredients.

References

- Acamovic, T., & Brooker, J. (2005). Biochemistry of plant secondary metabolites and their effects in animals. *The Proceedings of the Nutrition Society*, 64(3), 403-412. <http://dx.doi.org/10.1079/PNS2005449>. PMID:16048675.
- Alvis, A., Arrazola, G., & Martinez, W. (2012). Evaluación de la actividad y el potencial antioxidante de extractos hidro-alcohólicos de cúrcuma (*Cúrcuma longa*). *Información Tecnológica*, 23(2), 11-18. <http://dx.doi.org/10.4067/S0718-07642012000200003>.
- Anbuselvi, S., & Jeyanthi, R. (2017). Phytochemical biochemical and antimicrobial activity of *Psidium guajava* leaf extract. *Journal of Pharmaceutical Sciences and Research*, 9(12), 2431-2433. Retrieved from <https://www.jpsr.pharmainfo.in/Documents/Volumes/vol9Issue12/jpsr09121726.pdf>
- Archundia, E. D., Pinzón, D. L., Salem, A., Mendoza, P., & Mariezcurrena, M. D. (2019). Antioxidant and antimicrobial capacity of three agroindustrial residues as animal feeds. *Agroforestry Systems*, 1, 1-10. <http://dx.doi.org/10.1007/s10457-018-00343-7>.
- Arizmendi, D., Gómez, R., Dublán, O., Gómez, V., & Domínguez, A. (2015). Estudio de resonancia paramagnética electrónica de la relación peróxido de hidrógeno/ácido ascórbico como par iniciador redox en el ácido inulin-gálico molecular reacción de injerto. *Science Direct*, 136(1), 350-357. <http://dx.doi.org/10.1016/j.carbpol.2015.09.037>.
- Arukwe, U., Amadi, B. A., Duru, M. K. C., Agomuo, E. N., Adindu, E. A., Odika, P. C., Lele, K. C., Egejuru, L., & Anudike, J. (2012). Chemical composition of *Persea americana* leaf, fruit and seed. *International Journal of Research and Reviews in Applied Sciences*, 11(2), 346-349. Retrieved from https://www.arpapress.com/Volumes/Vol11Issue2/IJRRAS_11_2_20.pdf
- Beltrán-Delgado, Y., Morris-Quevedo, H. J., De la Cruz, R. E., Quevedo-Morales, Y., & Bermúdez-Savón, R. C. (2013). Contenido de fenoles totales en extractos de *Pleurotus* obtenidos con solventes de diferente polaridad. *Revista Cubana de Investigaciones Biomédicas*, 32(2), 121-129. Retrieved from http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-03002013000200001
- Bucic' -Kojic', A., Planinic', M., Tomas, S., Bilic', M., & Velic', D. (2007). Study of solid-liquid extraction kinetics of total polyphenols from grape seeds. *Journal of Food Engineering*, 81(1), 236-242. <http://dx.doi.org/10.1016/j.jfoodeng.2006.10.027>.
- Callejas, T., & Pablo, A. (2002). *Obtención de extractos de plantas en medios ácidos y/o alcohólicos para aplicaciones medicinales y alimenticia* (Doctoral dissertation). Universidad Nacional de Colombia, Manizales. Retrieved from <http://www.bdigital.unal.edu.co/1173/1/angelaandregonzalezvilla.2004.pdf>
- Chen, H. Y., & Yen, G. C. (2007). Antioxidant activity and free radical-scavenging capacity of extracts from guava (*Psidium guajava* L.) leaves. *Food Chemistry*, 101(2), 686-694. <http://dx.doi.org/10.1016/j.foodchem.2006.02.047>.
- Donald, D., Valencia, E., Cuyos, M., & Dueñas, R. (2017). Extracción, identificación y evaluación de saponinas en *Agaricus bisporus*. *Biotempo*, 5, 3-36. <http://dx.doi.org/10.31381/biotempo.v5i0.889>.
- Escribano-Bailón, M., & Santos-Buelga, C. (2003). Polyphenol extraction from foods. In C. Santos-Buelga & G. Williamson (Eds.), *Methods in polyphenol analysis* (pp. 1-16). Cambridge: Royal Society of Chemistry.
- Food and Agriculture Organization – FAO. (2014). *Residuos agrícolas y residuos ganaderos de FAO*. Rome: FAO. Retrieved from <http://www.fao.org/3/a-bp843s.pdf>
- García, E. M., Fernández, I., & Fuentes, A. (2015). *Determinación de polifenoles totales por el método de Folin-Ciocalteu*. España: Escuela Técnica Superior de Ingeniería Agronómica y del Medio Natural, Universidad Autónoma de Valencia. Retrieved from <https://riunet.upv.es/handle/10251/52056>
- Gutiérrez, A., Ledesma, L., García, I., & Grajales, O. (2006). Capacidad antioxidante total de los alimentos convencionales y regionales en Chiapas, México. *Revista Cubana de Salud Pública*, 33, 4-5. Retrieved from http://scielo.sld.cu/scielo.php?script=sci_arttext&ndpid=S0864-34662007000100008
- Henaó, G. J., & Márquez, L. Z. (2018). *Aprovechamiento de los residuos sólidos orgánicos* (Doctoral dissertation). Universidad de Antioquia, Medellín, Colombia. Retrieved from <http://tesis.udea.edu.co/dspace/bitstream/10495/45/1/AprovechamientoRSOUenColombia.pdf>
- Hernández-Ruiz, K. L., Ruiz Cruz, S., Rodríguez-Castro, C. A., Gassós-Ortega, L. E., & Valenzuela-López, C. C. (2015). Aplicación de extractos de subproductos de tomate, granada y aguacate y su efecto en la calidad antioxidante de aguacate fresco cortado. In *Congreso Internacional "CUCCAL"* (pp. 88-94). México: Sociedad Mexicana de Inocuidad y Calidad para Consumidores de Alimentos. Retrieved from <https://someicca.com.mx/wp-content/uploads/Memorias-del-Congreso-CUCCAL-8.pdf>
- Kagawa, Y. (2001). *Gotei Shokuhin Seibun Hyo (Standard Tables of Food Composition in Japan Fifth Edition)*. Tokyo: Kagawa Nutrition University Press.
- Koomson, D. A., Kwakye, B. D., Darkwah, W. K., Odum, B., Asante, M., & Aidoo, G. (2018). Phytochemical constituents, total saponins, alkaloids, flavonoids and vitamin C contents of ethanol extracts of five *Solanum torvum* fruits. *Pharmacognosy Journal*, 10(5), 946-950. <http://dx.doi.org/10.5530/pj.2018.5.160>.
- Makkar, H., Sen, S., Blummel, M., & Becker, K. (1998). Effects of fractions containing saponins from *Yucca schidigera*, *Quillaja saponaria* and *Acacia auriculiformis* on rumen fermentation. *Journal of Agricultural and Food Chemistry*, 46(10), 4324-4328. <http://dx.doi.org/10.1021/jf980269q>.
- Medina, N.N., and Valdés-Infante Herrero, J. (2015). Guava (*Psidium guajava* L.) cultivars: an important source of nutrients for human health. In M. S. J. Simmonds & V. R. Preedy (Eds.), *Nutritional composition of fruit cultivars* (pp. 287-315). Cambridge: Academic Press. <https://doi.org/10.1016/B978-0-12-408117-8.00013-1>.
- Mehta, S., Soni, N., Satpathy, G., & Gupta, R. (2014). Evaluation of nutritional, phytochemical, antioxidant and antibacterial activity of dried plum (*Prunus domestica*). *Journal of Pharmacognosy and Phytochemistry*, 3(2), 166-171. Retrieved from http://www.phytojournal.com/vol3Issue2/Issue_jul_2014/3-3-3.1.pdf

- México. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación SAGARPA. (2017). *Aumenta 8.2 Por Ciento Producción de Guayaba en México en el último Trienio*. México: SAGARPA. Retrieved from http://www.sagarpa.gob.mx/Delegaciones/distribufederal/boletines/2017/enero/Documents/JAC_0006-3.PDF
- Monroy-Vázquez, A., Totosaus, A., González-González, L. R., De la Fuente-Salazar, K. A., & García-Martínez, I. (2007). Antioxidantes I. Chile ancho (*Capsicum annum* L. *grossum* sendt.) y romero (*Rosmarinus officinalis* L.) como fuentes naturales de antioxidantes. *Ciencia y Tecnología*, 6, 112-116. Retrieved from https://www.researchgate.net/publication/28228511_Antioxidantes_I_Chile_ancho_Capsicum_annum_L_grossum_sendt_y_romero_Rosmarinus_officinalis_L_como_fuentes_naturales_de_antioxidantes
- Nose, M., & Fujino, N. (1982). Antioxidant activities of some vegetable foods and active component of avocado epicarp. *Nippon Shokuhin Kogyo Gakkaishi*, 29(9), 507-512. <http://dx.doi.org/10.3136/nshkk1962.29.9.507>.
- Pérez, E., Ettiene, G., Marín, M., Cassaca, A., Silva, N., Raga, J., González, C., Sandoval, L., & Medina, D. (2014). Determinación de fenoles y flavonoides totales en hojas de guayabo (*Psidium guajava* L.). *Revista de la Facultad de Agronomía*, 31, 60-67. Retrieved from http://150.187.103.120/revfacagronluz.org.ve/html/PDF/enero_marzo2014/v31n1a20146077.pdf
- Pineda, A. (2005). *Determinación de las propiedades antioxidantes de variedades de injerto (Pouteria viridis) que se cultivan en tres regiones de Guatemala* (Tesis de maestría). Universidad de San Carlos de Guatemala, Guatemala. Retrieved from <https://biblioteca-farmacia.usac.edu.gt/Tesis/QB807.pdf>
- Ramírez, A., Duque, J., Moreno, D., & Martínez, D. (2013). *Determinación de pH y acidez de productos*. Fusagasugá, Colombia: Facultad de Ingeniería Ambiental, Universidad de Cundinamarca. Retrieved from <https://es.scribd.com/document/167156731/Determinacion-de-Ph>
- Ringuelet, J., & Viña, S. (2013). *Productos naturales vegetales*. Buenos Aires, Argentina. Editorial de la Universidad de la Plata.
- Salem, N., Msaada, K., Hamdaoui, G., Limam, F., & Marzouk, B. (2011). Variación en la composición fólica y actividad antioxidante durante el desarrollo floral del cártamo (*Cartamus tinctorius* L.). *Journal of Agricultural and Food Chemistry*, 59(9), 4455-4463. <http://dx.doi.org/10.1021/jf1049936>. PMID:21434653.
- Salmerón, M. L. (2014). *Fracción indigestible, bioaccesibilidad in vitro y actividad antioxidante, de compuestos fenólicos de la cáscara de aguacate cv. "hass"* (Tesis de maestría). Centro de Investigación en Alimentación y Desarrollo, A.C. Sonora, México. Retrieved from <https://ciad.repositorioinstitucional.mx/jspui/bitstream/1006/391/1/SALMERON-RUIZ-ML14.pdf>
- Sánchez, L. C. A., Real, C. P. V., & Perez, Y. B. (2014). Effect of an edible crosslinked coating and two types of packaging on antioxidant capacity of castilla blackberries. *Food Science and Technology (Campinas)*, 34(2), 281-286. <http://dx.doi.org/10.1590/fst.2014.0047>.
- Sepúlveda, C., Ciro, G., & Zapata, E. (2016). Extracción de compuestos fenólicos y actividad antioxidante de hojas de *Bixa orellana* L. (achiote). *Revista Cubana de Plantas Medicinales*, 21(2), 133-144. Retrieved from http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1028-47962016000200002
- Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria – SENASICA. (2017). *México: Primer Productor Mundial de Aguacate*. México: SENASICA. Retrieved from <https://www.gob.mx/senasica/articulos/mexico-primer-productor-mundial-de-aguacate?idiom=es>
- Shahidi, F., & Ambigaipalan, P. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects- a review. *Journal of Functional Foods*, 18, 820-897. <http://dx.doi.org/10.1016/j.jff.2015.06.018>.
- Sharma, R., Joshi, V., & Rana, J. (2011). Nutritional composition and process sed products of quince (*Cydonia oblonga* Mill.). *Indian Journal of Natural Products and Resources*, 2(3), 354-357. Retrieved from https://www.researchgate.net/publication/267800315_Nutritional_composition_and_processed_products_of_Quince_Cydonia_oblonga_Mill
- Spizzirri, U. G., Iemma, F., Puoci, F., Cirillo, G., Curcio, M., Parisi, O., & Picci, N. (2009). Synthesis of antioxidant polymers by grafting of gallic acid and catechin on gelatin. *Biomacromolecules*, 10(7), 1923-1930. <http://dx.doi.org/10.1021/bm900325t>. PMID:19413362.
- Tachakittirungrod, S., Okonogi, S., & Chowwanapoonpohn, S. (2007). Study on antioxidant activity of certain plants in Thailand: Mechanism of antioxidant action of guava leaf extract. *Food Chemistry*, 103(2), 381-388. <http://dx.doi.org/10.1016/j.foodchem.2006.07.034>.
- Terasawa, N., Sakakibara, M., & Murata, M. (2006). antioxidative activity of avocado epicarp hot water extract. *Food Science and Technology Research*, 12(1), 55-58. <http://dx.doi.org/10.3136/fstr.12.55>.
- Vargas-Alvarez, D., Soto-Hernández, M., González-Hernández, V. A., Mark-Engleman, E., & Martínez-Garza, A. (2006). Cinética de acumulación y distribución de flavonoides en guayaba (*Psidium guajava* L.). *Agrociencia*, 40(1), 109-115. Retrieved from <http://www.redalyc.org/articulo.oa?id=30240111>
- Wang, W., Bostic, T., & Gu, L. (2010). Antioxidant capacities, procyanidins and pigments in avocados of different strains and cultivars. *Food Chemistry*, 122(4), 1193-1198. <http://dx.doi.org/10.1016/j.foodchem.2010.03.114>.
- Wojdyło, A., Oszmiański, J., & Bielicki, P. (2013). Polyphenolic composition, antioxidant activity, and polyphenol oxidase (PPO) activity of quince (*Cydonia oblonga* Miller) varieties. *Journal of Agricultural and Food Chemistry*, 61(11), 2762-2772. <http://dx.doi.org/10.1021/jf304969b>. PMID:23461298.
- Xavier, L., Freire, M., Vidal-Tato, I., & González-Álvarez, J. (2015). Application of aqueous two phase systems based on polyethylene glycol and sodium citrate for the recovery of phenolic compounds from Eucalyptus wood. *Maderas. Ciencia y Tecnología*, 17(2), 345-354. <http://dx.doi.org/10.4067/S0718-221X2015005000032>.