

## Short Communication

### Note on in vitro digestion of avocado products for pigs

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(Submitted 26 March 2020; Accepted 31 December 2020; Published 2 February 2021)

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## Abstract

In vitro (pepsin/pancreatin) digestibility coefficients of pulp, seed, and peel of avocados of the Creole and Hass varieties were studied according to a 2 x 3 factorial arrangement in which the factors were the variety and parts of the fruit. Creole avocado were heavier in natura than Hass exemplars (310.7 g and 156.8 g), whereas Hass had a greater proportion of pulp than the Creole fruits (76.0% and 64.6%). No significant interactions were observed. In vitro digestibility of dry matter (DM), organic matter (OM), and nitrogen (N) were higher for the Creole variety compared with the Hass. In vitro digestibility of N was similar in the pulp and seeds, and higher than in the peels (731, 773, and 550 g/kg<sup>-1</sup>, respectively). Use of the entire avocado as pig feedstuff would have a lower nutritional value compared with feeding just avocado pulp. Supplementation of a diet based on avocado with additional protein may be needed for optimal production.

**Keywords:** avocado, digestibility, pancreatin, pepsin

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The Hass avocado (*Persea americana* Mill) is a tropical fruit that is produced in Mexico (Zafar & Sidhu, 2018). In fact, Mexico leads the world in the production of avocados, with a contribution of 30%, the state of Nayarit being a primary area of production (SIAP, 2017).

In processing avocados, substantial quantities of the fruit are discarded. This by-product has high nutritional value and could be destined for animal feeding (Skenjana *et al.*, 2006; Grageola *et al.*, 2010; Skenjana, 2011; Carter, 2015; Carter *et al.*, 2015; Eliyahu *et al.*, 2015; Fránquez *et al.*, 2017). These local by-products could partially replace imported feed ingredients and reduce production costs (Woyengo *et al.*, 2014; Romero-Huelva *et al.*, 2017). Increasing the level of avocado flour in rations for sheep reduced the cost of the diet without affecting their performance (Lemus *et al.*, 2020). Avocado bagasse, the by-product of processing avocados for human consumption, has been evaluated as a feedstuff for ruminant animals (Skenjana *et al.*, 2006; Skenjana, 2011). However, few studies have evaluated avocado materials for use in feeding pigs, which is common practice in the extensive backyard pig production of rural Mexico (Grageola *et al.*, 2010; Wang *et al.*, 2016).

The in vitro digestibility (pepsin/pancreatin) technique is a rapid and useful way to determine the nutritive value of nonconventional feed resources (Dierick *et al.*, 1985; Boisen & Fernández, 1995). Thus, the aim of the current study was to assess the nutritive value of avocado materials of possible use for feeding pigs by applying the in vitro digestibility technique.

Pulp, peel and seeds from Hass and Creole avocados were used in this study. A total of 32 ripe fruits of each variety were collected from two local markets and two avocado plantations in Nayarit at the end of the harvest. Physical composition was determined by manual separation of pulp, seed and peel. The number of assays was reduced to eight per avocado cultivar by thoroughly mixing the parts from four fruits. The concentrations of DM (method 930.15) and N (method 984.13A-D) were determined in fresh aliquots from the samples (AOAC, 2006) and then the samples were dried in an oven at 60 °C. Organic matter content was calculated as 100 minus the percentage of ash. High-pressure liquid chromatography was used to

determine the amino acid content of the samples (AOAC, 2006) (method 982.30E) after acid hydrolysis of three lyophilized samples. In vitro digestibility of DM, OM, and N were determined according to Dierick *et al.* (1985). In brief, the samples were incubated with pepsin and 1 g/L HCl 0.075 N (pH 2.0) in a 39 °C bath with periodic agitation. Then 0.05 N NaOH was added to neutralize the solution, and incubation progressed for another four hours with a mixture of porcine pancreatin enzymes and 1 g/L phosphate buffer (pH 6.9). At the end of the incubation period, the samples were filtered and the residue was isolated, washed with ethanol (95%) and acetone (99.5%), and dried, and digestibility was estimated gravimetrically. Analytical grade casein was used as the reference material. All determinations were carried out in duplicate.

Data were analysed using Minitab 13.31 (Minitab Co. State College, Pennsylvania, USA). Tests of significance were made using analysis of variance, and mean separation was carried out using the Duncan multiple range test when the analysis of variance revealed significant ( $P < 0.05$ ) differences between treatments.

There were few similarities in the amino acid composition of avocados reported by Hall *et al.* (1980) and those obtained in this investigation (Table 1). More studies should be conducted to provide a more definitive characterization of the amino acid composition of avocado materials.

**Table 1** Amino acids profile of whole fresh avocado paste from Hass and Creole varieties (dry matter basis)

Amino acid	g/kg dry matter		g/kg amino acid	
	Mean	Standard deviation	Mean	Standard deviation
Methionine	0.8	0.1	21.8	0.3
Cysteine	0.6	0.1	15.7	0.1
Lysine	2.2	0.3	60.4	0.7
Threonine	1.9	0.2	52.5	0.4
Arginine	2.1	0.3	58.6	0.5
Isoleucine	2.0	0.3	54.8	3.2
Leucine	3.3	0.4	90.6	0.4
Valine	2.5	0.3	66.8	0.6
Histidine	1.0	0.1	28.0	0.4
Phenylalanine	2.2	0.3	60.7	1.2
Glycine	2.3	0.3	62.6	0.1
Serine	2.2	0.3	59.4	0.8
Proline	2.4	0.3	64.1	1.0
Alanine	2.7	0.3	72.9	1.4
Aspartic acid	4.0	0.5	109.1	1.0
Glutamic acid	4.5	0.6	123.0	0.7

There were no significant interactions between cultivars and the parts of the fruits. All parts and the entire Creole avocados were heavier in natura ( $P < 0.001$ ) than the Hass exemplars. However, compared with the Creole cultivar, Hass avocados had significantly greater proportions of pulp ( $76 \pm 2$  and  $65 \pm 2\%$ , respectively) and peel ( $10 \pm 1$  and  $12 \pm 1\%$ , respectively). The weights of the pulp, seed, peel and entire avocado fruits are shown in Table 2.

Some aspects of avocado chemical composition and in vitro digestibility coefficients (pepsin/pancreatic) are shown in Table 3. For comparison, Fránquez *et al.* (2017) reported that the fresh paste of whole avocado contained 32.34% DM, 3.33% ash, 14.33% crude fibre, 49.13% crude fat, and 9.20% crude protein. Both Creole- and Hass-type avocado samples showed a typical low N content (Hall *et al.*, 1980; Tango *et al.*, 2004; Vekiari *et al.*, 2004; Mooz *et al.*, 2012). There was a tendency for the N concentration to be higher in the pulp and peel than in the seeds.

**Table 2** Physical composition of Creole and Hass avocado fruits, based on 16 samples of each cultivar

Material	Cultivar		SE	P-value
	Creole	Hass		
Pulp	201.2	119.3	8.4	<0.001
Seed	79.6	18.2	3.3	<0.001
Peel	29.9	19.2	2.5	<0.001
Entire fruit	310.7	156.8	7.6	<0.001

**Table 3** Chemical composition and in vitro digestibility coefficients of Creole and Hass avocados from Nayarit state of Mexico (dry matter basis)

	Creole	Hass	SE	P-value	Pulp	Seed	Peel	SE	P-value
<i>Composition, g/kg<sup>-1</sup></i>									
n	8	8			16	16	16		
Dry matter	251.8	336.7	15.6	>0.05	227.0 <sup>a</sup>	429.0 <sup>b</sup>	226.6 <sup>a</sup>	10.2	0.002
Ash	31.8	25.9	1.9	>0.05	34.5 <sup>a</sup>	13.4 <sup>b</sup>	33.5 <sup>a</sup>	1.6	0.045
Organic matter	968.2	974.1	2.0	>0.05	965.5 <sup>a</sup>	982.6 <sup>b</sup>	965.5 <sup>a</sup>	1.5	0.033
Nitrogen	10.3	11.4	0.5	>0.05	12.3	8.8	11.6	0.4	0.055
<i>Digestibility, g/kg<sup>-1</sup></i>									
n	12	12			8	8	8		
Dry matter	553	435	17.8	0.035	631 <sup>a</sup>	460 <sup>b</sup>	392 <sup>b</sup>	22.1	0.010
Organic matter	567	442	18.9	0.025	635 <sup>a</sup>	466 <sup>b</sup>	414 <sup>b</sup>	28.6	0.050
Nitrogen	591	449	28.9	0.020	731 <sup>a</sup>	774 <sup>a</sup>	550 <sup>b</sup>	46.5	0.001

<sup>a,b,c</sup> Means in the same row with different letters differ significantly ( $P < 0.05$ )

The casein standard has in vitro DM digestibility of 0.973 and N digestibility of 0.990. In this assay, in vitro digestibility values for DM, OM, and N were higher ( $P < 0.05$ ) for Creole fruit than for the Hass avocado (Table 3) and the digestibility of DM and OM from the pulp was higher than for seeds and peels. However, the digestibility of N was similar in pulp and seeds, but higher than peels. The in vitro evaluations observed in this study tended to follow those found in vivo by Grageola *et al.* (2019), who observed that in situ digestibility of nutrients was higher in the entire fruit compared with seeds alone and mixed with peels. This result can be attributed to the higher digestibility of pulp compared with seeds and peels, as was found in the current investigation. The numerical dispersion of N digestibility was greater than that observed for either DM or OM.

The entire avocado fruit could be used as feed for pigs because of its high digestibility. However, the entire avocado as pig feedstuff would have lower nutritional value than the pulp. In application, the nutritive value of fruits varies according to the cultivar. Supplemental protein is likely to be needed if avocado is to comprise a significant portion of the diet for pigs. Additional evaluations should be undertaken to confirm the present results and to explore this nutritive value in avocado products that could be used to feed pigs.

#### Acknowledgments

Financial support was provided by the Biological, Zootechnical and Fishing Postgraduate Program of the Autonomous University of Nayarit, México. Thanks are expressed by the authors to Evonik, Mexico S.A. de C.V., for and participation in the amino acid determination of avocados used in the experimental work.

#### Authors' Contributions

JL designed the experiment, conducted the laboratory analyses, collaborated in interpreting the results, and wrote the initial draft of this manuscript. PF conducted the laboratory analysis, and collected the data for this study. GR conducted

the statistical analyses, collaborated in interpreting the results, and revised the initial draft of this manuscript. CL conducted the statistical analyses, collaborated in interpreting the results. IAD collaborated in interpreting the results, revised initial draft of this manuscript; FG developed the original hypotheses, designed the experiment, collaborated in interpreting the results, and finalized the manuscript. All authors have read and approved the finalized manuscript.

### Conflict of Interest Declaration

The authors have no conflicts of interest relative to this work.

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