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Use of Avocado and Tomato Paste as Ingredients to Improve Nutritional Quality of Pork Frankfurter

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Abstract

The objective of this research was to study the effect of avocado pulp (A) and tomato paste (T) addition on the physicochemical, nutritional and sensory quality of pork frankfurters. Treatments were: 1) Control; 2) A10 = 10% A; 3) A20 = 20% A; 4) T10 = 10% T; 5) T20 = 20% T; and 6) A10+T10 = 10% A+10% T. Colour (L^*, a^* and b^*), fatty acid profile, contents of phenols and flavonoids, and antioxidant capacity were measured. In the same way, sensory analysis was evaluated. Tomato paste decreased L^* but increased ($P < 0.05$) a^* and b^* values. On the other hand, A did not affect L^*, decreased a^* and increased b^*. Avocado pulp increased ($P < 0.05$) the proportion of monounsaturated fatty acids in the finished product. Antioxidant activity increased ($P < 0.05$) with incorporation of T, much higher than that observed by adding A. Frankfurters with T and with a combination of T and A had the best acceptance by the sensory panel. The use of T and A can be a good strategy to improve nutritional quality and antioxidant properties of pork frankfurters.

Keywords: functional foods, *Lycopersicum esculentum*, *Persea americana*

1. Introduction

One negative aspect that has come to affect the marketing and consumption of meat and meat products is its possible association as causal agent of cardiovascular disease (CVD) and certain types of cancer, due to its contents of saturated fat, cholesterol and salt (Cross et al., 2007; Marmot, 2007). This issue presents a challenge for the food technologist and at the same time an opportunity for the meat industry to innovate and develop new food alternatives that tend to maintain consumer's health. One of these opportunities to achieve the innovation and transformation of meat is in the field of functional foods (Jiménez-Comenero, 2007; Bhat & Bhat, 2011). Strategies for the development of functional meat products are diverse, one of them being the reformulation of meat products (Jiménez-Colmenero et al., 2010).

Several studies have shown the feasibility of adding different ingredients in the formulation of meat products such as dietary fibre (Garcia et al., 2002; Kerr et al., 2005), natural antioxidants (Alves et al., 2012; Doménech-Asensi et al., 2013) or polyunsaturated fatty acids (Rodríguez-Carpena et al., 2012; Singh et al., 2011).

Tomato and avocado are fruits that when consumed as part of a daily diet can provide several health benefits. Tomato is an excellent source of vitamins, minerals, and phytochemical compounds like lycopene (Erge & Karadeniz, 2011; Navarro-González et al., 2011). It has been demonstrated that consumption of foods rich in

lycopene, as tomato and its by-products, improve health due to its following properties: anti-inflammatory and anticoagulant (Yaping et al., 2003), anticarcinogenic (Guttenplan et al., 2001; Wertz et al., 2004) and antioxidant (Borguini & Ferraz Da Silva Torres, 2009). Avocado is a food rich in unsaturated fatty acids (Dreher & Davenport, 2013) tocopherols, phytosterols, phenolic compounds, and procyanidins (Wang et al., 2010); and it has been demonstrated that its consumption diminishes cancer incidence (Ding et al., 2007; Ding et al., 2009).

To take advantage of the biological properties of tomato and avocado they could be used as ingredients in meat products of major consumption as pork frankfurters. However, it is necessary to know the correct amount to which they should be added, without compromising the quality of the new meat product. Therefore, the objective of the present study was to evaluate the effect of addition of tomato paste and avocado pulp on the physicochemical, sensory and nutritional properties of pork frankfurters.

2. Materials and Methods

2.1 Experimental Design

Quality characteristics of pork frankfurters as affected by avocado pulp (A) and tomato paste (T) addition were studied. Both ingredients were incorporated into the formulation according to the following treatments: Control (without addition of A and T), treatment with 10% of A (A10), treatment with 20% of A (A20), treatment with 10% of T (T10), with 20% of T (T20) and treatment with 10% of A and 10% of T (A10+T10). Product quality was evaluated by determination of pH, colour, proximate analysis, sensory analysis, fatty acids profile, antioxidant, and total phenols and flavonoids. One-way analysis was performed on quality measurements with Number Cruncher Statistical Systems 2007 (NCSS, Kaysville, UT) software (Hintze, 2007). Significant differences were estimated at a probability level in the type I error of 0.05. When significant differences between treatments were found Tukey multiple range test was performed.

2.2 Ingredient Acquisition and Meat Preparation

For the preparation of pork frankfurter, 3 kg lots were used for each treatment. Meat (73% moisture, 6% fat, 20% protein, 1% ash), avocado (77% moisture, 15% fat, 1.86% protein, 1.55% ash, 4.65% carbohydrate), tomato paste (80% moisture, 0.4% fat, 2.3% protein, 3.1% ash, 14.2% carbohydrate) and 2% of polish-sausage-seasoning-spice unit (Excalibur Seasoning Company LTD, Pekin, IL, USA), were obtained from the local market. Pork meat was cut into 5 × 5 cm and was transferred to a cutter (Kilia Fleischereimaschinenfabrik, Kiel, Germany), where particle size was reduced to a fine paste. Subsequently salts, condiments, and the rest of the ingredients for the emulsion were added. The entire process was carried out in the shortest time possible (no more than 5 min), not exceeding a temperature of 10 °C.

Once the emulsion was obtained, the meat batter was stuffed (RISCO RS 2050, NJ, USA) into collagen casings (2 × 10 cm). Product was cooked in a smoke house oven (EnviroPak CVU350E, OR, USA) to an internal temperature of 71.1 °C. After heat treatment, product was subjected to a cold water bath (5 min) and subsequently refrigerated at 2 °C.

2.3 Proximate Composition, Colour and pH

Moisture, ash, protein and fat content were determined according to AOAC methods (AOAC, 2011). Moisture (g water/100 g sample) was determined by drying a 5 g sample at 100 °C to constant weight. Ash was performed at 550 °C for 4 h (g ash/100 g sample). Protein (g protein/100 g sample) was analysed according to the micro-Kjeldahl method. Factor 6.25 was used for conversion of nitrogen to crude protein. Fat (g fat/ 100 g sample) was calculated by weight loss after an extraction with petroleum ether in a goldfish apparatus. Surface colour was measured with a Minolta colorimeter using the D65 illuminant and 10° standard observer (Chroma meter CR-400, Konica Minolta Sensing, Inc., Osaka, Japan) recording L^*, a^* and b^* values. L^* indicates lightness; a^* redness; and b^* yellowness. For pH measurement, 5 g of ground patty sample was weighed into 100 mL beakers and 45 mL of distilled water was added and the mixture homogenized. A portable pH meter (Hanna, Model HI 98140, Woonsocket, RI, USA) equipped with a puncture type combination pH electrode was used, and the reading was taken once stabilized.

2.4 Sensory Evaluation

Sensory evaluation was performed by a trained panel of 8 members (ISO-8586-1, 1993) in a controlled environment (21 ± 1 °C, 55 ± 5% relative humidity). Frankfurters were cut in pieces of 2.5 cm length, using 6 pieces per treatment for each attribute. Each sample was randomly coded with three digits. Panellists were instructed to clean their palate between samples using water. Colour, taste, firmness, juiciness and overall acceptability were evaluated using a 9-point hedonic scale; 1 = dislike extremely, and 9 = extremely like.

2.5 Lipid Profile

Composition of methyl esters were analysed by gas chromatography using a Hewlett Packard 6890, equipped with a flame ionization detector (FID) and auto-sampler. An analytical capillary column, Supelco SPTM-2560 (Supelco Bellefonte, PA) (100 m × 0.25 mm × 0, 20 μm), was used. Injection port temperature was maintained at 250 °C and detector at 300 °C. Chromatograms were recorded and stored using the ChemStation software version A.10.01. Identification of fatty acids was made according to retention time and elution pattern of commercial standards (SupelcoTM-37 component FAME Mix, Supelco Bellefonte, PA). Quantification was carried out by measuring the area under the curve, expressed as fatty acid percentage of total fatty acids. Likewise, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and the ratio of PUFA/SFA and n-6/n-3 were calculated.

2.6 Total Phenols and Flavonoids

Total phenols were determined using spectrophotometry described by Singleton & Rossi (1965) with some modifications. Absorbance was read at 765 nm on a FLUOstar Omega (BMG Labtech Inc., Durham, NC, USA) microplate reader. Results were reported as mg of Gallic Acid Equivalent /100 g fresh weight (mg GAE/100 g FW). Total flavonoids content were determined according to the method described by Zhishen et al. (1999) with some modifications. Absorbance was read at 415 nm on a FLUOstar Omega (BMG Labtech Inc., Durham, NC, USA) microplate reader. Results were expressed as mg of Quercetin Equivalent/100 g fresh weight (mg QE/100 g FW).

2.7 Antioxidant Capacity

The capacity of the extracts to inactivate radical 2, 2-diphenyl-1-picryl-hidracil (DPPH) was calculated according to the method by Brand-Williams et al. (1995) with some modifications. Radical reduction was determined at 518 nm on a FLUOstar Omega (BMG Labtech Inc., Durham, NC, USA) microplate reader. The activity was expressed as micromoles of Trolox Equivalent /100 g fresh weight (μM TE/100 g FW). Trolox Equivalents Antioxidant Capacity (TEAC) was determined according to the methodology by Brand-Williams et al. (1995). The ability of extracts to reduce the radical ABTS• was monitored for 5 min at 762 nm on a FLUOstar Omega (BMG Labtech Inc., Durham, NC, USA) microplate reader. TEAC final value was calculated using a regression equation between the percentage of inhibition of the radical and the concentration of Trolox. Results were reported as micromoles Trolox Equivalent /100 g fresh weight (μM TE/100 g FW). The determination of the Oxygen Radical Absorption Capacity (ORAC) measures the effect of the antioxidant compounds in a sample on the reduction of fluorescein induced by peroxyl radicals AAPH generator (2, 2' - azobis (2-amidinopropane) dihydrochloride) (Ou et al., 2001). The decrease of the fluorescence was measured at an excitation wavelength of 485 nm and emission at 520 nm in a FLUOstar Omega (BMG Labtech Inc., Durham, NC, USA) microplate reader. Results were expressed as micromoles of Trolox Equivalent /100 g fresh weight (μM TE/100 g FW).

3. Results and Discussion

3.1 Proximate Composition, Colour and pH

Table 1 shows proximate composition of frankfurters. Moisture content ranged between 66.49 (A10) and 70.08% (T20), while that of fat ranged from 5.34 to 7.33%, being higher in treatment A20 and lower in the control. The contents of protein and ash in all treatments were approximately 19.0% and 2.0%, respectively. Protein content is high if compared with many of the products of this type available in the market (US Department of Agriculture, 2013; PROFECO, 2010), an attribute that may be attractive to the consumer at the time of purchase.

Table 1. Proximate analysis of frankfurters added with avocado and tomato paste

Sample	Moisture	Lipid	Protein	Ash
Control	69.99^{c}	5.34^{a}	20.85^{c}	2.27^{ab}
A10	69.49^{abc}	6.01^{a}	19.53^{b}	2.35^{ab}
A20	67.79^{a}	7.53^{c}	19.15^{ab}	2.56^{b}
T10	69.95^{bc}	6.14^{ab}	18.91^{ab}	2.16^{ab}
T20	70.08^{c}	6.04^{ab}	18.33^{a}	1.96^{a}
A10 + T10	68.29^{ab}	7.31^{bc}	19.39^{ab}	2.01^{a}
SEM	0.54	0.19	0.19	0.07

A10 = 10% avocado, A20 = 20% avocado, T10 = 10% tomato paste.

T20 = 20% tomato paste, A10 + T10 = 10% avocado + 10% tomato paste.

Average of three determinations. Different letters within the same column, indicate significant differences ($P < 0.05$).

SEM = Standard error of the mean.

On the other hand, it is observed that addition of avocado increased lipid content of the final product (A10 and A20 treatments). This increase is caused by the high lipid content (15.0%) in the avocado pulp (greater proportion of monounsaturated fatty acids).

In general, from the balance of nutrients stand point, proximate composition of the product developed in this research was better with respect to the frankfurters sold in Mexico. PROFECO (2010), in a quality study on 62 brands of frankfurters, reported contents of moisture, fat, and protein in the range of 66.8 to 68.3%, 4.6 to 12.0% and 6.0 to 11.9%, respectively. Besides, all of them contained starch as extender in the range between 4.9 and 15.0% with no health benefit, on the contrary adding only empty calories.

Table 2 shows the results of colour (L^*, a^* and b^*) and pH of control frankfurters and those added with A and T. Avocado addition to frankfurters did not affect ($P > 0.05$) luminosity (L). However, a^* value decreased ($P < 0.05$), while b^* value increased ($P < 0.05$). Avocado has a typical green colour due to chlorophyll, the main pigment present in the pulp (Wang et al., 2010), keeping this colour during the development of products (A10 and A20 treatments). Rodríguez-Carpena et al. (2012) studied the effect of avocado oil addition on the quality properties of pork burgers, reporting a decrease of a^* value, an increase in b^* and without changes in the L^*. This same behaviour was reported by Rodríguez-Carpena et al. (2011) when aqueous extract of avocado rind was added to pork burgers. On the other hand, the addition of tomato paste in the formulation of frankfurters decreased L^* value but increased a^* and b^*. Lycopene is a red pigment that imparts the characteristic colour to the tomato (Borguini & Ferraz Da Silva Torres, 2009) and its addition in the formulation of meat products can change the colour towards reddish-orange tones (Garcia et al., 2009), what explains the increase in a^* and b^* values observed in the present study. Calvo et al. (2008) developed a fermented sausage enriched with lycopene, and as in our study reported an increase in the values of a^* and b^*.

Table 2. Effect of avocado and tomato paste addition on colour and pH of pork frankfurters

Sample	*L**	*a**	*b**	pH
Control	73.08^{c}	8.24^{c}	12.09^{a}	6.21^{c}
A10	73.06^{c}	3.37^{b}	18.96^{b}	6.26^{cd}
A20	73.68^{c}	1.39^{a}	20.92^{b}	6.27^{d}
T10	64.10^{b}	19.28^{e}	31.14^{c}	6.03^{b}
T20	58.30^{a}	25.49^{f}	43.24^{e}	5.81^{a}
A10 + T10	63.09^{b}	17.75^{d}	36.,09^{d}	6.20^{c}
SEM	0.44	0.26	0.61	0.01

A10 = 10% avocado, A20 = 20% avocado, T10 = 10% tomato paste.

T20 = 20% tomato paste, A10 + T10 = 10% avocado + 10% tomato paste.

Average of three determinations. Different letters within the same column, indicate significant differences ($P < 0.05$).

SEM = Standard error of the mean.

Avocado and tomato paste addition affected pH of product. Avocado slightly increased pH values, while tomato paste decreased them ($P < 0.05$). The acidic nature of tomato paste (pH = 4.2) caused this pH reduction. Similar results were reported by Candogan (2002) in beef burgers made with 10 and 15% of tomato paste. Garcia et al. (2009) and Deda et al. (2007) also reported a decrease in pH by adding tomato paste in different meat products.

3.2 Sensory Evaluation

Sensory evaluation results are presented in Table 3. It was observed that flavour of the treatments with avocado (A10 and A20) was assessed with a lower score than the rest of the treatments. Juiciness was equal among the evaluated treatments ($P > 0.05$). Firmness, colour and overall acceptance of treatments with 20% of tomato paste and the combination of 10% avocado and 10% tomato paste had the highest evaluation by the panellists. On the other hand, the colour was favoured when tomato paste was added in the formulation of frankfurters, noting otherwise when adding avocado. Colour is a very important quality parameter in meat products and one that most influences consumer purchase decision (Troy & Kerry, 2010). It is also a parameter that is easily altered by the proportion of non-meat ingredients in the formulation (Whyte, 2006), as observed in our study. Deda et al. (2007) reported that acceptance of sausages by panellists increased as the addition of tomato paste increased in formulation, having an optimal at a 12% level.

Table 3. Sensory analysis of pork frankfurters added with avocado and tomato paste

Sample	Flavour	Firmness	Juiciness	Colour	Overall Acceptance
Control	6.37^{ab}	5.00^{a}	5.75^{a}	7.00^{ac}	5.87^{ab}
A10	4.87^{a}	5.50^{ab}	5.12^{a}	5.62^{ab}	5.12^{a}
A20	5.75^{ab}	5.62^{ab}	5.50^{a}	5.12^{b}	5.75^{ab}
T10	6.75^{b}	6.00^{ab}	6.00^{a}	7.37^{c}	6.75^{b}
T20	6.50^{ab}	6.00^{ab}	5.87^{a}	7.00^{ac}	6.62^{b}
A10-T10	7.19^{b}	6.34^{b}	6.00^{a}	6.62^{abc}	7.08^{b}
SEM	0.42	0.25	0.22	0.39	0.33

A10 = 10% avocado, A20 = 20% avocado, T10 = 10% tomato paste.

T20 = 20% tomato paste, A10 + T10 = 10% avocado + 10% tomato paste.

Average of three determinations. Different letters within the same column, indicate significant differences ($P < 0.05$).

SEM = Standard error of the mean.

3.3 Lipid Profile

Lipid profile is presented in Table 4. Predominant saturated fatty acids (SFA) were Palmitic (C16:0) and stearic (C18:0); amongst the monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) were oleic (C18:1n-9) and linoleic (C18:2n-6), respectively. The lipid profile of the control treatment was similar to that reported in pork sausages by Valencia et al. (2008) and by Delgado-Pando et al. (2010). There were significant differences ($P < 0.05$) in the type and quantity of lipids between the control treatment and those with the addition of avocado. The largest quantities of SFA occur in control treatments and in those which only contain tomato, while the MUFA were higher in treatments with avocado, mainly due to the high content of oleic acid present in the avocado (Ozdemir & Topuz, 2004). SFA decreased by 8% and MUFA increased in the same amount when 20% of avocado was added in the formulation of the product. PUFA/SFA ratio was in the range of 0.35 to 0.46 for all treatments, and as it was expected was greater for the treatment with 20% of avocado. With respect to the n-6/n-3 ratio, it was similar among treatments ranging from 11.24 to 12.80. These results were similar to those obtained by Delgado-Pando et al. (2010) for low fat pork sausages, who reported a ratio of PUFA/SFA and n-6/n-3 of 0.27 and 9.20, respectively.

Table 4. Fatty acid profile of pork frankfurters added with avocado and tomato paste

	Control	A10	A20	T10	T20	A10 + T10
Saturated						
C10:0	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.04 ± 0.00	0.03 ± 0.00	0.03 ± 0.00
C12:0	0.05 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	0.04 ± 0.00
C14:0	1.24^{c} ± 0.12	0.87^{ab} ± 0.01	0.78^{a} ± 0.05	1.09^{bc} ± 0.02	1.11^{bc} ± 0.00	0.84^{ab} ± 0.01
C16:0	24.14^{b} ± 0.70	22.044^{a} ± 0.00	22.61^{ab} ± 0.40	23.60^{ab} ± 0.04	23.58^{ab} ± 0.01	23.07^{ab} ± 0.22
C17:0	0.36^{c} ± 0.02	0.26^{abc} ± 0.00	0.20^{a} ± 0.04	0.33^{c} ± 0.01	0.31^{bc} ± 0.01	0.21^{ab} ± 0.01
C18:0	14.47^{c} ± 0.06	11.42^{b} ± 0.03	8.88^{a} ± 0.03	14.47^{c} ± 0.18	13.89^{c} ± 0.02	11.03^{b} ± 0.16
C20:0	0.20^{b} ± 0.10	0.20^{b} ± 0.10	0.16^{a} ± 0.00	0.19^{b} ± 0.10	0.17^{ab} ± 0.09	0.17^{ab} ± 0.09
Σ saturated	40.25^{c}± 0.99	34.88^{ab} ± 0.14	32.71^{a} ± 0.52	39.79^{c} ± 0.23	39.18^{c}1 ± 0.11	35.39^{b} ± 0.31
monounsaturated						
C14:1	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.01	0.02 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
C16:1	2.12^{ab} ± 0.01	3.27^{c} ± 0.02	4.60^{d} ± 0.01	2.05^{a} ± 0.03	2.22^{b} ± 0.02	3.33^{c} ± 0.02
C18:1 n9c	41.88^{a} ± 1.42	46.83^{c} ± 0.02	46.94^{c} ± 0.74	43.15^{abc} ± 0.03	42.82^{ab} ± 0.08	46.23^{bc} ± 0.53
C20:1	0.85^{b} ± 0.01	0.74^{ab} ± 0.00	0.59^{a} ± 0.00	0.84^{b} ± 0.06	0.75^{ab} ± 0.04	0.71^{ab} ± 0.01
C22:1 n9	0.13^{b} ± 0.00	0.10^{ab} ± 0.00	0.08^{a} ± 0.01	0.10^{ab} ± 0.00	0.12^{ab} ± 0.00	0.09^{ab} ± 0.00
Σ mono unsaturated	44.69^{a} ± 1.41	50.75^{b} ± 0.04	52.07^{b} ± 0.72	45.95^{a} ± 0.01	45.72^{a} ± 0.02	50.21^{b} ± 0.50
Polyunsaturated						
C18:2 n6c	12.80 ± 0.40	12.44 ± 0.00	13.23 ± 0.35	12.35 ± 0.14	13.03 ± 0.1	12.52 ± 0.06
C18:3 n6	0.13 ± 0.03	0.09 ± 0.00	0.11 ± 0.04	0.11 ± 0.01	0.11 ± 0.00	0.09 ± 0.00
C18:3 n3	0.79 ± 0.03	0.77 ± 0.00	0.81 ± 0.00	0.75 ± 0.02	0.75 ± 0.04	0.82 ± 0.00
C20:3 n6	0.13^{d} ± 0.00	0.12^{c} ± 0.00	0.09^{a} ± 0.00	0.12^{c} ± 0.00	0.13^{d} ± 0.00	0.10^{b} ± 0.00
C20:3 n3	0.11^{a} ± 0.00	0.09^{c} ± 0.00	0.07^{a} ± 0.00	0.11^{d} ± 0.00	0.10^{cd} ± 0.00	0.08^{b} ± 0.00
C20:4 n6	0.52^{d} ± 0.01	0.45^{c} ± 0.00	0.35^{a} ± 0.01	0.43^{c} ± 0.01	0.52^{d} ± 0.00	0.40^{b} ± 0.00
C20:5 n3	0.08 ± 0.01	0.06 ± 0.00	0.05 ± 0.00	0.06 ± 0.01	0.08 ± 0.00	0.05 ± 0.00
C22:6 n3	0.16 ± 0.02	0.11 ± 0.00	0.32 ± 0.17	0.14 ± 0.00	0.14 ± 0.00	0.15 ± 0.05
Σ Polyunsaturated	14.74 ± 0.53	14.14 ± 0.01	15.05 ± 0.20	14.08 ± 0.13	14.89 ± 0.04	14.21 ± 0.10
Σ unsaturated	59.74^{a} ± 0.89	65.11^{bc} ± 0.04	67.28^{c} ± 0.52	60.21^{a} ± 0.14	60.82^{a} ± 0.02	64.60^{b} ± 0.40
PUFA/SFA	0.37^{ab} ± 0.00	0.40^{c} ±0.00	0.46^{d} ± 0.00	0.35^{a} ± 0.00	0.38^{b} ± 0.00	0.40^{c} ± 0.00
n-6/n-3	11.93 ± 0.27	12.65 ± 0.01	11.24 ± 1.85	12.25 ± 0.36	12.80 ± 0.45	11.86 ± 0.50

A10 = 10% avocado, A20 = 20% avocado, T10 = 10% tomato paste, T20 = 20% tomato paste, A10 + T10 = 10% avocado + 10% tomato paste.

Average of three determinations ± SE. Different letters within the same column, indicate significant differences ($P < 0.05$).

3.4 Phenolic Compounds and Antioxidant Capacity

Figure 1 shows the effect of tomato and avocado addition to frankfurters on phenols and flavonoids content. It can be observed that 10% of avocado or 10% of tomato addition had no effect on phenols content ($P > 0.05$), but there was an increase ($P < 0.05$) at 20% addition either avocado or tomato or in the combination treatment. On the other hand, flavonoids contents only increased in the 20% avocado treatment.

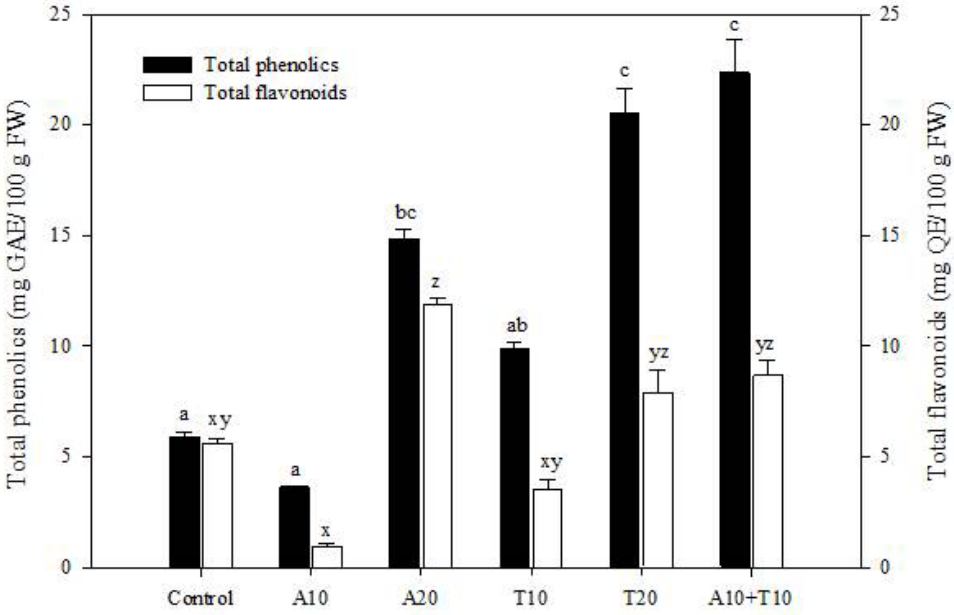

Figure 1. Tomato and avocado effect on phenolics and flavonoids contents in pork frankfurters

A10 = 10% Avocado; A20 = 20% avocado; T10 = 10% tomato; T20 = 20% tomato; A10 + T10 = 10% avocado + 10% tomato.

Different letters on columns (a-c), (x-z), show significative differences ($P < 0.05$)

Each value is the average of 6 replicates ± SE.

As for the antioxidant capacity, shown in Figure 2 and measured by the methods of DPPH, TEAC and ORAC, addition of 10% or 20% of avocado or 10% tomato had no significant effect ($P > 0.05$). However, the addition of 20% tomato or 10% tomato and 10% avocado increased ($P < 0.05$) antioxidant capacity, regardless of method used. Apparently the contribution of antioxidant compounds contained in tomato was greater than those in avocado. The addition of 10% avocado and 10% tomato had an additive effect on the antioxidant capacity. However, the 20% tomato treatment had the highest antioxidant capacity. The main antioxidant compound in tomato is lycopene (Erge & Karadeniz, 2011) and apparently its contribution to the antioxidant capacity was greater than those antioxidant compounds provided by the avocado.

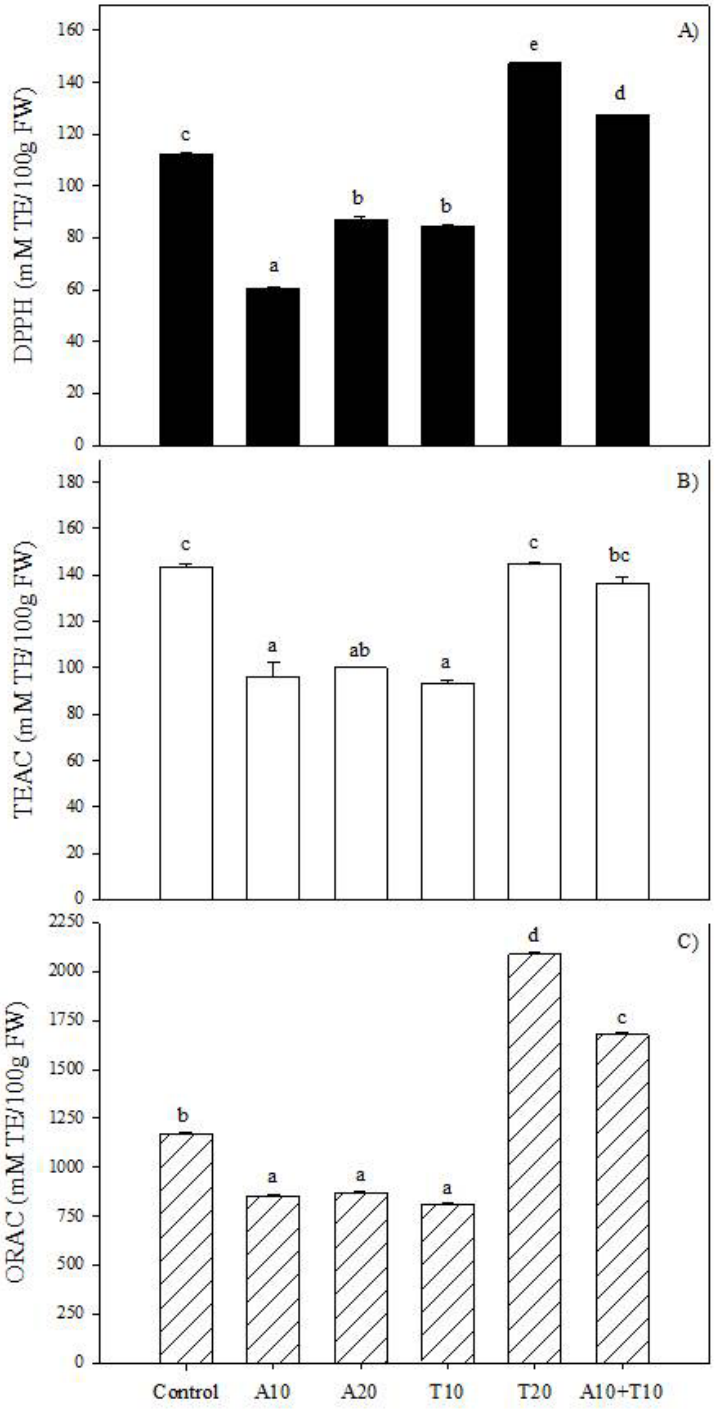

Figure 2. Tomato and avocado effect on (a) DPPH, (b) ORAC and (c) TEAC of pork frankfurters extracts

A10 = 10% Avocado; A20 = 20% avocado; T10 = 10% tomato; T20 = 20% tomato; A10 + T10 = 10% avocado + 10% tomato.

Different letters on columns show significative differences ($P < 0.05$).

Each value is the average of 6 replicates ± SE.

4. Conclusion

Tomato and avocado addition affected nutritional and sensory qualities of pork frankfurters in different ways. Tomatoes did not modify fatty acid profile, but increased antioxidant capacity and overall acceptance. On the

other hand, avocado increased oleic acid (C18:1) and decreased stearic acid (C18:0) contents. However antioxidant capacity was not modified and sensory attributes decreased. Nevertheless the combination of both, tomato and avocado, showed better fatty acid profile and antioxidant capacity compared to control and exceeded sensory characteristics to all treatments. For these reasons, the use of tomato and avocado as ingredients in pork frankfurters could be a good alternative to consumers looking for healthy food choices. Further studies to determine the stability of the product during refrigeration storage and research to show beneficial effects on health are in progress.

References

Alves, A., Bragagnolo, N., da Silva, M., Skibsted, L. H., & Orlien, V. (2012). Antioxidant protection of high-pressure processed minced chicken meat by industrial tomato products. *Food and Bioproducts Processing, 90*, 499-505. http://dx.doi.org/10.1016/j.fbp.2011.10.004

AOAC. (2011). *Official of Analysis of AOAC International.* Arlington, VA, USA, AOAC International.

Bhat, Z., & Bhat, H. (2011). Functional meat products: a review. *International Journal of Meat Science, 1*, 1-14. http://dx.doi.org/10.3923/ijmeat.2011.1.14

Borguini, R. G., & Ferraz Da Silva Torres, E. A. (2009). Tomatoes and tomato products as dietary sources of antioxidants. *Food Reviews International, 25*, 313-325. http://dx.doi.org/10.1080/87559120903155859

Brand-Williams, W., Cuvelier, M., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT-Food Science and Technology, 28*, 25-30. http://dx.doi.org/10.1016/S0023-6438(95)80008-5

Calvo, M., García, M., & Selgas, M. (2008). Dry fermented sausages enriched with lycopene from tomato peel. *Meat Science, 80*, 167-172. http://dx.doi.org/10.1016/j.meatsci.2007.11.016

Candogan, K. (2002). The effect of tomato paste on some quality characteristics of beef patties during refrigerated storage. *European Food Research and Technology, 215*, 305-309. http://dx.doi.org/10.1007/s00217-002-0567-1

Cross, A. J., Leitzmann, M. F., Gail, M. H., Hollenbeck, A. R., Schatzkin, A., & Sinha, R. (2007). A prospective study of red and processed meat intake in relation to cancer risk. *PLoS Medicine, 4*, e325. http://dx.doi.org/10.1371/journal.pmed.0040325.g002

Deda, M., Bloukas, J., & Fista, G. (2007). Effect of tomato paste and nitrite level on processing and quality characteristics of frankfurters. *Meat Science, 76*, 501-508. http://dx.doi.org/10.1016/j.meatsci.2007.01.004

Delgado-Pando, G., Cofrades, S., Ruiz-Capillas, C., & Jiménez-Colmenero, F. (2010). Healthier lipid combination as functional ingredient influencing sensory and technological properties of low-fat frankfurters. *European Journal of Lipid Science and Technology, 112*, 859-870. http://dx.doi.org/10.1002/ejlt.201000076

Ding, H., Chin, Y. -W., Kinghorn, A. D., & D'Ambrosio, S. M. (2007). Chemopreventive characteristics of avocado fruit. *Seminars in Cancer Biology, 17*, 386-394. http://dx.doi.org/10.1016/j.semcancer.2007.04.003

Ding, H., Han, C., Guo, D., Chin, Y.-W., Ding, Y., Kinghorn, A. D., & D'Ambrosio, S. M. (2009). Selective induction of apoptosis of human oral cancer cell lines by avocado extracts via a ROS-mediated mechanism. *Nutrition and Cancer, 61*, 348-356. http://dx.doi.org/10.1080/01635580802567158

Doménech-Asensi, G., García-Alonso, F., Martínez, E., Santaella, M., Martín-Pozuelo, G., Bravo, S., & Periago, M. (2013). Effect of the addition of tomato paste on the nutritional and sensory properties of mortadella. *Meat Science, 93*, 213-219. http://dx.doi.org/10.1016/j.meatsci.2012.08.021

Dreher, M. L., & Davenport, A. J. (2013). Hass avocado composition and potential health effects. *Critical Reviews in Food Science and Nutrition, 53*, 738-750. http://dx.doi.org/10.1080/10408398.2011.556759

Erge, H. S., & Karadeniz, F. (2011). Bioactive Compounds and Antioxidant Activity of Tomato Cultivars. *International Journal of Food Properties, 14*, 968-977. http://dx.doi.org/10.1080/10942910903506210

Garcia, L. M., Calvo, M. M., & Dolores Selgas, M. (2009). Beef hamburgers enriched in lycopene using dry tomato peel as an ingredient. *Meat Science, 83*, 45-49. http://dx.doi.org/10.1016/j.meatsci.2009.03.009

Garcia, M., Dominguez, R., Galvez, M., Casas, C., & Selgas, M. (2002). Utilization of cereal and fruit fibres in low fat dry fermented sausages. *Meat Science, 60*, 227-236. http://dx.doi.org/10.1016/S0309-1740(01)00125-5

Guttenplan, J. B., Chen, M., Kosinska, W., Thompson, S., Zhao, Z., & Cohen, L. A. (2001). Effects of a

lycopene-rich diet on spontaneous and benzo [a] pyrene-induced mutagenesis in prostate, colon and lungs of the *lacZ* mouse. *Cancer Letters, 164*, 1-6. http://dx.doi.org/10.1016/S0304-3835(00)00705-9

Hintze, J. (2007). NCSS 2007 user guide. *Number Cruncher Statistical Systems Software NCSS, Kaysville, Utah*.

ISO-8586-1. (1993). Sensory Analysis: General Guidance for the Selection, Training and Monitoring of Assessors. Selected Assessors. International Organization for Standardization.

Jiménez-Colmenero, F., Cofrades, S., López-López, I., Ruiz-Capillas, C., Pintado, T., & Solas, M. (2010). Technological and sensory characteristics of reduced/low-fat, low-salt frankfurters as affected by the addition of konjac and seaweed. *Meat Science, 84*, 356-363. http://dx.doi.org/10.1016/j.meatsci.2009.09.002

Jiménez-Comenero, F. (2007). Functional foods based on meat products. *Handbook of Food Products Manufacturing,* 989-1015. http://dx.doi.org/10.1002/9780470113554.ch44

Kerr, W., Wang, X., & Choi, S. (2005). Physical and sensory characteristics of low-fat italian sausage prepared with hydrated oat. *Journal of Food Quality, 28*, 62-77. http://dx.doi.org/10.1111/j.1745-4557.2005.00010.x

Marmot, M. A. T., Byers, T., Chen, J., Hirohata, T., Jackson, A., James, W., … Zeisel, S. (2007). Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Roma, Italia: Amer Inst for Cancer Research.

Navarro-González, I., García-Valverde, V., García-Alonso, J., & Periago, M. J. (2011). Chemical profile, functional and antioxidant properties of tomato peel fiber. *Food Research International, 44*, 1528-1535. http://dx.doi.org/10.1016/j.foodres.2011.04.005

Ou, B., Hampsch-Woodill, M., & Prior, R. L. (2001). Development and validation of an improved oxygen radical absorbance capacity assay using fluorescein as the fluorescent probe. *Journal of Agricultural and Food Chemistry, 49*, 4619-4626. http://dx.doi.org/10.1021/jf010586o

Ozdemir, F., & Topuz, A. (2004). Changes in dry matter, oil content and fatty acids composition of avocado during harvesting time and post-harvesting ripening period. *Food Chemistry, 86*, 79-83. http://dx.doi.org/10.1016/j.foodchem.2003.08.012

PROFECO. (2010). *Salchichas para hot dogs* (pp. 34-44). México, D.F: PROFECO.

Rodríguez-Carpena, J. -G. N., Morcuende, D., Andrade, M. A. -J. S., Kylli, P., & Estévez, M. (2011). Avocado (*Persea americana* Mill.) phenolics, in vitro antioxidant and antimicrobial activities, and inhibition of lipid and protein oxidation in porcine patties. *Journal of Agricultural and Food Chemistry, 59*, 5625-5635. http://dx.doi.org/10.1021/jf1048832

Rodríguez-Carpena, J., Morcuende, D., & Estévez, M. (2012). Avocado, sunflower and olive oils as replacers of pork back-fat in burger patties: Effect on lipid composition, oxidative stability and quality traits. *Meat Science, 90*, 106-115. http://dx.doi.org/10.1016/j.meatsci.2011.06.007

Singh, R., Chatli, M. K., Biswas, A. K., & Sahoo, J. (2011). Quality and storage stability of chicken meat patties incorporated with linseed oil. *Journal of Food Quality, 34*, 352-362. http://dx.doi.org/10.1111/j.1745-4557.2011.00395.x

Singleton, V., & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture, 16*, 144-158.

Troy, D., & Kerry, J. (2010). Consumer perception and the role of science in the meat industry. *Meat Science, 86*, 214-226. http://dx.doi.org/10.1016/j.meatsci.2010.05.009

US Department of Agriculture, A. R. S. (2013). USDA National Nutrient Database for Standard Reference: Release 25. USDA-ARS Washington.

Valencia, I., O'Grady, M., Ansorena, D., Astiasaran, I., & Kerry, J. (2008). Enhancement of the nutritional status and quality of fresh pork sausages following the addition of linseed oil, fish oil and natural antioxidants. *Meat Science, 80*, 1046-1054. http://dx.doi.org/10.1016/j.meatsci.2008.04.024

Wang, W., Bostic, T. R., & Gu, L. (2010). Antioxidant capacities, procyanidins and pigments in avocados of different strains and cultivars. *Food Chemistry, 122*, 1193-1198. http://dx.doi.org/10.1016/j.foodchem.2010.03.114

Wertz, K., Siler, U., & Goralczyk, R. (2004). Lycopene: modes of action to promote prostate health. *Archives of Biochemistry and Biophysics, 430*, 127-134. http://dx.doi.org/10.1016/j.abb.2004.04.023

Whyte, R. (2006). Does it look cooked? A review of factors that influence cooked meat color. *Journal of Food Science, 71*, R31-R40. http://dx.doi.org/10.1111/j.1750-3841.2006.00029.x

Yaping, Z., Wenli, Y., Weile, H., & Ying, Y. (2003). Anti-inflammatory and anticoagulant activities of lycopene in mice. *Nutrition Research, 23*, 1591-1595. http://dx.doi.org/10.1016/S0271-5317(03)00177-5

Zhishen, J., Mengcheng, T., & Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry, 64*, 555-559. http://dx.doi.org/10.1016/S0308-8146(98)00102-2