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Effect of Tomato Industrial Processing (Different Hybrids, Paste, and Pomace) on Inhibition of Platelet Function *In Vitro*, *Ex Vivo*, and *In Vivo*

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ABSTRACT Cardiovascular disease (CVD) is the leading cause of death worldwide. Healthy eating is among its safeguards, especially the daily intake of fruits and vegetables. In this context it has been shown that tomato (*Solanum lycopersicum*) presents antiplatelet activity. In the present study, we evaluated *in vitro* antiplatelet activity of fresh hybrid tomato process (nine hybrids: Apt 410, H 9888, Bos 8066, Sun 6366, AB3, HMX 7883, H 9665, H 7709, and H 9997), paste and its by-product of industrial processes (pomace). We assessed antiplatelet activity *ex vivo* and bleeding time in rats that ingested 0.1 and 1.0 g/kg of pomace each day. In studies *in vitro*, no significant differences in antiplatelet activity was observed in fresh tomato hybrids. Furthermore, the agro-industrial process did not affect the antiplatelet activity of paste and pomace. Likewise, pomace intake of 1.0 g/kg per day prolonged bleeding time and reduced *ex vivo* platelet aggregation in rats. The data obtained indicate that tomato has one or more compounds that caused antiplatelet activity. Regular consumption of tomato and its industrial derivatives could be part of a CVD prevention regimen.

KEY WORDS: • ***cardiovascular disease*** • ***paste*** • ***platelet*** • ***pomace*** • ***tomato***

INTRODUCTION

Cardiovascular diseases (CVD)—myocardial infarction, cerebrovascular disease, and peripheral arterial thrombosis—represent a major public health problem worldwide.[1,2] According to the World Health Organization, CVD account for about 30% of global deaths, with a relative increase over time, in the aging population.[3,4] In addition, CVD are an important source of morbidity, hospitalization, and disability.[5]

In most cases, CVD are the consequence of atherosclerotic plaque rupture and thrombus formation. The inflammatory component present in all stages of the atherosclerotic process is regulated by both genetic and environmental factors (*e.g.,* dyslipidemia, hypertension, smoking, diabetes, and obesity).[6,7] Platelets have been identified as regulators of the inflammatory processes that control both the initiation of the atherosclerotic lesion and plaque instability at late stages of disease progression, leading to the generation of a thrombotic event.[8–10]

Epidemiological studies have shown the cardiovascular protective role of a healthy diet. In this area, the effect of fruit and vegetables could be related to their bioactive compounds, suggesting an increasing attention to research on phytochemicals in the prevention of CVD.[11] In this context, the tomato (*Solanum lycopersicum*), in addition to their antioxidant and nutritional value, has cardioprotective effects through its antiplatelet activity.[12–14] The tomato is the most consumed vegetable in the world.[15] For the period 2010–11, the industrial tomato cultivation area in Chile was 6325 hectares, of which just over half of them were in Maule Region.[16]

The aim of this study was to evaluate the inhibitory activity of platelet function of tomato (fresh tomato hybrids, pasta of different stages, and pomace) *in vitro*, *ex vivo*, and *in vivo*.

MATERIALS AND METHODS

Samples of tomato, pasta, and pomace

We used three types of samples: fresh tomato, pasta, and tomato pomace, which were provided by the Sugal Chile Talca Plant.

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Fresh tomato hybrids. We included nine commercial hybrids; three early season hybrids (120 days, Apt410, H9888, and Bos8066), three midseason hybrids (128 days, Sun6366, AB3, and HMX7883), and late midseason harvest (135 days, H9665, H7709, and H9997). The sample collection was performed using completely random sampling properties located in Libertador Bernardo O'Higgins and Maule Regions, Chile.

Tomato pastes. The pastes studied were obtained from hybrids of the three growing seasons: early (Apt410 y Bos8066), intermediate (Sun6366), and late (H9665). In the agro-industrial plant, tomatoes were manually selected discarding the unripe fruits and those with fungi and strange materials. Then, a second manual and mechanical (electronic color selector) selection was carried out, discarding tomatoes with defects and unripe ones, respectively. After that, tomatoes were crushed and subjected to thermal breakdown (75°C in cold break or 90°C hot break); then, the material was passed through a sieve and subjected to evaporation processes to achieve the desired concentration (30–32° Brix or 36–38° Brix, respectively), and finally it was sterilized.

Pomace. Tomato pomace is a byproduct of the industrial production of tomato paste, containing mainly skin and seeds. Given the production line of the plant, it was not possible to define specific hybrids that correspond to the residue; it was only possible to identify the studied blends including middle growing cicle pomace cultivars (Sun6366, AB3, and HMX7883) and late (H9665, H7709, and H9997).

Preparation of aqueous extracts

For the preparation of fresh tomato extracts, 1 kg of each hybrid was washed with water and then it was separated into skin and pulp (including seeds and the gel surrounding them). Then, small pieces of flesh and skin were macerated separately in a blender (Oster). The resulting homogenate was filtered through gauze, then the process was repeated with cotton wool filter and then with filter paper to obtain a yellow ocher liquid. The aforementioned aqueous extract was lyophilized (Ilshin Lab. Co. Ltd.) until the total disposal of water and it was stored in a −70°C freezer (CVU27 B1 Consul) until use. For the aqueous paste extracts, it was followed the same filtration protocol to obtain a reddish-yellow liquid, which was also lyophilized and stored in a −70°C freezer until use. To prepare the aqueous extracts of pomace, the sample was resuspended in water and kept at 80°C for 10 min, once it was cold, it was filtered, lyophilized, and stored as previously described.

Preparation of standard solutions of the extracts

The lyophilized aqueous extracts of fresh tomatoes, pasta, and pomace, were weighed on an analytical balance (Sartorius AG) and resuspended in a 0.9% saline solution. The concentration used in the assays of platelet aggregation was 1 mg/mL final reaction volume and it was kept at −70°C until use.

Preparation of human platelet suspensions

Venous blood samples were taken from two volunteers (healthy university students), who previously signed informed consent in 3.2% citrate tubes (9:1 v/v) by phlebotomy with vacuum tube system (Becton Dickinson Vacutainer Systems). The protocol was authorized by the ethic committee of Universidad de Talca in accordance with the Declaration of Helsinki (approved by the 18th World Medical Assembly in Helsinki, Finland, in 1964). The samples were gently homogenized by five-fold inversion and allowed to stand for 5 min. Then, they were centrifuged (DCS-16 Centrifugal Presvac RV) at 240 g for 10 min, and 1 mL of platelet-rich plasma (PRP) was taken from each tube for platelet count (in triplicate) in a hematologic counter (Bayer Advia 60 Hematology System). The original tubes were centrifuged at 650 g for 10 min to obtain the platelet-depleted plasma (PDP). Finally, the PRP was adjusted to 2×10^5 platelets/μL with PDP.

Antiplatelet activity in vitro *assay*

Platelet aggregation was monitored by light transmission turbidimetric method according to Born and Cross,[17] using a lumi-aggregometer (Chrono-Log). Briefly, 480 μL of PRP (2×10^5 platelets/μL) in the reaction vessel were preincubated with 20 μL of sample (all extracts at 1 mg/mL final reaction volume), negative control (saline 0.9%), or positive control (prostaglandin E1 [PGE1] 250 μg/mL; Sigma). After 3 min of incubation, Platelet aggregation was initiated by addition of 20 μL agonist, which was measured for 6 min. ADP 8 μM (adenosine 5′-diphosphate sodium salt, bacterial source; Sigma Chemical Co.) was used as an agonist. All measurements were performed in triplicate. The results of platelet aggregation (maximum aggregation [%], slope, area under curve and lag-time [sec]) were determined by the software AGGRO/LINK (Chrono-Log) and the relative inhibition of the maximum platelet aggregation: $100 - (\%AgX \times 100)/\%AgC$), where %AgX is the relative aggregation of the component under study and %AgC is the relative aggregation of control.

Animal study

To study the effect of pomace on bleeding time (*in vivo*) and antiplatelet activity (*ex vivo*), an experiment was designed to use 15 female Wistar rats of 200–225 g in weight. All animals were maintained at 22°C ± 2°C in a regular cycle of light–dark 12:12 h (light from 8:00 a.m. to 8:00 p.m.) and food and water were freely available. Rats were fed a normal diet (Champion SA).

The 15 rats were separated into three groups, a control group ($n = 5$) and two study groups. In the latter, a group ($n = 5$) was administered 0.1 g pomace/kg each day and the other ($n = 5$) was given 1 g pomace/kg daily.

The ground pomace was dried in an oven at 65°C for 20 h; then, it was macerated in a food processor (Oster) and subsequently transformed into the finest powder in a manual mortar.

In both groups of rats, the ground pomace was dissolved in 2 mL of distilled water. The administration of pomace solution was carried out for 15 days through a gastric tube $\sim 50.8\,cm \times 3.81\,cm$ (20 inches × 1.5 inches: Popper and Sons, Inc.), a procedure that required rats to be anesthetized with ethyl ether (Imported by Equilab) for the minimum required time. The control group received only 2 mL of distilled water.

Antiplatelet ex vivo *assay.* At the end of the experiment, rats were anesthetized with a mixture of ketamine 10% (Alpha San) and xylazine 2% (Lab. Centrovet) in a 1:3 ratio administered intraperitoneally. Blood samples were taken from the abdominal aorta in tubes containing 0.105 M sodium citrate (9:1 blood: anticoagulant). PRP and PDP were prepared as described above and the PRP was adjusted to 5×10^5 platelets/μL used in the assays of platelet aggregation.

Bleeding time. To study the effect of pomace *in vivo*, rats underwent bleeding time. Briefly, an incision was made on the ventral surface of the rat tails about 2 mm from the tip.[18] The bleeding time was measured until bleeding stopped.

Statistical analysis

In platelet aggregation assays, $n \geq 3$ was used for each of the situations and the results were expressed as average and ± standard deviation. For statistical analysis we used GraphPad software, version 5.0. For comparison of three or more groups, we used analysis of variance of one or two tracks and post-test Newman–Keuls and Bonferroni. The statistical significance level was set up at $P < .05$.

RESULTS

Characteristics of tomato hybrids

The main differences between the hybrids correspond to the yield of production, planting-to-harvest time, harvest season, climate adaptation, water stress, soil needs, fertilization, and adaptation to diseases, among others. These characteristics modulate the difference between the berry size and the yield of the plant (Table 1).[19]

The relationship between the fresh tomato and the tomato paste is the following: 6 kg of fresh tomato are needed to produce 1 kg of tomato paste. Of the total amount of fresh tomato entering to the industrial plant, 2% of the incoming volume corresponds to tomato pomace.

In brief: 1000 g of fresh tomato = 166 g of paste, final product = 20 g of tomato pomace.

Antiplatelet activity in vitro

Fresh tomato hybrids. Table 2 shows several indicators of platelet aggregation (lag time, slope, maximum platelet aggregation, and area under the curve) of the aqueous extracts of fresh tomatoes from the nine hybrids studied, three from each season. It was observed that prior to the incubation of the PRP with the extracts of different hybrids studied, compared to the negative control, the variables mentioned above were significantly lower ($P < .0001$), especially inhibited platelet aggregation. Thus, the average inhibition of the aqueous extracts (skin + fresh tomato pulp) was 39.5% ± 6.9% (early hybrid), 28.5% ± 6.4% (intermediate), and 31% ± 8.6% (late). The table also shows the results observed with the positive control, PGE1.

Tomato pastes. Indicators of platelet aggregation found when using aqueous extracts of pasta, tomato obtained from three cycles under study (early, middle, and late) shown in Table 3. when preincubated with the different extracts indicators: lag time, slope, maximum platelet aggregation, and the area under the curve were significantly lower than the

Table 1. Processing Tomatoes: Company, Varieties, and Disease Resistance

Variety	*Company*	*Approximate days of maturity in the seventh region of Maule, Chile*	*Industry ID*	*Variety name*	*Disease resistance*[a]
Apt410	Monsanto	120	410, APT	Seminis Apt 410	VFFNP
H9888	Heinz	120	9888, HZ	Heinz 9888	VFFNP
Bos8066	Orsetti	120	8066, BOS	Orsetti Bos 8066	VFFNP
Sun6366	Nunhems	128	6366, SUN	Sun 6366	VFFNP
AB3	Monsanto	128	3, AB	Seminis AB3	VFFNP
HMX7883	Harris Morán	128	7883, HM	Harris Moran HM 7883	VFFNP
H9665	Heinz	135	9665, HZ	Heinz 9665	VFFNP
H7709	Heinz	135	7709, HZ	Heinz 7709	VFFNP
H9997	Heinz	135	9997, HZ	Heinz 9997	VFFNP

Adapted from the University of California Cooperative Extension Fresh Market Tomato Variety Trial Report 2007–2012.[19]

[a]All descriptions were provided by participating seed companies; check with seed company to confirm disease resistance. V: Verticillium Wilt race 1; FF: Fusarium Wilt races 1 and 2; N: Root Knot nematode; P: Bacterial speak (Bsp) race 0.

Table 2. Maximum Platelet Aggregation, Slope, Lag Time, and Area Under the Curve Induced by ADP 8 μM, Prior Incubation with Aqueous Extracts from Fresh Tomatoes (Skin and Pulp) 1 mg/mL Obtained from Hybrids of Three Cultivar Growing Periods

Cultivars	*Hybrid*		*Lag time (sec)*	*Slope*	*Maximum aggregation (%)*	*Area under the curve*
Early	Apt410	Skin	0.2 ± 0.1	38 ± 5.2	51 ± 4.6	224 ± 23.2
		Pulp	0.3 ± 0.1	28 ± 6.7	47 ± 8.2	203 ± 35.9
	H9888	Skin	0.3 ± 0.1	36 ± 4.7	49 ± 4.3	208 ± 19.7
		Pulp	0.2 ± 0.1	34 ± 6.9	50 ± 6.9	217 ± 36.7
	Bos8066	Skin	0.2 ± 0.1	37 ± 5.0	48 ± 5.4	217 ± 30.9
		Pulp	0.3 ± 0.1	38 ± 10.2	46 ± 5.1	204 ± 25.6
	Average	Skin	0.2 ± 0.1	37 ± 0.9	49 ± 1.5***,†††	216 ± 7.9***,†††
		Pulp	0.3 ± 0.1	33 ± 5.2	48 ± 2.1†††	208 ± 7.1
Middle	Sun6366	Skin	0.3 ± 0.1	37 ± 7.9	59 ± 3.5	250 ± 28.2
		Pulp	0.3 ± 0.02	30 ± 6.6	53 ± 3.5	219 ± 13.2
	AB3	Skin	0.2 ± 0.1	40 ± 7.2	60 ± 4.2	263 ± 30.2
		Pulp	0.2 ± 0.1	27 ± 5.4	53 ± 6.3	215 ± 35.1
	HMX7883	Skin	0.1 ± 0.1	39 ± 5.0	57 ± 4.9	261 ± 23.8
		Pulp	0.2 ± 0.1	34 ± 4.8	61 ± 3.4	261 ± 15.7
	Average	Skin	0.2 ± 0.1	39 ± 1.6	59 ± 1.7†††	258 ± 7.2†††
		Pulp	0.2 ± 0.1	30 ± 3.4	56 ± 4.3†††,φ	232 ± 25.4
Late	H9665	Skin	0.2 ± 0.1	43 ± 16.6	65 ± 6.4	289 ± 47.0
		Pulp	0.2 ± 0.1	34 ± 6.5	54 ± 5.2	240 ± 33.7
	H7709	Skin	0.2 ± 0.1	42 ± 14.1	51 ± 8.4	227 ± 33.2
		Pulp	0.2 ± 0.1	35 ± 5.3	49 ± 5.4	214 ± 29.3
	H9997	Skin	0.3 ± 0.1	34 ± 4.8	63 ± 3.3	261 ± 16.0
		Pulp	0.2 ± 0.1	27 ± 4.5	50 ± 4.4	205 ± 14.2
	Average	Skin	0.2 ± 0.1	39 ± 5.1	60 ± 7.3***	259 ± 31.3***
		Pulp	0.2 ± 0.1	32 ± 4.2	51 ± 2.7φ	220 ± 18.3
Negative control (saline 0.9%)			0.2 ± 0.1	71 ± 6	80 ± 2.7	385 ± 23.2
Positive control (PGE1)			3.4 ± 2.4	4.7 ± 1	3 ± 1.8	8.9 ± 10.2

Platelet aggregation induced by ADP 8 μM and the measurements were performed 6 min after agonist was added. Values are average ± standard deviation of five determinations.

Maximum aggregation average (%) of the different growing seasons showed significant differences compared with negative control (saline 0.9%) ($P < .0001$). ***$P < .0001$ between late and early cultivars; †††$P < .0001$ between early and middle cultivars; $^{\varphi}P < .05$ between middle and late cultivars.

PGE1, Prostaglandin E1 250 μg/mL.

negative control ($P < .0001$), inhibiting platelet aggregation maximum of 30% ± 7.1% on average.

Pomace. Table 4 shows the results on platelet aggregation variables obtained using aqueous extracts of pomace. Extracts of the two growing seasons of pomace studied (middle and late), compared with negative control values, were significantly lower in slope, maximum platelet aggregation, and the area under the curve ($P < .0001$), lag time was not different. Average inhibition of platelet aggregation was 45% ± 2% (middle cultivars) and 53% ± 1% (late hybrids). The maximum platelet aggregation pomace extracts with high and low proportion of seeds was 29% ± 4.6% and 53% ± 5%, respectively. The pomace showed higher inhibitory activity of maximum platelet aggregation (51% ± 16%) than different fresh tomato hybrids (33% ± 9.1%) and pasta (29% ± 7.1%) ($P < .0001$).

Antiplatelet activity ex vivo *and bleeding time*

Since increased antiplatelet activity *in vitro* presented in pomace aqueous extract, we performed a study in rats to assess the activity *in vivo* and *ex vivo,* after pomace was included in their diet for 15 days (Table 5).

Antiplatelet activity ex vivo. Rats that received 1 g/kg of aqueous extract of pomace each day had lower maximum platelet aggregation (49% ± 3%) than control rats (58% ± 5%) $P < .05$. No such effect was observed in rats receiving 0.1 g/kg of aqueous extract of pomace each day.

Bleeding time. The bleeding time was higher in rats administered 1 g/kg of aqueous extract of pomace each day (4.5 ± 0.7 min) than in the control group (2.9 ± 0.5 min) $P < .05$. The group given a daily dose of 0.1 g/kg of aqueous extract showed no different pomace with the control group. It was observed that the clot that formed in the rats administered 1 g/kg pomace aqueous extract each day was unstable and more easily destroyed than in the control group.

DISCUSSION

It is known that tomato, among other biological activities, inhibits platelet function.[12,13] In this study, various hybrids of fresh tomatoes, pasta, and pomace showed antiplatelet activity *in vitro*, *ex vivo*, and *in vivo*. It was observed that the antiplatelet ability of tomato is maintained during the agro-industrial process, which implies that the

Table 3. Maximum Platelet Aggregation, Slope, Lag Time, and Area Under the Curve Induced by ADP 8 μM, After Incubation with Aqueous Extracts from Paste Industrial Product 1 mg/mL Obtained from Hybrids of Three (Early, Middle, and Late) Cultivar Growing Periods

Cultivars	*Stage industrial product*	*Hybrid*	*Lag time*	*Slope*	*Maximum aggregation (%)*	*Area under the curve*
Early	End-product	Apt410/Bos8066[A]	0.2 ± 0.1	26 ± 4.5	58 ± 6.1	231 ± 37
		Apt410/Bos8066[B]	0.2 ± 0.1	30 ± 3.6	55 ± 7.0	228 ± 47
		Apt410/Bos8066[C]	0.2 ± 0.1	27 ± 3.8	58 ± 5.8	220 ± 41
		Average	0.2 ± 0.1†††,***	27 ± 4.0	57 ± 5.7†	226 ± 37
Middle	End-product	Sun 6366[A]	0.3 ± 0.1	29 ± 6.5	49 ± 7.1	201 ± 37
		Sun 6366[B]	0.3 ± 0.1	28 ± 6.7	49 ± 6.7	204 ± 38
		Sun 6366[C]	0.3 ± 0.1	25 ± 1.2	53 ± 2.6	203 ± 21
		Average	0.3 ± 0.1†††	27 ± 4.9	50 ± 5.4$^{\dagger,\varphi}$	203 ± 28
Late	End-product	22 H9665[A]	0.3 ± 0.1	28 ± 5.5	50 ± 4.2	203 ± 38
		23 H9665[B]	0.3 ± 0.1	28 ± 5.3	60 ± 2.6	208 ± 24
		00 H9665[C]	0.3 ± 0.2	29 ± 5.3	57 ± 4.6	214 ± 19
		Average	0.3 ± 0.1***	28 ± 4.7	56 ± 5.7$^{\varphi}$	208 ± 25
Negative control (Saline 0.9%)			0.2 ± 0.1	71 ± 6.0	80 ± 2.7	385 ± 23.2
Positive control (PGE1)			3.4 ± 2.4	4.7 ± 1.0	3 ± 1.8	8.9 ± 10.2

Platelet aggregation induced by ADP 8 μM and the measurements were performed 6 min after agonist was added. Values are average ± standard deviation of five determinations.

Maximum aggregation average (%) of the different growing seasons showed significant differences compared with negative control (saline 0.9%) ($P < .0001$). ***$P < .0001$ between late and early cultivars; $^{\dagger\dagger\dagger}P < .0001$ between middle and early cultivars; $^{\varphi}P < .05$ between middle and late cultivars.

[ABC]The letters A, B, and C indicate different samples collected at different times of the day of the industrial process line.

molecule (s) of such activity is/are not affected, at least significantly, during the thermal processing used in the pulp production. This confirms what was previously described in relation to the thermal stability of antiplatelet compounds in tomatoes.[14–18,20]

It is also noted that regardless of the growing season or the hybrid under study, the antiplatelet capability is maintained, no matter the geographical location of cultivation in Maule Region, Chile.

This indicates that the antiplatelet activity is not associated with a particular genetic variant of *S. lycopersicum* cultivars used in this study. This genetic difference, in this case, is associated with resistance to pathogen.[19]

Unlike what was observed by Yamamoto *et al.*, who observed in other cultivars, the antiplatelet activity of tomato extracts depended on the cultivars studied.[21]

The aqueous extract of pomace, compared with aqueous extracts of fresh tomatoes and pasta, showed greater inhibitory activity of platelet aggregation. The aqueous extract of pomace, compared with aqueous extracts of fresh tomatoes and pasta, showed greater inhibitory activity of platelet aggregation. This may be explained because pomace consists mainly of seeds and skin. In addition a higher proportion of seeds in pomace increased the antiplatelet activity. Meanwhile, Fuentes *et al.* showed that pomace extracts exerted a potent inhibition of platelet aggregation induced by ADP, collagen, TRAP-6, and arachidonic acid, respectively.[22] According to Dutta-Roy *et al.,* compounds that exert antiplatelet activity are found in the yellow liquid located around the seeds.[20]

According to Fuentes *et al.*, the great concentration of crude fiber and fat from pomace, could explain the increase

Table 4. Maximum Platelet Aggregation, Slope, Lag Time, and Area Under the Curve Induced by ADP 8 μM, After Incubation with Aqueous Extracts from (Skin and Seed) Pomace 1 mg/mL Obtained from Hybrids of Two (Middle and Late) Growing Periods

Cultivars	*Pomace*	*Lag time (sec)*	*Slope*	*Maximum aggregation %*	*Area under the curve*
Middle	Rich in skin	0.2 ± 0.1	38 ± 2.3	57 ± 4.6**	253 ± 7.8*
	Rich in seed	0.2 ± 0.1	28 ± 15.6	31 ± 5.6	142 ± 15.7
	Average	0.2 ± 0.1	33 ± 11.3	44 ± 15	197 ± 61.8
Late	Rich in skin	0.2 ± 0.1	37 ± 5.1	48 ± 5.3**	207 ± 28.6*
	Rich in seed	0.2 ± 0.1	32 ± 9	27 ± 3.5	125 ± 20.8
	Average	0.2 ± 0.1	34 ± 7.4	37 ± 11.8	166 ± 49.3
Negative control (Saline 0.9%)		0.2 ± 0.1	71 ± 6.0	80 ± 2.7	385 ± 23
Positive control (PGE1)		3.4 ± 2.4	4.7 ± 1.0	3 ± 1.8	8.9 ± 10

Platelet aggregation induced by ADP 8 μM and the measurements were performed 6 min after agonist was added. Values are average ± standard deviation of five determinations.

Maximum aggregation average (%) of the different growing seasons showed significant differences compared with negative control (saline 0.9%) ($P < .0001$). *$P < .05$, **$P < .001$ between middle and late cultivars.

Table 5. Platelet Antiaggregation Activity *Ex Vivo* and Bleeding Time in Rats Subjected to Chronic Treatment with Pomace

		Platelet aggregation			
Experiment	*Bleeding time (min)*	*Lag time (sec)*	*Slope*	*Maximum aggregation (%)*	*Area under the curve*
1 g/kg/day	4.5 ± 0.7*,†	0.3 ± 0.01	75 ± 7	49 ± 3*	270 ± 58
0.1 g/kg/day	2.9 ± 0.3*	0.4 ± 0.1	82 ± 2	51 ± 2	277 ± 27
Control	2.9 ± 0.5†	0.3 ± 0.1	88 ± 9	58 ± 5*	370 ± 61

Wistar rats received, in addition to their normal diet, 1 g/kg or 0.1 g/kg pomace each day via nasogastric for 15 days; control group received the same volume (2 mL) of distilled water.

*$P < .05$; †$P < .05$.

of its antiplatelet activity. Further discloses that the antioxidant capacity as measured by DPPH and phenol concentration is higher in tomato skin, followed by pulp and seed.[22]

According to Fuentes *et al.*, the fat content of the seeds was found to be in the range of 15% to 30%.[22] Other study established that 80% of the fatty acids correspond to unsaturated fatty acids (linoleic, oleic, and palmitic acids).[23] Unsaturated fatty acids inhibit human platelet phospholipase A2 activity,[24] thus hindering the progression of atherogenesis.[25] This property is directly related to the prevention of CVD.

Since most *in vitro* antiplatelet activity was observed in pomace, we performed an experiment administering ground pomace to Wistar rats. The antiplatelet activity *ex vivo* was similar to that observed by Yamamoto *et al.*, who showed that intake of tomato components with *in vitro* antiplatelet activity affects *ex vivo* platelet function in a dose-dependent manner.[21] Meanwhile, O'Kennedy *et al.* observed antiplatelet activity 3 h after eating tomato fractions.[12] Given the involvement of platelets in atherogenesis, from early stages of this process, together with other cardioprotective functions of bioactive compounds in tomatoes, and reduction of low density lipoprotein and decreased blood pressure.[25] Future analysis will be necessary to study the effect of the extract/fractions of tomato/pasta/pomace on other aspects of the atherothrombotic process, such as platelet function (adhesion, spreading, secretion, and platelet aggregation), endothelial function, and platelet–leukocyte function among others. Inhibition of platelet function could be beneficial in preventing thrombosis and proinflammatory events associated with platelet activation.

CONCLUSION

The data obtained indicate that tomato has compounds with inhibitory activity of platelet function. Regular consumption of tomato and its industrial derivatives could be part of a preventive regimen against the development of CVD. Additional use of the products of tomato processing industry represents an untapped field with a high potential for use in functional cardioprotective ingredients. Studies are needed to identify the molecule(s) with antiplatelet activity and its/their mechanisms of action.

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AUTHOR DISCLOSURE STATEMENT

The authors report no competing financial interests exist.

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