WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.6 (3&4) : 41-46. 2008 *www.world-food.net*

Relationships between antiplatelet activity, dry matter content and flavor in onion cultivars

Maria M. Sance [1, 2], Roxana E. González [1, 2], Verónica C. Soto [1] and Claudio R. Galmarini [1, 2, 3] *

[1]Department of Agronomy, National University of Cuyo, Almirante Brown 500, M5528 AHB, Chacras de Coria, Luján, Mendoza, Argentina. [2] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). [3] Instituto Nacional de ecnología Agropecuaria (INTA), Experimental Station La Consulta, CC8 (5567), La Consulta, Mendoza, Argentina.
**e-mail:crgalmarini@laconsulta.inta.gov.ar, crgalmarini@mendoza.inta.gov.ar*

Received 17 June 2008, accepted 2 September 2008.

Abstract

A number of studies suggest that dietary intake of onion (*Allium cepa* L.) benefits cardiovascular health. The *in vitro* antiplatelet activity observed in Alliums is influenced by genotype and environmental factors. Few descriptions about Argentinean onion cultivars and their health benefits have been reported. To investigate the relationship between antiplatelet effect, pyruvic content, soluble solids content and total dry matter, eight Argentinean onion cultivars ('Angaco INTA', 'Antartica INTA', 'Ancasti INTA', 'Refinta 20', 'Valcatorce INTA', 'Valuno INTA', 'Cobriza INTA' and 'Navideña INTA') of different physiological requirements for bulbification and genetic background were grown during two years. Thirty days after harvest onion bulbs were sampled, and pungency, dry matter, soluble solids and *in vitro* antiplatelet activity were analyzed. Significant cultivar x year interactions were observed for all studied variables ($P < 0.05$). 'Refinta 20' and 'Antartica INTA' showed 100% inhibition of platelet aggregation, while 'Angaco INTA' presented the lowest inhibiting effect. Significant positive correlations were found between *in vitro* antiplatelet activity and pyruvic acid content, soluble solids and dry matter content in both years. There seems to be interesting differences among cultivars according to their origins. 'Angaco INTA' originated from 'Valencianita' populations shows low pungency and also low *in vitro* antiplatelet activity, whereas cultivars selected from 'Valenciana' type populations show intermediate pungency and antiplatelet activity. 'Refinta 20' selected from 'Southport White Globe' populations has the highest antiaggregatory effect, pungency and solids. Another interesting relationship seems to be related to bulb color; white–bulb cultivars ('Ancasti INTA', 'Refinta 20', and 'Antartica INTA') have more soluble solids content and *in vitro* antiplatelet activity than colored bulb cultivars.

Key words: Alliums, *Allium cepa* L., health benefits, antiaggregatory effect, platelets, pungency, solids, dry matter, flavor, organosulfur compounds.

Introduction

The onion crop is of great importance in Argentina, along with garlic, are the main fresh vegetables exported. About 600,000 tons of onions are produced yearly on 19,000 ha, for fresh market and the dehydration industry [1]. For decades, onion-breeding programs in Argentina have been developing short, intermediate and long-day cultivars [2]. However, no descriptions about their health benefits have been reported.

There is an increasing demand for foods with good organoleptic characteristics and also with beneficial attributes for health, nevertheless it is important to establish scientific bases to support the consumption of food with potential nutritional active ingredients.

Onion and garlic consumption have been associated with decreased cardiovascular events, because of their hypocholesterolemic, hypolipidemic, anti-hypertensive, anti-diabetic, antithrombotic and anti-hyperhomocysteinemia effects[3], as well as with many other biological activities including antimicrobial, antioxidant, anticarcinogenic, antimutagenic, antiasthmatic, inmunomodulatory and prebiotic activity [4].

Onions are primarily consumed for their distinctive flavor or their ability to enhance flavors in other foods [5]. The pungency [6] and antiplatelet activity [7] in onion and other Alliums are attributed to the organosulfur products arising from the enzymatic decomposition of S-alk(en)yl-L-cysteine sulfoxides (ACSOs), following tissue disruption.

Platelet aggregation is an important cause of thrombosis leading to cardiovascular disease [8]. Inhibitors of aggregation can provide protection against these syndromes that affect millions of people worldwide [9]. Onion and garlic juice inhibits platelet aggregation in human blood *in vitro* [10, 11] and *in vivo* [12-15]. Several epidemiologic studies have reported that antiplatelet activity of onion is considered to be a property of organo-sulphur and flavonoid compounds. The possible mechanism of the antiplatelet effect of onion includes thromboxane A_2 TXA2 synthase inhibition and TXA2/PGH2 receptor blockade [16].

Among the first scientific investigations of onion antiplatelet activity, two separate studies were reported comparing bleeding time and fibrinolytic activity in blood [17, 18]. Both showed that heating onions increased coagulation time and fibrinolytic activity *ex vivo*. Furthermore, Bordia *et al*. [19] showed that garlic oil administration to healthy subjects and patients with coronary artery disease (CAD) inhibited platelet aggregation *ex vivo*. Likewise, consumption of raw Welsh onion by rats has also been shown to inhibit aggregation and other platelet functions *ex vivo*[20].

In raw onions, significant correlations have been reported among *in vitro* antiplatelet activity, pungency and the solid content [7, 21-23], also common QTL for these properties have been detected [11, 23].

The Argentinean onion germplasm trace back mainly to European origins. 'Valenciana' populations were used to develop the cultivars 'Valcatorce INTA', 'Valuno INTA', 'Cobriza INTA' and 'Antartica INTA'. 'Valenciana' populations are related to 'Grano' type onions from the Valencia region of Spain; the long-storing cv. Pukekohe Long Keeper of New Zealand and its Australian derivative cv. Creamgold are believe to derive from the same Spanish origin [24]. 'Torrentina' populations were used to develop 'Navideña INTA'. 'Torrentina' populations have been known for more than 100 years in Argentina and it may have been originated in the south of Spain. 'Angaco INTA' trace back to 'Valencianita' populations that were introduced to Argentina from southern Spain more than 100 years ago. 'Refinta 20' was originated from a selection of 'Southport White Globe' populations[25]. S_1 family selection was the common strategy used for the development of 'Navideña INTA', 'Cobriza INTA' and 'Refinta 20' [2]. Mass selection was used in the case of 'Valcatorce INTA', 'Valuno INTA' and 'Antártica INTA'. Currently available cultivars are described in Galmarini [2].

The beneficial health-effects attributed to onions are important for consumers and breeders. The characterization of germplasm according to antiplatelet activity would help the selection of onion cultivars with enhanced flavor and defined medicinal benefits. There are not published data about the variation of the *in vitro* antiplatelet activity of Argentinean onion cultivars. It is also relevant to investigate the relationship among antiplatelet effect, pungency, soluble solids content and total dry matter of cultivars from different origins.

Materials and Methods

Plant material and experimental design: Eight onion cultivars: 'Navideña INTA', 'Valuno INTA', 'Valcatorce INTA', 'Cobriza INTA', 'Ancasti INTA', 'Antartica INTA', 'Refinta 20' and 'Angaco INTA', were chosen from the germplasm collection of INTA La Consulta. These cultivars were grown in la Consulta, Mendoza, Argentina (33º44´S, 69º07´W) during 2004-2005 and 2005-2006. A randomized complete block design with four replicates for each cultivar and year was used. The crop was implanted using seedlings in early September (09/08/04; 09/09/05), 72 plants per plot (2 m x 3 m) were implanted. The onions were grown in a loam soil. Physical and chemical properties of the soil are described in Table 1. The average temperatures and precipitations for both years are indicated in Table 2. Irrigation was applied every 8 days, using furrow irrigation. No fertilizers were applied. Onion bulbs were harvested when 50% of foliage leaves were collapsed. At harvest bulbs were collected and stored in sheds at room temperature. After harvest the bulbs were stored in a cool storage room.

Table 1. Physical and chemical properties of La Consulta's soil.

Textural class	Loam
EC (dSm^{-1})	3.77
SAR ($(meq/l)^{1/2}$)	3.47
N (mg kg^{-1})	693.00
Pa (mg kg^{-1}) *	3.15
Ki (mg kg^{-1})**	175.50
Ca (meq l^{-1})	31.80
Mg (meq l^{-1})	4.00
Na (meq l^{-1})	14.59
Cl^- (meq l^{-1})	15.00
$SO4^=$ (meq l^{-1})	33.00
Organic carbon (g kg^{-1})	12.5

*Pa, available phosphorus, ** Ki, exchangeable potassium.

Sample processing: Ten unsprouted bulbs per replication were sampled 30 days after harvest and evaluated for antiplatelet activity (IVAA), pyruvic acid content (PC), soluble solids content (SSC) and total dry matter (TDM). These ten chosen bulbs after removing the dry outer scales were quartered along the longitudinal axis to obtain a representative sample of outer and inner scales. One quarter of each bulb was combined and used to measure TDM and SSC. The other ten quarters were juiced using a mechanical juicer. The juice was collected, filtered and left on the bench for 15 minutes to allow enzymatic hydrolysis of the flavor precursors. For PC analysis a juice aliquot was added with an equal volume of 5% triclhoroacetic acid and centrifuged for 10 minutes at 10,000 rpm. For IVAA determination, onion juice was centrifuged for 20 minutes at 10,000 rpm and the supernatant was frozen at -80ºC [7].

Measurement of in vitro antiplatelet activity: IVAA was measured using a whole blood electrical impedance aggregometer (Chrono-Log, Corp.) in whole blood [26]. Blood was drawn from three healthy human donors who had abstained from eating onion; others related *Alliums*, or other known platelet-inhibitory foods (e.g., wine, beer, etc.) for at least 72 h. Also, the donors had not taken drugs known to affect platelet aggregation (e.g., aspirin) for at least two weeks prior to blood sampling. Venipuncture was performed by the Hematology Service of the 'Hospital Central' of Mendoza, following all the ethical and safety precautions required by Human Public Health Committee of Mendoza. These blood samples were anticoagulated with sodium citrate (3.8%, 1 vol anticoagulant:9 vol of blood) and were diluted 1:1 with TRIS-buffered saline (pH 7.4) and vortexed. The diluted blood was maintained at room temperature during the experiment and used within 2 hours of extracted.

For all experiments, 1 ml of blood/TBS was transferred to cuvettes containing a stir bar. After incubation at 37ºC for 3 min., a dose of onion juice was added. The inhibitory dose of onion juice at which all cultivars showed antiplatelet activity was previously established (data not shown). Each dose was assayed twice. After juice addition (200 µl), the electrodes were inserted into the blood mixture and platelet aggregation was induced by the addition of 2.5 µl collagen (1 mg ml^{-1}). Change in the impedance was recorded over 6 minutes; this change is proportional to platelet aggregation.

Table 2. Average temperatures and rainfall during the period of grow in both studied years.

Average t (ºC)*		Maximum t (ºC)*		Minimum t (ºC)*		Rainfall (mm)*	
2005	2006	2005	2006	2005	2006	2005	2006
18.1	18.2	26.3	27.1	9.9	9.8	44	23.5

*Values corresponding to the period September to February.

IVAA was expressed as percent of inhibition of platelet aggregation, compared to control samples prepared in the same way but without adding onion juice.

Pungency determination: Pyruvate content was determinate according to Schwimmer and Weston [27]. For all experiments, 0.3 ml of juice/TCA previously centrifuged were taken and diluted with distilled water (1:20). One ml of 0.0125% 2,4-DNPH in 2 N HCl was added to 2 ml of juice/TCA diluted (1:20). The tubes were incubated at 37ºC during 10 minutes in a thermostatized bath, then 5 ml of NaOH 0.6 N were added. The color developed by the samples was measured in a spectrophotometer (Beckman DU Serie 500 UV/Visible) at 420 nm. The pyruvic acid concentration of the onion juice was determined using as a reference a standard curve developed with known concentrations of pyruvate. Values were expressed as μmol g^{-1} of onion fresh weight.

Determination of total dry matter and soluble solids content: Fresh onion bulb tissues were crushed and dried in a stove at 50°C for 20 hours until constant weight. Values were expressed as g kg^{-1}.

Ten quarters were blended for a minute in a blender and the resulting juice was squeezed through cheesecloth. Several drops of juice were applied to a hand refractometer to measure soluble solids content (expressed as ºBrix) [28].

Statistical analysis: The data were expressed as mean ± SD. IVAA, PC, SSC and TDM were analyzed by ANOVA procedure using the software STATGRAPHICS Plus for Windows 4.0. Means of each group were compared by honestly significant difference (Tukey HSD) test. Correlation analysis among variables was performed using the same software.

Results

In vitro antiplatelet activity: Onion juice inhibited aggregation in a dose-dependent manner (data not shown). Based on these results a concentration of 200 μl onion juice/ml blood was chosen for all experiments. The ANOVA analysis revealed significant differences for antiplatelet activity among cultivars and years. The cultivar x year interaction was significant at $P < 0.05$ (Fig. 1). Nevertheless, ANOVA analysis of cultivar, year and their interaction contributed 85.52, 0.53 and 10.58% of variation to the IVAA in this study, respectively (Table 3); indicating that genetic differences were the main factor determining IVAA, and that year and cultivar x year interaction, played a minor role.

Averaged over all cultivars, antiplatelet activity was significantly higher in 2005 compared to 2006. 'Refinta 20' and 'Antartica INTA' showed 100% inhibition of platelet aggregation in both years, while 'Angaco INTA' presented the lowest inhibiting effect. 'Valcatorce INTA' showed greater IVAA during 2005 (94.0±5.4%) than 2006 (45.7±22.7%). However, 'Ancasti INTA' showed greater IVAA during 2006 (89.9±12.4%) than 2005 (58.0±4.5%), (Fig. 1, Tables 4 and 5).

There seems to be differences between Valencianita cultivars and Valenciana cultivars for this character. There are also differences between white colored bulb cultivars ('Ancasti INTA', 'Refinta 20') and colored ones for IVAA.

Pungency: Significant differences among cultivar and year x cultivar interactions for pungency were observed. The lowest levels of pyruvic acid were observed in 'Angaco INTA' (Tables 4 and 5). 'Refinta 20' exhibited the highest pyruvic acid content, 2.7-fold and 1.8-fold difference in 2005 and 2006, respectively, when compared to the 'Angaco INTA', the lowest pyruvic acid content cultivar. 'Valuno INTA' showed significant variability for pungency among years. The other cultivars did not show significant differences for pungency. The overall ranking was maintained. There seems to be differences between Valencianita, Torrentina and Valenciana cultivars and 'Refinta 20', originated from 'Southport White Globe', 'Refinta 20' being the most pungent one, and 'Angaco INTA', derived from Valencianita populations, sweeter.

Total dry matter and soluble solids content: 'Refinta 20' had the highest dry matter content whereas the cultivar 'Angaco INTA' showed the lowest among the studied materials, in both years. There are differences between white colored bulb cultivars ('Ancasti INTA', 'Refinta 20', and 'Antartica INTA') and colored ones for SSC.

Soluble solids content ranged from 21.6 ºBrix and 22.3 ºBrix for 'Refinta 20' in 2005 and 2006 respectively, to 7.7 ºBrix for 'Valuno INTA' in 2005 and 6.9 ºBrix for 'Angaco INTA' in 2006 (Tables 4 and 5). The cultivar x year interaction was significant at $p < 0.05$ for SSC as well as for dry matter content.

'Refinta 20' had the highest dry matter content whereas the cultivar 'Angaco INTA' showed the lowest among the studied materials, in both years. There were differences between white colored bulb cultivars ('Ancasti INTA', 'Refinta 20', and 'Antartica INTA') and colored ones for SSC.

Relation between antiplatelet activity and other variables: Significant positive correlation were found between IVAA and PC (r = 0.69*** in 2005 and r = 0.80*** in 2006), SSC (r = 0.38*in 2005 and r = 0.69***) and dry matter content (r = 0.43* in 2005 and r = 0.71*** in 2006) in both studied years (Table 6). Soluble solids content and total dry matter correlated with pungency.

The principal components analysis indicated that the first principal component accounted for 79% of total trait variation and allows the discrimination of cultivars in four groups. In one the long-day cultivars 'Cobriza INTA', 'Valcatorce INTA' and 'Valuno INTA', all derived from selections of Valenciana populations, and the intermediate cultivar 'Navideña INTA',

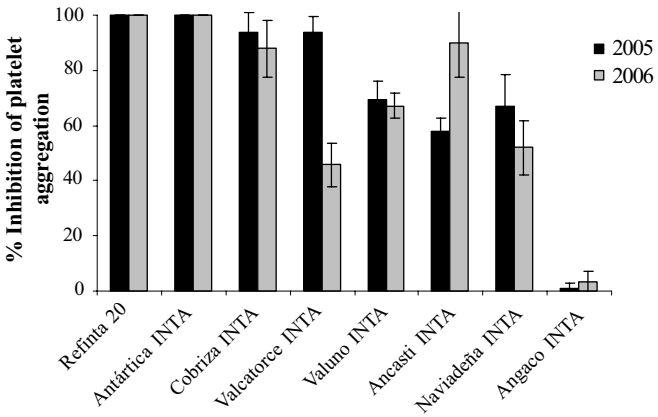

Figure 1. Antiplatelet activity of onion cultivars extracts during 2005 and 2006.

Table 3. ANOVA table of IVAA variation due to cultivar, year, and their interaction.

Source	d.f	Sum of square		F-value	P>F
Cultivar	7	55730.5	(85.52 %)	174.47	0.0000
Year	1	347.4	(0.53 %)	7.62	0.0082
Cultivar x year	7	6895.1	(10.58 %)	21.59	0.0000
Error	48	2190.26	(3.36 %)		
Total	63	65162	(100 %)		

Table 4. *In vitro* antiplatelet activity, pyruvic acid content, total dry matter and soluble solids content of onion cultivars in 2005.

Cultivar	PC[a]		TDM		SSC		IVAA	
Refinta 20	7.4 ± 1.2[b]	a	220.8 ± 11.3	a	21.6 ± 1.2	a	100.0 ± 0.0	a
Antartica INTA	4.8 ± 0.3	b	163.8 ± 4.9	b	15.0 ± 0.7	b	100.0 ± 0.0	a
Cobriza INTA	5.0 ± 0.3	b	109.9 ± 5.6	c	9.2 ± 0.4	c	94.0 ± 7.0	a
Valcatorce INTA	4.9 ± 0.7	b	103.7 ± 1.4	cd	8.3 ± 0.4	cd	94.0 ± 5.4	a
Valuno INTA	3.7 ± 0.1	bc	96.0 ± 3.5	cde	7.7 ± 0.7	d	69.3 ± 6.7	b
Navideña INTA	3.9 ± 0.5	bc	89.3 ± 5.8	e	8.1 ± 0.5	cd	67.0 ± 11.5	b
Ancasti INTA	4.5 ± 1.0	b	173.2 ± 4.2	b	15.7 ± 0.3	b	58.0 ± 4.5	b
Angaco INTA	2.7 ± 0.1	c	89.9 ± 6.2	de	8.1 ± 0.2	cd	1.0 ± 2.0	c

[a]PC, pyruvic acid content (µmol g^{-1} of onion fresh weigh); TDM, total dry matter (g kg^{-1}); SSC, soluble solids content (ºBrix); IVAA, *in vitro* antiplatelet activity (%). [b]Each value is the mean ± SD of fresh material. Values followed by the same letter were not significantly different according to the Tukey test ($p \leq 0.05$).

Table 5. *In vitro* antiplatelet activity, pyruvic acid content, total dry matter and soluble solids content of onion cultivars in 2006.

Cultivar	PC[a]		TDM		SSC		IVAA	
Refinta 20	6.35± 0.2	a	242.0 ± 5.8	a	22.5 ± 0.3	a	100.0 ± 0.0	a
Antartica INTA	5.5 ± 0.1	b	160.8 ± 2.6	c	14.5 ± 0.5	c	100.0 ± 0.0	a
Cobriza INTA	5.3 ± 0.3	b	115.0 ± 2.5	d	9.0 ± 0.3	d	87.9 ± 10.3	a
Valcatorce INTA	4.6 ± 0.1	c	103.6 ± 4.6	de	8.7 ± 0.3	de	45.7 ± 22.7	c
Valuno INTA	4.6 ± 1.1	bc	91.7 ± 1.3	ef	7.9 ± 1.0	def	67.0 ± 30.2	b
Navideña INTA	3.6 ± 0.2	d	88.9 ± 6.6	f	7.5 ± 0.4	ef	52.1 ± 9.8	bc
Ancasti INTA	5.1 ± 0.4	bc	214.8± 9.9	b	20.0 ± 1.2	b	89.9 ± 12.4	a
Angaco	3.5 ± 0.2	d	80.5 ± 1.5	f	6.9 ± 0.2	f	3.3 ± 3.8	d

[a]PC, pyruvic acid content (µmol g^{-1} of onion fresh weigh); TDM, total dry matter (g kg^{-1}); SSC, soluble solids content (ºBrix); IVAA, in vitro antiplatelet activity (%). [b]Each value is the mean ± SD of fresh material. Values followed by the same letter were not significantly different according to the Tukey test ($p \leq 0.05$).

Table 6. Correlation values (r) among *in vitro* antiplatelet activity, pyruvic acid content, total dry matter and soluble solids content of onion cultivars in 2005 and 2006.

Variable	PC	TDM	SSC	IVAA
		2005		
PC		0.76***	0.75***	0.69***
TDM			0.99***	0.43*
SSC				0.38*
IVAA				
		2006		
PC		0.74***	0.71***	0.83***
TDM			0.99***	0.71***
SSC				0.69***
IVAA				

The symbol *, *** denotes significant at $P < 0.05$, and 0.001 respectively.

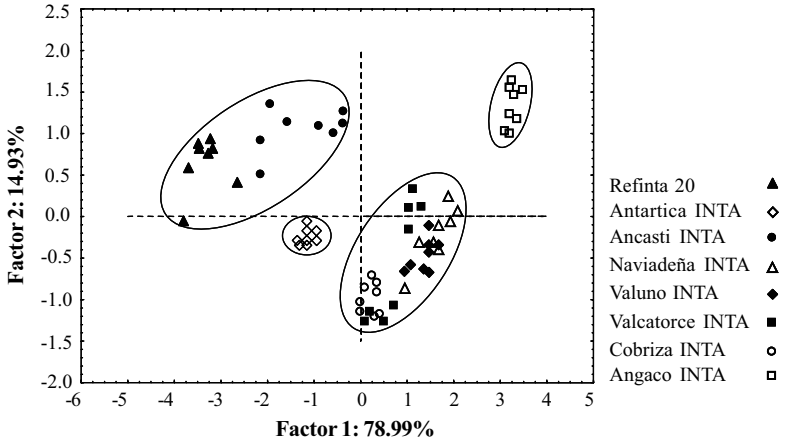

Figure 2. Principal components analysis of studied variables in onion cultivars.

selected from Torrentina populations are grouped. In other group 'Angaco INTA' a short-day Valencianita-type cultivar appears alone; in a third group a white Valenciana-type cultivar 'Antartica INTA' appears also alone and in the last group two white type-cultivars used for the dehydration industry, 'Refinta 20' and 'Ancasti INTA' are grouped together (Fig. 2).

Discussion

This is the first study on the relationship between antiplatelet activity, dry matter and flavor of Argentinean onion germplasm. The positive correlation observed between antiplatelet activity and pungency, soluble solids and dry matter content indicates that onion cultivars with higher solids and higher pyruvic content exhibit greater antiplatelet activity. These results agree with the phenotypic correlation previously found by Mann and Hoyle [28], Goldman *et al.*[7] and Debaene *et al.*[29] and the phenotypic and genetic correlation reported by Galmarini *et al.* [11] using other genetic backgrounds.

Pungency and solids content are important attributes of onion bulb quality for processing and storage. Dry matter content is important for dehydration industry because it has a direct impact on the energy required for drying. Sinclair *et al.*[30] classified 49 varieties on the basis of their dry matter content. Varieties for fresh market showed dry matter content ranging from 74 to 147 g kg^{-1}, whereas the dry matter content of dehydrating varieties ranged from 159 to 215 g kg^{-1}. Thus, in agreement with Sinclair *et al.* [30], 'Refinta 20' and 'Ancasti INTA' are suitable for dehydration and other cultivars are classified as "fresh market" type; these two cultivars, as was mentioned, grouped together in our analysis. Previous studies have evaluated the relationship between soluble solids content and total dry matter with pungency [21] indicating a positive correlation among these variables. Our results showed that cultivars with high solids content are more pungent. Onion cultivars are classified on the basis of pungency as low pungency/ sweet (0-3 µmol pyruvic acid g^{-1} fresh weight); medium pungency (3-7 µmol pyruvic acid g^{-1} fresh weight) and high pungency (above 7 µmol pyruvic acid g^{-1} fresh weight) [31]. According to this classification, 'Refinta 20' can be classified as highly pungent and the other cultivars as mild pungent.

The phenotypic correlation between pyruvic acid content and antiplatelet activity may be indicative of S-alk(en)yl-L-cysteine sulfoxides concentrations and alliinase activity [32]. ACSOs composition is important because it is responsible for nature and intensity of flavor. Once onion is crushed, these compounds are transformed into thiosulfinates and disulfides[33] which have proven inhibitor effect of platelet aggregation *in vitro* [9]. The strong positive correlation observed in our study suggests that onion cultivars with greater antiplatelet activity have high levels of ACSOs. Pungency was a good indicator of IVAA; suggesting that this measure could be usde as a predictor of the biological activity. In the near future we will analyze the ACSOs levels in Argentinean onion cultivars, to corroborate this hypothesis.

In this study all cultivars analyzed inhibited platelet aggregation in a dose-dependent manner exhibiting a broad range of variation (from 0 to 100%). Our results agree with those reported by Goldman *et al.* [7], indicating that antiplatelet activity of onion extract is genotype dependent. Also cultivar x year interaction was observed, it indicates that the environmental factors in any given year influence onion-induced antiplatelet activity, observation already made by Debaene *et al.* [29]. Nevertheless, we found that most of the variation was due to genetic differences.

One way to express the difference among cultivars according to their capacity to prevent platelet aggregation is trying to establish the amount of fresh onion juice that can cause equal antiplatelet effects. As an example, in the case of 'Angaco INTA' it was necessary to triplicate the dose of juice to equal similar effects caused by 'Refinta 20', this is shown in Fig. 3. Assuming that *in vitro* evaluation is correlated with fresh onion consumption, there would be differences among cultivars in the quantity of fresh onion necessary to reach similar health-benefits effects. These results should be taken into consideration in onion breeding programs and also in the recommendations for onion consumers.

There seems to be interesting differences among cultivars according to their origins. 'Angaco INTA' originated form Valencianita populations shows low pungency and also low IVAA, cultivars selected from Valenciana type populations show intermediate pungency and also intermediate antiplatelet activity. 'Refinta 20' selected from SWG populations has the highest IVAA, PC and dry matter content.

Another interesting relationship seems to be related to bulb color. White–bulb cultivars ('Ancasti INTA', 'Refinta 20', and 'Antartica INTA') have more SSC and IVAA than colored bulb cultivars. This relationship needs to be further explored.

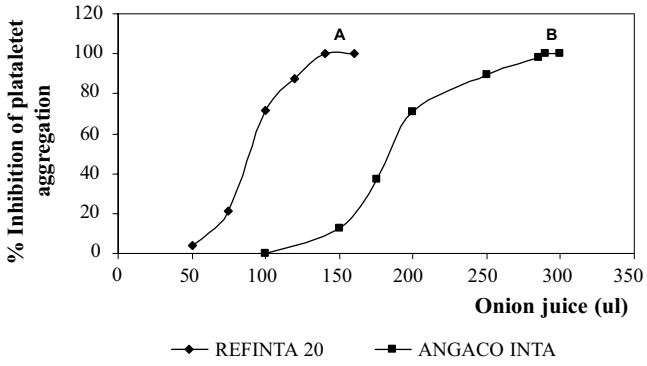

Figure 3. Dose-response curve of the highest (A) and lowest (B) antiplatelet activity onion cultivars.

Acknowledgements

Part of this research was made in Toxic Residues Analytical Laboratory, Agricultural Faculty, National University of Cuyo, and was supported by grant INTA BID 1728 OC-AR PICT 08-12902, for which the authors are grateful. We thank the Hematology Service, 'Hospital Central' of Mendoza, Argentina, for making the equipment available to us and for their kind cooperation.

References

[1]Galmarini, C.R., Gaviola, J.C., Pereyra, M., Burzichelli, S. and Ruiz, A.M. 2003. Breve caracterización de la cadena cebolla en la Argentina. IDIAXXI **III**(4):77-79.

[2]Galmarini, C.R. 2000. Onion cultivars released by La Consulta Experiment Station, INTA, Argentina. HortScience **35**(7):1360-1362.

[3]Lanzotti, V. 2006. The analysis of onion and garlic. Journal of Chromatography A **1112**:3-22.

[4]Corzo-Martínez, M., Corzo, N. and Villamiel, M. 2007. Biological

properties of onions and garlic. Trends in Food Science and Technology **18**:609-625.

[5]Kopsell, D. and Randle, W. 2002. Incubation time, cultivar, and storage duration affect onion lachrymatory factor quantification. HortScience **37**(3):567-570.

[5]Kopsell, D. and Randle, W. 2002. Incubation time, cultivar, and storage duration affect onion lachrymatory factor quantification. HortScience **37**(3):567-570.

[6]Lancaster, J.E. and Boland, M.J. 1990. Flavor biochemistry. In Rabinowitch, H.D. and Brewster, J.L. (eds). Onions and Allied Crops. vol 3. CRC Press, Boca Raton, pp. 33-72.

[7]Goldman, I.L., Kopelberg, M., Debaene, J.P. and Schwartz B.S. 1996. Antiplatelet activity in onion (*Allium cepa* L.) is sulfur dependent. Thromb. Haemost. **76**:450-452.

[8]Osmont, K.S., Arnt, C.R. and Goldman, I.L. 2003. Temporal aspect of onion-induced antiplatelet activity. Plant Food for Human Nutrition **58**:27-40.

[9]Briggs, W., Xiao, H., Parkin, K., Shen, C. and Goldman, I. 2000. Differential inhibition of human platelet aggregation by selected *Allium* thiosulfinates. J. Agric. Food Chem. **48**:5731-5735.

[10]Bordia, A. 1978. Effect of garlic on human platelet aggregation *in vitro*. Atherosclerosis **30**:355-360.

[11]Galmarini, C.R., Goldman, I.L. and Havey, M. J. 2001. Genetic analyses of correlated solids, flavor, and health-enhancing traits in onion (*Allium cepa* L.). Mol. Genet Genomics **265**:543-551.

[12]Briggs, W.H., Folts, J.D., Osman, H.E. and Goldman, I.L. 2001. Administration of raw onion inhibits platelet-mediated thrombosis in dogs. The Journal of Nutrition **131**:2619-2622.

[13]Bordia, A. K., Sharma, K. D., Parmar, V. K. and Varma, S. K. 1982. Protective effect of garlic oil on the changes produced by 3 weeks of fatty diet on serum cholesterol, serum triglycerides, fibrinolytic activity and platelet adhesion in man. Ind. Heart J. **34**:86-88.

[14]Kiesewetter, H., Jung, F., Jung, E. M., Mrowietz, C., Koscielny, J. and Wenzel, E. 1993. Effect of garlic on platelet aggregation in patients with increased risk of juvenile ischaemic attack. Eur. J. Clin. Pharmacol. **45**:333-336.

[15]Legnani, C., Frascaro, M., Guazzaloca, G., Ludovici, S., Cesarano, G. and Coccheri, S. 1993. Effects of a dried garlic preparation on fibrinolysis ad platelet aggregation in healthy subjects. Arzneimittelforschung **43**:119-122.

[16]Jung, Y.S., Kim, M.H., Lee, S.H., Baik, E.J., Park, S.W. and Moon, C.H. 2002. Prostaglandins. Leukotr. and Essent. Fatty Acids **66**(4):453-458.

[17]Grupta, N.N., Mehrota, R.M.L. and Sircar, A.R. 1966. Effect of onion on serum colesterol, blood coagulation factors and fibrinolitic activity in alimentary lipemia. Ind. Jour. Med. Res. **54**:48-53.

[18]Menon, I.S., Kendal, R.Y., Dewar, H.A. and Newell, D.J. 1968. Effect of onions on blood fibrinolytic activity. Brit. Med. Jour. **3**:351-352.

[19]Bordia, A., Verma, S.K. and Srivastava, C. 1996. Effect of garlic on platelet aggregation in human: A study in healthy subjects and patients with coronary artery disease. Prostaglandins, Leukotrienes and Essential Fatty Acids **55**(3):201-205.

[20]Chen, J.H., Chen, H., Tsai, S.J. and Jen, C.J. 2000. Chronic consumption of raw but not boiled Welsh onion juice inhibits rat platelet function. Journal of Nutrition **130**:34-37.

[21]Randle, W.M. 1992. Onion germplasm interacts with sulphur fertility for plant sulphur utilization and bulb pungency. Euphytica **59**:151-156.

[22]Simon, P.W. 1995. Genetic analysis of pungency and soluble solids in long-storage onions. Euphytica **82**:1-8.

[23]Havey, M.J., Galmarini, C.R., Gokce, A.F. and Henson, C. 2004. QTL affecting soluble carbohydrates concentrations in stored onion bulbs and their association with flavor and health-enhancing attributes. Genome **47**:463-468.

[24]Brewster, J. L. 1994. Onions and Other Vegetable Alliums. CAB International, UK, 236 p.

[25]Galmarini, C.R. 1998. Onion breeding for the dehydration industry in Argentina. Proceedings of the 1998 National Onion Research Conference, Sacramento, California, pp. 42-47.

[26]Cardinal, D.C. and Flower, R.J. 1980. The electronic aggregometer: A novel device for assessing platelet behavior in blood. Jour. Pharm. Met. **3**:135-158.

[27]Schwimmer, S. and Weston, W.J. 1961. Enzymatic development of pyruvic acid in onion as a measure of pungency. J. Agric. Food Chem. **9**:301-304.

[28]Mann, L.K. and Hoyle, E.J. 1945. Use of the refractometer for selecting onion bulb high in dry matter for breeding. Proc. Amer. Soc. Hort. Sci. **46**:285-292.

[29]Debaene, J.P., Goldman, I.L. and Yandell, B. 1999. Postharvest flux and genotype environment effects for onion induced antiplatelet activity, pungency, and soluble solids in long-day onion during postharvest cold storage. J. Amer. Soc. Hort. Sci. **124**:366-372.

[30]Sinclair, P.J., Blakeney, A.B. and Barlow, E.W.R. 1995. Relationships between bulb dry matter content, soluble solids concentration and non-structural carbohydrate composition in the onion (*Allium cepa*). J. Sci. Food Agric. **69**:203-209.

[31]Dhumal, K., Datir, S. and Pandey, R. 2007. Assessment of bulb pungency level in different Indian cultivars of onion (*Allium cepa* L.).Food Chem. **100**:1328–1330.

[32]Randle, W.M. 1995. Quantifying onion flavor compounds responding to sulfur fertility-Sulfur increases levels of S-alk(en)yl-L-cysteine sulfoxides and biosynthetic intermediates. J. Amer. Soc. Hort. Sci. **120**(6):1075-1081.

[33]Block, E. 1992. The organosulfur chemistry of the genus *Allium* - Implications for the organic chemistry of sulfur. Angewandte Chemie—International Edition **31**:1135-1178.