



WHITE PAPER



Authentication of Fruit Juice by Isotope Ratio Mass Spectrometry

Fruit juice is a widely consumed product that is susceptible to adulteration. Common types of adulteration are addition of cheap sugars such as cane sugar and corn syrup and water addition to juice sold as not-from-concentrate. Carbon isotope ratio analysis can detect sugar addition, because of inherent metabolic differences between most types of fruit and sugar cane and corn syrup. In products with pulp, the pulp and sugar can be compared to improve detection. In addition, the oxygen and hydrogen isotope composition of the juice water can be used to detect dilution with water, because genuine fruit water has a distinct evaporative signal. In this study, the methods are applied to commercially available products.

Method

Juice products (orange, apple, pineapple, guava, soursop, mango coconut, plum, blackberry, blueberry, beetroot, passionfruit) from multiple suppliers and countries of origin were purchased. In addition, grapefruit juice was prepared in the lab from fresh grapefruit. Samples were analyzed for carbon isotope ratios using a Finnigan MAT252 isotope ratio mass spectrometer coupled to an elemental analyzer (Carlo Ebra NC 1500) using a ConFlo III system. Oxygen and hydrogen isotope analysis was performed using a TCEA coupled to a Delta Plus XL mass spectrometer by a ConFlo III interface (Thermo-Finnigan).

Results

The results are summarized in Table 1. In total, 8 of the 33 commercial products appear to be adulterated with added sugar. These include 3 coconut waters and 1 each of guava, mango, plum, and soursop juice from 3 different brands. The added sugar is clearly reflected in difference between pulp and juice sugar (Fig. 1). Five of the adulterated samples were also found to have added water, despite being labeled as not-from-concentrate (Fig. 2). A single orange juice sample was labeled as containing added high-fructose corn syrup and the results reflect this addition. Adulteration of pineapple juice with cane sugar or corn syrup is difficult to detect by this method, as is beet sugar addition to other types of fruit juice.

Table 1. Summary of results.

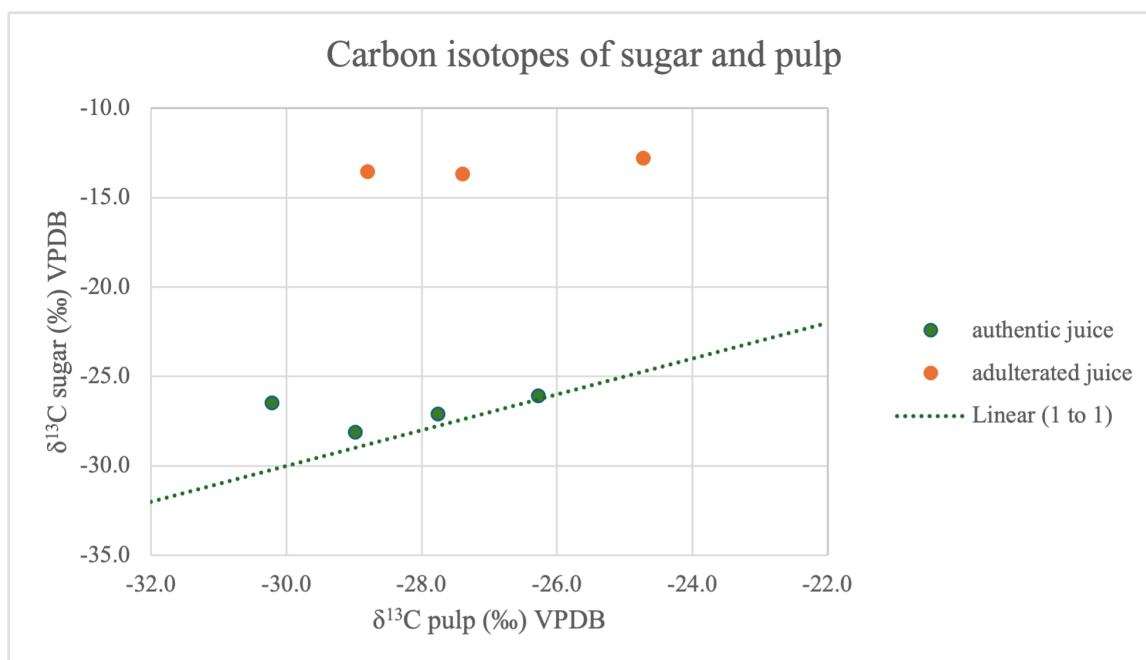
Samples highlighted in green appear to be authentic. Samples highlighted in orange appear to be adulterated. The first sample, highlighted in purple, was prepared in lab from fresh grapefruit. Sample OJ9, highlighted in blue, is labeled as containing high fructose corn syrup.

Product Information				Sugar $\delta^{13}\text{C}$ VPDB (‰)	Pulp $\delta^{13}\text{C}$ VPDB (‰)	Water	
ID	Type	Country	From Concentration?			$\delta^2\text{H}$ VSMOW (‰)	$\delta^{18}\text{O}$ VSMOW (‰)
GF1	grapefruit juice	USA	no	-28.1	-29.0	6.6	3.3
AJ1	apple cider	USA	no	-26.5	-30.2	-8.9	-96.6
AJ2	apple juice	USA	yes	-25.02	-	-	-
AJ3	apple juice	China	yes	-23.61	-	-	-
BR1	beetroot juice	Georgia	no	-25.7	-	-	-
BB1	blackberry juice	Georgia	no	-26.2	-	-	-
BL1	blueberry juice	Georgia	no	-25.7	-	-	-
CW1	coconut water	-	-	-24.4	-	2.6	-1.0

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ID	Type	Country	From Concentration?			$\delta^2\text{H}$ VSMOW (‰)	$\delta^{18}\text{H}$ VSMOW (‰)
CW2	coconut water	Vietnam	no	-13.5	-	-4.2	-34.9
CW3	coconut water	Thailand, other Asian countries	no	-24.4	-	1.7	-9.0
CW4	coconut water	Thailand	no	-17.4	-	-4.6	-39.2
CW5	coconut water	Philippines	no	-25.8	-	-	-
CW6	coconut water	Vietnam	no	-12.9	-	-	-
CW7	coconut water	Thailand	no	-24.0	-26.3	-	-
CW8	coconut water	Thailand	no	-24.96	-	-	-
CW9	coconut water	Thailand	no	-24.43	-	-	-
CW10	coconut water	Thailand	no	-24.78	-	-	-
CW11	coconut water	Thailand	no	-24.05	-	-	-
CW12	coconut water	Thailand	no	-24.2	-	-	-
CW13	coconut water	Thailand	no	-23.74	-	-	-
CW14	coconut water	Thailand	no	-24.8	-	-	-
CW15	coconut water	Thailand	no	-24.32	-	-	-
GJ1	guava juice	Vietnam	no	-13.6	-28.8	-4.5	-36.6
MJ1	mango juice	Vietnam	no	-12.8	-24.7	-5.1	-36.0
OJ1	orange juice	USA , Brazil	no	-25.5	-	-	-
OJ2	orange juice	USA, Mexico	yes	-24.95	-	-	-
OJ3	orange juice	USA, Mexico	no	-27.32	-	-	-
OJ4	orange juice	USA, Brazil	no	-25.74	-	-	-
OJ5	orange juice	Brazil	yes	-25.78	-	-	-
OJ6	orange juice	USA, Brazil, Costa Rica	yes	-25.81	-	-	-
OJ7	orange juice	USA	no	-26.1	-26.3	1.3	-27
OJ8	orange juice	-	yes	-24.75	-	-	-
OJ9	orange juice	-	yes	-12.23	-	-	-

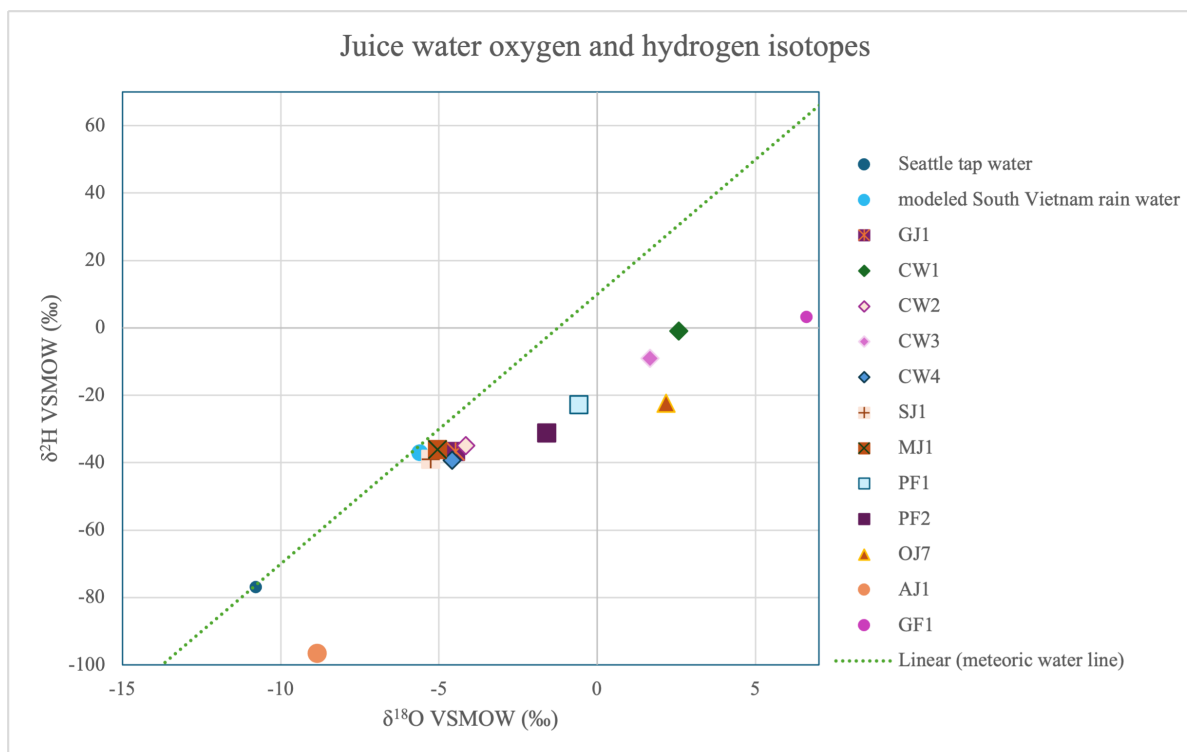
Product Information				Sugar $\delta^{13}\text{C}$ VPDB (‰)	Pulp $\delta^{13}\text{C}$ VPDB (‰)	Water	
ID	Type	Country	From Concentration?			$\delta^2\text{H}$ VSMOW (‰)	$\delta^{18}\text{H}$ VSMOW (‰)
PF1	passionfruit juice	-	no	-27.1	-27.8	-0.6	-22.8
PF2	passionfruit juice	-	?	-26.8	-	-1.6	-31.1
PJ1	Pineapple Juice	-	yes	-12.18	-	-	-
PJ2	Pineapple Juice	Costa Rica	yes	-12.51	-	-	-
PJ3	Pineapple Juice	Vietnam	no	-12.8	-	-	-
PL1	Plum Juice	Georgia	no	-16.2	-	-	-
SJ1	Soursop Juice	Vietnam	no	-13.7	-27.4	-5.3	-38.9

Fig 1. Comparison of carbon isotopes in sugar and pulp from fruit juice samples.



Authentic samples have similar pulp and sugar values, plotting near the 1:1 line (green dashed line). Samples with added sugar have very different pulp and sugar values, plotting significantly above the line.

Fig 2. Juice water isotopes.



The dashed green line is the meteoric water line. Natural, unevaporated rain and groundwaters plot along this. Juice samples plotting close to the line (orange shaded area) likely contain added water. Samples plotting significantly below the line (green shaded area) show an evaporation signal and are likely authentic not-from-concentrate juice. The adulterated samples are isotopically similar to rainwater in Southern Vietnam based on their position on the meteoric water line, consistent with their country of origin.

To learn more about our juice authenticity study, or how we can help with your juice authenticity testing needs, please contact us:

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