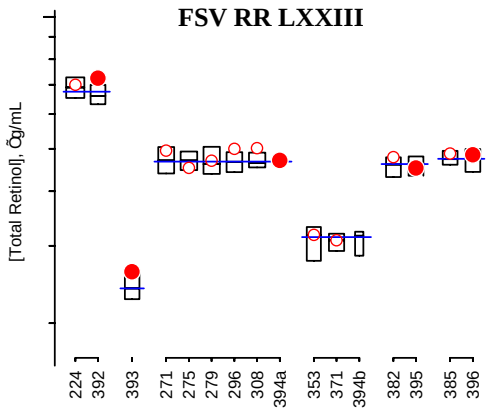
NISTIR 7880-41

NIST Micronutrients Measurement Quality Assurance Program Winter 2013 Comparability Studies

Results for Round Robin LXXIII Fat-Soluble Vitamins and Carotenoids in Human Serum and Round Robin 38 Ascorbic Acid in Human Serum



David L. Duewer
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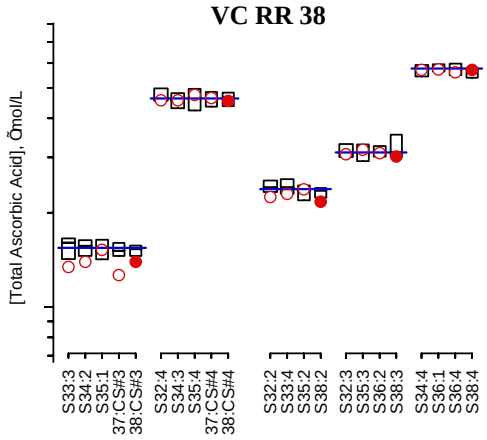

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U.S. Department of Commerce

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NISTIR 7880-41

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Results for Round Robin LXXIII Fat-Soluble Vitamins and Carotenoids in Human Serum and Round Robin 38 Ascorbic Acid in Human Serum

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Materials Measurement Laboratory

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November 2014

U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie E. May, Acting Under Secretary of Commerce for Standards and Technology and Acting Director

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Abstract

The National Institute of Standards and Technology coordinates the Micronutrients Measurement Quality Assurance Program (MMQAP) for laboratories that measure fat- and water-soluble vitamins and carotenoids in human serum and plasma. This report describes the design of and results for the Summer 2013 MMQAP measurement comparability improvement studies: 1) Round Robin LXXIII Fat-Soluble Vitamins and Carotenoids in Human Serum and 2) Round Robin 38 Total Ascorbic Acid in Human Serum. The materials for both studies were shipped to participants in January 2013; participants were requested to provide their measurement results by April 1, 2013.

Keywords

Human Serum
Retinol, α-Tocopherol, γ-Tocopherol, Total and *Trans*-β-Carotene
Total Ascorbic Acid

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Introduction

Beginning in 1988, the National Institute of Standards and Technology (NIST) has coordinated the Micronutrients Measurement Quality Assurance Program (MMQAP) for laboratories that measure fat- and water-soluble vitamins and carotenoids in human serum and plasma. The MMQAP provides participants with measurement comparability assessment through use of interlaboratory studies, Standard Reference Materials (SRMs) and control materials, and methods development and validation. Serum-based samples with assigned values for the target analytes (retinol, alpha-tocopherol, gamma/beta-tocopherol, *trans*- and total beta-carotene, and total ascorbic acid) and performance-evaluation standards are distributed by NIST to laboratories for analysis.

Participants use the methodology of their choice to determine analyte content in the control and study materials. Participants provide their data to NIST, where it is compiled and evaluated for trueness relative to the NIST value, within-laboratory precision, and concordance within the participant community. NIST provides the participants with a technical summary report concerning their performance for each exercise and suggestions for methods development and refinement. Participants who have concerns regarding their laboratory's performance are encouraged to consult with the MMQAP coordinators.

All MMQAP interlaboratory studies consist of individual units of batch-prepared samples that are distributed to each participant. For historical reasons these studies are referred to as "Round Robins". The MMQAP program and the nature of its studies are described elsewhere. [1,2]

Round Robin LXXIII: Fat-Soluble Vitamins and Carotenoids in Human Serum

Participants in the MMQAP Fat-Soluble Vitamins and Carotenoids in Human Serum Round Robin LXXIII comparability study (hereafter referred to as RR73) received one lyophilized and four liquid-frozen human serum test samples for analysis. Unless multiple vials were previously requested, participants received one vial of each serum. These sera were shipped on dry ice to participants in January 2013. The communication materials included in the sample shipment are provided in Appendix A.

Participants are requested to report values for all fat-soluble vitamin-related analytes that are of interest to their organizations. Not all participants report values for the target analytes, and many participants report values for non-target analytes.

The final report delivered to every participant in RR73 consists of three documents:

- A cover letter for the current study, a brief description of the other two documents, and a discussion of our analysis of the overall results that may be of broad interest. This cover letter is reproduced as Appendix B.

- The "All-Lab Report" that lists all of the reported measurement results, a number of consensus statistics for analytes reported by more than one participant, and the mean median and pooled SD from any prior distributions of the serum. This report also provides a numerical "score card" for each participant's measurement comparability for the more commonly reported analytes. This All-Lab Report is reproduced as Appendix C.

- An "Individualized Report" that graphically analyzes each participant's results for all analytes reported by at least five participants. This report also provides a graphical summary of their measurement comparability. The graphical tools used in the Individualized Report are described in detail elsewhere [3]. An example Individualized Report is reproduced as Appendix D.

Round Robin 38: Vitamin C in Human Serum

Participants in the MMQAP Vitamin C in Human Serum Round Robin 38 comparability study (hereafter referred to as RR38) received four frozen serum test samples and two frozen control sera. Unless multiple vials were previously requested, participants received one vial of each material. These sample materials were shipped on dry ice to participants in January 2013. The communication materials included in the sample shipment are provided in Appendix E.

The test and control serum materials were prepared by adding equal volumes of 10 % metaphosphoric acid (MPA) to human serum that had been spiked with ascorbic acid. While these samples contain some dehydroascorbic acid, its content is variable. Therefore, the participants report only total ascorbic acid (TAA, ascorbic acid plus dehydroascorbic acid).

The final report delivered to every participant in RR38 consists of three documents:

- A cover letter for the current study, a brief description of the other two documents, and a discussion of our analysis of overall results that may be of broad interest. This cover letter is reproduced as Appendix F.

- The "All-Lab Report" that summarizes all of the reported measurement results and provides several consensus statistics. This All-Lab Report is reproduced as Appendix G.

- An "Individualized Report" that graphically analyzes each participant's results for TAA, including a graphical summary of their measurement comparability. The graphical tools used in the Individualized Report are described in detail elsewhere [3]. An example Individualized Report is reproduced as Appendix H.

References

1 Duewer DL, Brown Thomas J, Kline MC, MacCrehan WA, Schaffer R, Sharpless KE, May WE, Crowell JA. NIST/NCI Micronutrients Measurement Quality Assurance Program: Measurement Repeatabilities and Reproducibilities for Fat-Soluble Vitamin-Related Compounds in Human Sera. Anal Chem 1997;69(7):1406-1413.

2 Margolis SA, Duewer DL. Measurement Of Ascorbic Acid in Human Plasma and Serum: Stability, Intralaboratory Repeatability, and Interlaboratory Reproducibility. Clin Chem 1996;42(8):1257-1262.

3 Duewer DL, Kline MC, Sharpless KE, Brown Thomas J, Gary KT, Sowell AL. Micronutrients Measurement Quality Assurance Program: Helping Participants Use Interlaboratory Comparison Exercise Results to Improve Their Long-Term Measurement Performance. Anal Chem 1999;71(9):1870-1878.

Appendix A. Shipping Package Inserts for RR73

The following three items were included in each package shipped to an RR73 participant:

- Cover letter
- Datasheet
- Packing List and Shipment Receipt Confirmation Form

The cover letter and datasheet were enclosed in a sealed waterproof bag along with the samples themselves. The packing list was placed at the top of the shipping box, between the cardboard covering and the foam insulation.

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

January 21, 2013

Dear Colleague:

Enclosed are samples for the first fat-soluble vitamins and carotenoids in serum study (Round Robin LXXIII) for the 2013 NIST Micronutrients Measurement Quality Assurance Program. The set of samples (Sera 392- 396) consists of one vial of lyophilized serum and one vial each of four liquid-frozen serum samples for analysis along with a form for reporting your results. These samples should be stored in the dark at or below –20 °C upon receipt. When reporting your results, please submit one value for each analyte for a given serum sample. If a value obtained is below your limit of quantification, please indicate this result on the form by using NQ *(Not Quantified)*. Results are due to NIST by **April 1, 2013**. Results received more than two weeks after the due date may not be included in the summary report for this round robin study. The feedback report concerning the study will be distributed in May 2013.

Samples should be allowed to stand at room temperature under subdued light until thawed. We recommend that sample mixing be facilitated with 3 to 5 min agitation in an ultrasonic bath or at least 15 min at room temperature with intermittent swirling. (CAUTION: Vigorous shaking will cause foaming and possibly interfere with accurate measurement. The rubber stopper contains phthalate esters that may leach into the sample upon intermittent contact of the liquid sample with the stopper. These esters absorb strongly in the UV region and elute near retinol in most LC systems creating analytical problems.) **Water should not be added to the liquid-frozen samples.**

For consistency, we request that laboratories use the following absorptivities (dL/g · cm): retinol, 1843 at 325 nm (ethanol); retinyl palmitate, 975 at 325 nm (ethanol); α-tocopherol, 75.8 at 292 nm (ethanol); γ-tocopherol, 91.4 at 298 nm (ethanol); α-carotene, 2800 at 444 nm (hexane); β-carotene, 2560 at 450 nm (ethanol), 2592 at 452 nm (hexane); and lycopene, 3450 at 472 nm (hexane).

Please report your results for Round Robin LXXIII by e-mail to david.duewer@nist.gov or fax to 301-977-0685. If you have questions or comments regarding this study, please call me at (301) 975-3120 or e-mail me at jbthomas@nist.gov.

Sincerely,

Jeanice Brown Thomas
Program Coordinator/Research Chemist
Analytical Chemistry Division
Material Measurement Laboratory

NIST

Participant #: _____ Date: _____

Round Robin LXXIII: Human Sera

NIST Micronutrients Measurement Quality Assurance Program

Analyte	392	393	394	395	396	Units*
total retinol						
trans-retinol						
retinyl palmitate						
α-tocopherol						
γ/β-tocopherol						
δ-tocopherol						
total β-carotene						
trans-β-carotene						
total cis-β-carotene						
total α-carotene						
total lycopene						
trans-lycopene						
total β-cryptoxanthin						
total α-cryptoxanthin						
total lutein						
total zeaxanthin						
total lutein&zeaxanthin						
total coenzyme Q10						
ubiquinol (QH_2)						
ubiquinone (Qox)						
phylloquinone (K_1)						
25-hydroxyvitamin D						
Phytoene						
Phytofluene						

* we prefer **µg/mL**

Were the samples frozen when received? Yes | No

Comments:

Mail: M^2QAP
NIST, Stop 8392
Gaithersburg, MD 20899-8392

Please return results by
1-April-2013

Fax: 301-977-0685
Email: David.Duewer@NIST.gov

Participant #: _____ Date: _____

Fat-Soluble Vitamins Round Robin LXXIII

NIST Micronutrients Measurement Quality Assurance Program

Packing List and Shipment Receipt Confirmation Form

This box contains: one vial each of the following five FSV M^2QAP sera

Serum	Form	Reconstitute?	Vial/Cap
#392	Lyophilized	Yes	5 mL clear / silver
#393	Liquid frozen	No	5 mL clear / silver
#394	Liquid frozen	No	2 mL amber / blue
#395	Liquid frozen	No	2 mL clear / green
#396	Liquid frozen	No	2 mL clear / black

Please
1) Open the pack immediately
2) Check that it contains all of the above samples
3) Check if the vials are intact
4) Store the sera at -20 ˚C or below until analysis
5) Email (david.duewer@nist.gov) or fax (301-977-0685) us the following information:

1) Date this shipment arrived: _____

2) Are all five sera vials intact? Yes | No
If "No", which one(s) were damaged?

3) Was there any dry-ice left in cooler? Yes | No

4) Did the samples arrive frozen? Yes | No

5) At what temperature are you storing the serum samples? _____ ˚C

6) When do you anticipate analyzing these samples? _____

Your prompt return of this information is appreciated.

The M^2QAP Gang

Mail: M^2QAP
NIST, Stop 8392
Gaithersburg, MD 20899-8392

Fax: 301-977-0685
Email: David.Duewer@NIST.gov

Appendix B. Final Report for RR73

The following three pages are the final report for RR73 as provided to all participants:

- Cover letter.
- An information sheet that:
  - describes the contents of the "All-Lab" report,
  - describes the content of the "Individualized" report,
  - describes the nature of the test samples and details their previous distributions, if any, and
  - summarizes aspects of the study that we believe may be of interest to the participants.

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

May 16, 2013

Dear Colleague:

Enclosed is the summary report of the results for "Round Robin" LXXIII (RR73) of the 2013 NIST Micronutrients Measurement Quality Assurance Program (M^2QAP) for the fat-soluble vitamins and carotenoids in human serum. Included in this report are: 1) a summary of data and measurement comparability scores for all laboratories, 2) a detailed graphical analysis of your results; and 3) a graphical summary of your measurement comparability. RR73 (Sera 392 - 396) consisted of one vial of lyophilized serum and one vial each of four liquid-frozen serum samples. Details regarding the samples can be found in the enclosed report.

Your overall measurement comparability is summarized in the "Score Card" summary, page 7 of the All Lab Report. Combined results rated 1 to 3 are within 1 to 3 standard deviations of the assigned value, respectively; those rated 4 are >3 standard deviations from the assigned value. Similar information is presented graphically in the "target plots" that are the last page of your Individualized Report. If you have concerns regarding your laboratory's performance, please contact us for consultation.

Samples for the second set of fat-soluble vitamins and carotenoids in serum interlaboratory exercise (RR74) will be shipped **starting June 10, 2013**. Please contact us immediately if this schedule is problematic for your laboratory.

We are currently in the process of providing on-line documentation of data and reports from the MMQAP studies (past and present). The results for Round Robin 71 Fat-Soluble Vitamins and Carotenoids in Human Serum and and Round Robin 36 Ascorbic Acid in Human Serum are available at: http://www.nist.gov/manuscript-publication-search.cfm?pub_id=911458. Click on the DOI link to access the manuscript. Data summaries have been altered to ensure confidentiality of identification codes assigned to laboratories. We will update you as additional on-line documents become available.

If you have questions or concerns regarding this report, please contact David Duewer at 301-975-3935; e-mail: david.duewer@nist.gov or me at 301-975-3120; e-mail: jbthomas@nist.gov; or fax: 301-977-0685.

Sincerely,

Jeanice Brown Thomas, M.B.A.
Research Chemist
Analytical Chemistry Division
Material Measurement Laboratory

David L. Duewer, Ph.D.
Research Chemometrician
Analytical Chemistry Division
Material Measurement Laboratory

Enclosures

Cc: L.C. Sander

NIST

The NIST MMQAP Round Robin LXXIII (RR73) report consists of:

Page	All-Lab Report
1-5	A listing of all results and statistics for analytes reported by more than one participant.
6	A listing of the analytes reported by only one participant and a legend for the list of results and statistics.
7	The text Comparability Summary ("Score Card") of measurement performance.

Page	Individualized Report
1	Your values, the number of labs reporting values, and our assigned values.
2 to n	"Four Plot" summaries of your current and past measurement performance, one page for each analyte you report that is also reported by at least eight other participants.
n+1	The graphical Comparability Summary (target plot) of measurement performance.

Samples. Five samples were distributed to each participant in RR73. Unfortunately, the sample distributed as Serum 394 was a mixture of two materials. Fortunately, the two materials have distinctive levels for several analytes and we have been able to unambiguously identify who got which material. We have *post-facto* designated these two materials Serum 394a and Serum 394b. The All Lab Report therefore lists values for six samples. The Individualized Reports for every participant reflect the results just for the five materials that they evaluated.

Serum	Description	Prior Distributions
392	Lyophilized, multi-donor stripped serum augmented with retinol, retinyl palmitate, α- and γ-tocopherol, α- and β-carotene, lycopene, β-cryptoxanthin, lutein, and zeaxanthin prepared in 1995.	#224:RR38-9/96
393	Liquid-frozen, multi-donor heparin-treated plasma material augmented with glycyrrhetinic acid prepared in 1989.	First MMQAP distribution
394a	Fresh-frozen, native, single donor serum prepared in 1999.	#271:RR49-3/01, #275:RR50-9/01, #279:RR51-3/02, #296:RR54-9/03, #308:RR56-9/04
394b	Liquid-frozen, multi-donor serum augmented with *trans*-β-carotene in a lipoprotein carrier prepared in 2008.	#353:RR65-3/09, #371:RR68-9/10
395	Fresh-frozen, native, multi-donor serum prepared in 2011. This material has relatively high contents of α- and β-carotene.	#382:RR71-3/12
396	Fresh-frozen, native, multi-donor serum prepared in 2011.	#385:RR71-3/12

Results

1) Serum 392. This serum was constructed to test whether it was practical to spike sera with very lipophilic analytes. While we did not fully achieve the targeted levels for the carotenoids, the augmentation method used appeared to be relatively effective. This distribution of the material was intended to access the material's stability over time and storage. The median value for many, but not all, of the analytes is lower than that of 18 years ago. We speculate that due to the aging of the material, the augmented analytes in this lyophilized material have become more difficult to reconstitute and/or extract.

2) Serum 393. This material was prepared as part of an investigation into the chemopreventative potential of glycyrrhetinic acid (the main metabolite of the glucoside glycyrrhizin obtained from licorice root, *Glycyrriza glabra*). This relatively polar compound's absorbance maxima is at 248 nm and should not interfere with the analysis of the usual MMQAP analytes. However, if any of your results are uniquely high in Serum 393, please check the chromatogram for evidence of interference. If you find such evidence, please contact JBThomas@nist.gov.

3) Sera 394a and 394b. We apologize for the confusion. We unintentionally combined amber vials with blue caps that were labeled "271" and "371". The median levels and variability of the results for both "Serum 394" materials are essentially unchanged from their prior levels.

4) Sera 395 and 396. The median levels and variability of the results for both of these relatively new materials are essentially unchanged from their prior levels.

Appendix C. "All-Lab Report" for RR73

The following seven pages are the "All-Lab Report" for RR73 as provided to all participants, with two exceptions:

- the participant identifiers (Lab) have been altered.
- the order in which the participant results are listed has been altered.

The data summary in the "All-Lab Report" has been altered to ensure confidentiality of identification codes assigned to laboratories.

Round Robin LXXIII Laboratory Results

	Total Retinol, µg/mL						Retinyl Palmitate, µg/mL						α-Tocopherol, µg/mL						γ/β-Tocopherol, µg/mL					
Lab	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396
FSV-BA	0.724	0.262	0.470		0.452	0.484	0.078	0.011	0.048		0.056	0.031	8.53	4.09	6.95		10.78	7.11	4.33	0.84	2.00		1.42	1.90
FSV-BB	0.714	0.272	0.484		0.500	0.486	0.070	0.004	0.044		0.069	0.006	8.49	4.12	6.83		11.73	7.14	3.85	0.82	1.84		1.41	1.75
FSV-BC	0.717	0.289	0.489		0.463	0.513																		
FSV-BD	0.623	0.226	0.436		0.401	0.412							7.40	4.10	6.30		9.30	6.10						
FSV-BE	0.660	0.220		0.300	0.440	0.450							9.00	4.20		8.5	12.50	7.80	3.70	0.70		2.90	1.30	1.60
FSV-BF	0.550	0.240		0.240	0.280	0.270							7.30	4.30		5.2	9.10	6.40						
FSV-BG	0.698	0.265	0.470		0.474	0.480	0.049	*nd*	0.024		0.054	0.013	8.56	4.42	7.33		11.79	7.53	4.07	0.86	1.89		1.41	1.84
FSV-BH	0.684	0.229	0.481		0.486	0.455							8.88	4.03	6.73		11.51	7.15	4.16	0.75	1.80		1.37	1.70
FSV-BJ	0.756	0.260	0.465		0.480	0.474							8.39	4.18	7.34		12.27	7.87	4.33	0.78	1.95		1.36	1.81
FSV-BK	0.619	0.226	0.426		0.426	0.432							7.91	3.98	6.54		10.37	6.80						
FSV-BL	0.690	0.200	0.460		0.460	0.490							8.60	3.90	6.90		10.80	7.80						
FSV-BM	0.590	0.240	0.400		0.420	0.430							8.20	4.50	6.80		11.20	8.70						
FSV-BN	0.685	0.236	0.484		0.451	0.474							7.44	3.66	6.38		9.83	6.46						
FSV-BNa	0.717	0.256	0.516		0.489	0.504							8.19	4.15	7.00		10.81	7.13						
FSV-BO	0.660	0.240		0.320	0.470	0.500							8.70	4.10		8.4	11.60	7.70	3.70	0.90		3.00	1.50	1.80
FSV-BP	0.657	0.194	0.505		0.456	0.482							8.51	4.37	7.78		12.39	7.72						
FSV-BQ	0.640	0.250	0.470		0.430	0.460							9.00	5.00	7.00		12.00	7.00						
FSV-BR	≥0.65	≥0.225	≥0.46		≥0.44	≥0.45							8.10	4.20	7.40		11.33	7.40						
FSV-BS																								
FSV-BT	0.704	0.317	0.469		0.484	0.482							8.47	4.15	6.87		11.10	7.21	3.76	0.90	1.91		1.42	1.80
FSV-BU	0.400	0.280	0.490		0.460	0.520							10.00	5.28	7.04		12.24	7.63	4.70	0.98	1.89		1.43	1.85
FSV-BV	0.454	0.120		0.257	0.355	0.386							7.30	3.84		7.1	9.75	7.04	3.47	0.72		2.76	1.21	1.71
FSV-BW	0.670	0.240	0.490		0.480	0.510	0.085	0.014	0.084		0.072	0.047	7.97	3.58	6.69		10.72	7.15	4.20	0.80	1.99		1.35	1.85
FSV-CD	0.628	0.245		0.348	0.470	0.518	0.120	*nq*		*nq*	0.087	*nq*	10.46	5.85		10.2	13.02	9.49	4.22	1.02		3.31	1.46	1.98
FSV-CE	0.635	0.224		0.313	0.422	0.177							6.38	3.51		6.1	11.23	3.96						
FSV-CG	0.664	0.273		0.324	0.463	0.475							7.13	3.86		7.4	10.82	7.04	3.62	0.83		3.13	1.39	1.86
FSV-CI	0.641	0.231	0.459		0.438	0.445	0.083	0.007	0.043		0.047	0.014	8.12	4.09	6.43		10.14	6.57	2.92	0.60	1.34		0.92	1.23
FSV-CO													8.41	3.78	6.96		11.93	7.40	4.22	0.84	2.01		1.51	1.89
FSV-CZ	0.460	0.229		0.391	0.556	0.560							8.88	4.91		8.4	11.95	8.50	3.76	0.73		2.70	1.12	1.70
FSV-DD	0.660	0.160		0.280	0.430	0.440																		
FSV-DV	0.748	0.259	0.512		0.507	0.551							8.10	4.30	6.30		10.30	8.00						
FSV-EE																								
FSV-EZ	0.693	!0.699	0.459		0.463	0.469	0.059	<0.02	0.025		0.031	<0.02	8.89	4.30	7.64		11.66	7.73	3.84	0.75	1.77		1.40	1.75
FSV-FK	0.702	0.254		0.321	0.466	0.498							9.60	4.40		8.8	11.40	7.30						
FSV-FZ	0.641	0.365	0.445		0.524	0.440	0.047	0.006	0.037		0.047	0.019	8.62	3.97	7.15		11.21	7.53	4.06	0.74	1.87		1.35	1.76
N	31	30	21	10	31	31	8	5	7	0	8	6	31	31	22	9	31	31	18	18	12	6	18	18
Min	0.400	0.120	0.400	0.240	0.280	0.177	0.047	0.004	0.024		0.031	0.006	6.38	3.51	6.30	5.2	9.10	3.96	2.92	0.60	1.34	2.70	0.92	1.23
Median	0.660	0.240	0.470	0.317	0.463	0.475	0.074	0.007	0.043		0.055	0.017	8.47	4.15	6.92	8.4	11.23	7.30	3.96	0.81	1.89	2.95	1.39	1.80
Max	0.756	0.365	0.516	0.391	0.556	0.560	0.120	0.014	0.084		0.087	0.047	10.46	5.85	7.78	10.2	13.02	9.49	4.70	1.02	2.01	3.31	1.51	1.98
eSD	0.055	0.026	0.021	0.036	0.034	0.043	0.019	0.005	0.009		0.016	0.010	0.61	0.27	0.34	1.5	0.83	0.59	0.38	0.10	0.11	0.28	0.06	0.08
eCV	8	11	4	11	7	9	26	70	21		30	63	7	6	5	18	7	8	10	12	6	9	4	5
N_{past}	47	0	37	31	31	31	15	0	12	8	7	5	45	0	41	31	29	29	23	0	24	18	16	16
$Median_{past}$	0.690		0.467	0.313	0.460	0.473	0.243		0.055	0.014	0.070	0.014	8.28		7.11	7.9	11.33	7.51	3.87		1.96	3.15	1.36	1.77
SD_{past}	0.057		0.040	0.024	0.030	0.024	0.129		0.014	0.011	0.009	0.012	0.55		0.57	0.6	1.23	0.76	0.46		0.15	0.33	0.09	0.09
NAV	0.660	0.240	0.470	0.317	0.463	0.475	0.074	0.007	0.043		0.055	0.017	8.47	4.15	6.92	8.4	11.23	7.30	3.96	0.81	1.89	2.95	1.39	1.80
NAU	0.055	0.026	0.038	0.036	0.037	0.043	0.021	0.010	0.015		0.017	0.011	0.68	0.44	0.58	1.5	0.87	0.60	0.38	0.10	0.20	0.28	0.16	0.19

C2

Round Robin LXXIII Laboratory Results

	δ-Tocopherol, µg/mL						Total β-Carotene, µg/mL						trans-β-Carotene, µg/mL						Total cis-β-Carotene, µg/mL					
Lab	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396
FSV-BA	0.749	0.040	0.117		0.083	0.126	0.299	0.019	0.332		0.636	0.052	0.286	0.014	0.309		0.597	0.045	0.013	0.005	0.023		0.039	0.007
FSV-BB	0.686	0.046	0.129		0.093	0.093	0.323	0.014	0.319		0.705	0.048	0.311	0.011	0.301		0.668	0.047	0.011	0.003	0.018		0.037	0.001
FSV-BC																								
FSV-BD																								
FSV-BE							0.290	<0.02		0.300	0.670	0.050												
FSV-BF							0.108	*nq*		0.255	0.393	0.056												
FSV-BG							0.350	0.016	0.372		0.696	0.057												
FSV-BH							0.381	*nq*	0.338		0.739	0.046												
FSV-BJ							0.192	*nq*	0.280		0.555	0.034												
FSV-BK																								
FSV-BL																								
FSV-BM																								
FSV-BN							0.293	0.012	0.318		0.609	0.045												
FSV-BNa							0.282	0.031	0.307		0.564	0.047	0.230	0.017	0.250		0.468	0.033	*0.052*	*0.014*	*0.057*		*0.096*	*0.014*
FSV-BO							0.363	0.013		0.311	0.616	0.053												
FSV-BP							0.222	0.053	0.203		0.651	0.329												
FSV-BQ																								
FSV-BR																								
FSV-BS							≥0.443	*nq*	≥0.448		≥0.762	≥0.13	0.443	*nq*	0.448		0.762	0.130						
FSV-BT	0.485	0.079	0.111		0.090	0.070	0.360	0.015	0.328		0.683	0.053	0.317	0.013	0.281		0.582	0.048	0.012	*nq*	0.017		0.037	0.001
FSV-BU							0.335	0.018	0.316		0.664	0.065												
FSV-BV							0.240	0.019		0.249	0.545	0.048												
FSV-BW							0.221	0.006	0.388		0.643	0.065												
FSV-CD							0.427	0.066		0.387	0.801	0.114												
FSV-CE	*nq*	*nq*		0.167	0.659	*nq*																		
FSV-CG	0.629	0.128		0.167	0.139	0.141	0.328	0.015		0.294	0.667	0.054	0.317	0.013		0.278	0.626	0.050	0.011	0.005		0.016	0.040	0.005
FSV-CI							0.259	0.009	0.343		0.720	0.041												
FSV-CO							0.347	0.021	0.354		0.705	0.061												
FSV-CZ							0.632	0.088		0.279	0.674	0.120												
FSV-DD																								
FSV-DV																								
FSV-EE																								
FSV-EZ							0.473	<0.059	0.321		0.593	<0.059												
FSV-FK																								
FSV-FZ							0.597	0.020	0.375		0.725	0.070												
N	4	4	3	2	5	4	22	17	15	7	22	21	6	5	5	1	6	6	5	4	4	1	5	5
Min	0.485	0.040	0.111	0.167	0.083	0.070	0.108	0.006	0.203	0.249	0.393	0.034	0.230	0.011	0.250		0.468	0.033	0.011	0.003	0.017		0.037	0.001
Median	0.658	0.062	0.117	0.167	0.093	0.109	0.325	0.018	0.328	0.294	0.666	0.053	0.314	0.013	0.301	0.278	0.612	0.047	0.012	0.005	0.020	0.016	0.039	0.005
Max	0.749	0.128	0.129	0.167	0.659	0.141	0.632	0.088	0.388	0.387	0.801	0.329	0.443	0.017	0.448		0.762	0.130	0.052	0.014	0.057		0.096	0.014
eSD	0.089	0.029			0.015	0.035	0.073	0.006	0.022	0.025	0.066	0.011	0.023	0.002	0.030		0.064	0.004	0.001	0.002	0.004		0.002	0.005
eCV	14	46			16	32	23	35	7	9	10	20	7	13	10		10	8	10	37	21		5	107
N_{past}	5	0	6	4	4	4	32	0	29	21	19	18	12	0	13	7	5	5	8	0	9	6	4	0
$Median_{past}$	0.750		0.132	0.087	0.081	0.067	0.624		0.350	0.305	0.653	0.055	0.587		0.323	0.288	0.634	0.054	0.027		0.024	0.016	0.038	
SD_{past}	0.119		0.053	0.016	0.065	0.048	0.103		0.040	0.053	0.122	0.007	0.103		0.027	0.027	0.126	0.004	0.019		0.007	0.003	0.005	
NAV	0.658	0.062	0.117		0.093	0.109	0.325	0.018	0.328	0.294	0.666	0.053	0.314	0.013	0.301		0.612	0.047	0.012	0.005	0.020		0.039	0.005
NAU					0.023		0.073	0.008	0.047	0.043	0.090	0.011	0.034	0.007	0.032		0.064	0.009	0.004				0.015	0.005

C3

Round Robin LXXIII Laboratory Results

	Total α-Carotene, µg/mL						Total Lycopene, µg/mL						trans-Lycopene, µg/mL						Total β-Cryptoxanthin, µg/mL					
Lab	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396
FSV-BA	0.372	0.004	0.030		0.340	0.020	0.299	0.135	0.307		0.260	0.214	0.204	0.071	0.171		0.130	0.104	0.059	0.011	0.061		0.071	0.101
FSV-BB	0.347	0.003	0.025		0.343	0.018	0.296	0.125	0.289		0.284	0.208	0.173	0.059	0.137		0.110	0.085	0.051	0.010	0.050		0.066	0.091
FSV-BC																								
FSV-BD																								
FSV-BE																								
FSV-BF																								
FSV-BG	0.344	0.008	0.033		0.326	0.024	0.338	0.147	0.340		0.280	0.248	0.230	0.078	0.191		0.138	0.123	0.055	0.011	0.054		0.067	0.103
FSV-BH	0.466	*nq*	0.022		0.367	0.018	0.469	0.165	0.387		0.352	0.272							0.082	*nq*	0.067		0.088	0.126
FSV-BJ	0.413	*nq*	*nq*		0.383	*nq*	0.305	0.201	0.328		0.276	0.258							*nq*	*nq*	*nq*		0.066	0.080
FSV-BK																								
FSV-BL																								
FSV-BM																								
FSV-BN	0.393	0.003	0.040		0.355	0.020	0.324	0.141	0.367		0.307	0.251							0.049	0.010	0.049		0.051	0.094
FSV-BNa	0.374	*nd*	0.041		0.333	0.023	0.327	0.164	0.369		0.349	0.284	0.153	0.068	0.180		0.127	0.120	0.044	0.017	0.048		0.057	0.082
FSV-BO																								
FSV-BP	0.051	*nd*	0.010		0.350	0.024	0.742	0.220	0.143		0.271	0.232							0.094	0.090	0.046		0.062	0.143
FSV-BQ																								
FSV-BR																								
FSV-BS	0.620	0.073	0.068		0.432	0.041	0.565	0.267	0.815		0.399	0.452	0.315	0.136	0.348		0.159	0.188	0.123	0.069	0.185		0.124	0.190
FSV-BT	0.417	0.007	0.031		0.347	0.026	0.315	0.123	0.297		0.292	0.219	0.168	0.056	0.139		0.121	0.099	0.057	0.012	0.053		0.058	0.095
FSV-BU	0.434	0.005	0.026		0.376	0.029	0.335	0.133	0.305		0.274	0.231							0.052	0.012	0.056		0.071	0.092
FSV-BV	0.355	0.006		0.026	0.340	0.023	0.242	0.099		0.362	0.224	0.206							0.029	0.006		0.058	0.042	0.071
FSV-BW	0.684	0.015	0.017		0.540	0.015	0.275	0.136	0.332		0.226	0.234												
FSV-CD	0.597	*nq*		0.050	0.525	0.033	0.385	0.152		0.543	0.309	0.280							0.081	0.019		0.128	0.105	0.124
FSV-CE																								
FSV-CG	0.471	0.005		0.042	0.459	0.030	0.367	0.154		0.513	0.340	0.273	0.264	0.083		0.274	0.157	0.131	0.069	0.020		0.129	0.104	0.129
FSV-CI	0.333	0.008	0.028		0.338	0.020																		
FSV-CO							0.376	0.140	0.336		0.276	0.239												
FSV-CZ																								
FSV-DD																								
FSV-DV																								
FSV-EE																								
FSV-EZ																								
FSV-FK																								
FSV-FZ																								
N	16	11	12	3	16	15	16	16	13	3	16	16	7	7	6	1	7	7	13	12	10	3	14	14
Min	0.051	0.003	0.010	0.026	0.326	0.015	0.242	0.099	0.143	0.362	0.224	0.206	0.153	0.056	0.137		0.110	0.085	0.029	0.006	0.046	0.058	0.042	0.071
Median	0.403	0.006	0.029	0.042	0.353	0.023	0.331	0.144	0.332	0.513	0.282	0.243	0.204	0.071	0.176	0.274	0.130	0.120	0.057	0.012	0.054	0.128	0.066	0.098
Max	0.684	0.073	0.068	0.050	0.540	0.041	0.742	0.267	0.815	0.543	0.399	0.452	0.315	0.136	0.348		0.159	0.188	0.123	0.090	0.185	0.129	0.124	0.190
eSD	0.086	0.002	0.008		0.025	0.005	0.052	0.022	0.052		0.035	0.039	0.053	0.017	0.038		0.014	0.024	0.018	0.005	0.008		0.013	0.025
eCV	21	41	29		7	21	16	15	16		12	16	26	24	22		10	20	32	43	14		20	25
N_{past}	28	0	24	17	15	15	28	0	24	16	13	13	8	0	11	8	6	6	20	0	24	17	14	14
$Median_{past}$	0.428		0.030	0.033	0.384	0.025	0.377		0.353	0.506	0.278	0.237	0.288		0.186	0.234	0.132	0.119	0.060		0.054	0.089	0.065	0.106
SD_{past}	0.082		0.007	0.007	0.117	0.004	0.086		0.054	0.078	0.053	0.056	0.063		0.041	0.028	0.021	0.022	0.015		0.009	0.013	0.005	0.034
NAV	0.403	0.006	0.029	0.042	0.353	0.023	0.331	0.144	0.332	0.513	0.282	0.243	0.204	0.071	0.176		0.130	0.120	0.057	0.012	0.054	0.128	0.066	0.098
NAU	0.100	0.003	0.010		0.088	0.008	0.074	0.038	0.074		0.065	0.058	0.053	0.017	0.038		0.023	0.024	0.018	0.005	0.013		0.016	0.025

C4

Round Robin LXXIII Laboratory Results

	Total α-Cryptoxanthin, µg/mL						Total Lutein, µg/mL						Total Zeaxanthin, µg/mL						Total Lutein&Zeaxanthin, µg/mL					
Lab	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396	392	393	394a	394b	395	396
FSV-BA	0.046	0.006	0.031		0.026	0.014													0.179	0.033	0.103		0.151	0.105
FSV-BB	0.040	0.007	0.023		0.020	0.015	0.128	0.031	0.097		0.157	0.097	0.083	0.014	0.043		0.043	0.042	0.211	0.045	0.140		0.199	0.139
FSV-BC																								
FSV-BD																								
FSV-BE																								
FSV-BF																								
FSV-BG																			0.193	0.040	0.118		0.158	0.116
FSV-BH							0.116	0.015	0.077		0.123	0.069	0.093	0.009	0.033		0.027	0.035	0.209	0.025	0.110		0.015	0.104
FSV-BJ							0.144	*nq*	0.081		0.135	0.085												
FSV-BK																								
FSV-BL																								
FSV-BM																								
FSV-BN																			0.196	0.032			0.114	0.105
FSV-BNa							0.143	0.040			0.133	0.087	0.064	0.020			0.028	0.032	0.208	0.061			0.161	0.119
FSV-BO																								
FSV-BP																			0.160	0.152	0.096		0.150	0.113
FSV-BQ																								
FSV-BR																								
FSV-BS							0.212	0.054	0.258		0.252	0.170	0.126	0.095	0.121		0.094	0.102	0.338	0.149	0.379		0.346	0.272
FSV-BT	0.040	0.006	0.024		0.022	0.019													0.201	0.042	0.110		0.165	0.119
FSV-BU																			0.216	0.040	0.118		0.178	0.124
FSV-BV																			0.197	0.026		0.213	0.181	0.134
FSV-BW																								
FSV-CD	0.064	0.011		0.058	0.039	0.027													0.284	0.086		0.288	0.238	0.201
FSV-CE																								
FSV-CG																			0.237	0.051		0.251	0.229	0.158
FSV-CI							0.135	0.019	0.070		0.129	0.068	0.077	0.011	0.021		0.015	0.024	*0.212*	*0.030*	*0.091*		*0.144*	*0.092*
FSV-CO																								
FSV-CZ																								
FSV-DD																								
FSV-DV																								
FSV-EE																								
FSV-EZ																								
FSV-FK																								
FSV-FZ																								
N	4	4	3	1	4	4	6	5	5	0	6	6	5	5	4	0	5	5	14	14	9	3	14	14
Min	0.040	0.006	0.023		0.020	0.014	0.116	0.015	0.070		0.123	0.068	0.064	0.009	0.021		0.015	0.024	0.160	0.025	0.091	0.213	0.015	0.092
Median	0.043	0.007	0.024	0.058	0.024	0.017	0.139	0.031	0.081		0.134	0.086	0.083	0.014	0.038		0.028	0.035	0.209	0.041	0.110	0.251	0.163	0.119
Max	0.064	0.011	0.031		0.039	0.027	0.212	0.054	0.258		0.252	0.170	0.126	0.095	0.121		0.094	0.102	0.338	0.152	0.379	0.288	0.346	0.272
eSD	0.005	0.000			0.004	0.003	0.012	0.017	0.016		0.012	0.021	0.015	0.008	0.016		0.019	0.011	0.018	0.016	0.012		0.027	0.021
eCV	11	5			16	20	8	56	20		9	24	18	56	43		69	31	9	38	11		17	18
N_{past}	4	0	6	5	4	4	14	0	16	8	4	4	11	0	14	7	0	0	20	0	23	17	14	14
$Median_{past}$	0.042		0.025	0.031	0.023	0.021	0.148		0.089	0.124	0.137	0.086	0.082		0.027	0.061			0.222		0.119	0.182	0.160	0.120
SD_{past}	0.006		0.005	0.008	0.008	0.010	0.030		0.019	0.022	0.022	0.024	0.012		0.007	0.021			0.044		0.019	0.029	0.062	0.044
NAV	0.043	0.007	0.024		0.024	0.017	0.139	0.031	0.081		0.134	0.086	0.083	0.014	0.038		0.028	0.035	0.209	0.041	0.110	0.251	0.163	0.119
NAU							0.026	0.017	0.016		0.025	0.021	0.022	0.008			0.019	0.011	0.044	0.016	0.023		0.034	0.025

C5

Round Robin LXXIII Laboratory Results

	Coenzyme Q10, µg/mL						Phylloquinone (K1), ng/mL					
Lab	392	393	394a	394b	395	396	392	393	394a	394b	395	396
FSV-BA												
FSV-BB												
FSV-BC												
FSV-BD												
FSV-BE	1.12	0.65		0.990	0.78	1.02	1.209	0.399		0.869	4.665	0.274
FSV-BF												
FSV-BG												
FSV-BH												
FSV-BJ	1.03	0.70	0.850		0.71	1.15						
FSV-BK												
FSV-BL												
FSV-BM												
FSV-BN												
FSV-BNa												
FSV-BO	0.80	0.49		0.890	0.62	0.79						
FSV-BP												
FSV-BQ												
FSV-BR												
FSV-BS												
FSV-BT												
FSV-BU												
FSV-BV												
FSV-BW	1.33	0.65	0.840		0.71	1.08						
FSV-CD												
FSV-CE												
FSV-CG												
FSV-CI	0.73	0.48	0.670		0.53	0.77	0.613	0.161	0.504		1.727	0.125
FSV-CO												
FSV-CZ	1.08	0.79		1.227	0.94	1.09						
FSV-DD												
FSV-DV												
FSV-EE	0.88	0.56	0.860		0.66	1.02						
FSV-EZ												
FSV-FK												
FSV-FZ												
N	7	7	4	3	7	7	2	2	1	1	2	2
Min	0.73	0.48	0.670	0.890	0.53	0.77	0.613	0.161			1.727	0.125
Median	1.03	0.65	0.845	0.990	0.71	1.02	0.911	0.280	0.504	0.869	3.196	0.200
Max	1.33	0.79	0.860	1.227	0.94	1.15	1.209	0.399			4.665	0.274
eSD	0.23	0.13	0.015		0.10	0.10						
eCV	22	20	2		15	10						
N_{past}	0	0	5	8	9	9	0	0	0	0	0	0
$Median_{past}$			0.887	1.044	0.73	0.99						
SD_{past}			0.171	0.136	0.07	0.03						
NAV	1.03	0.65	0.845	0.990	0.71	1.02						
NAU	0.23	0.13			0.10	0.10						

C6

Round Robin LXXIII Laboratory Results

Analytes Reported By One Laboratory

Values in µg/mL

Analyte	Code	392	393	394a	394b	395	396
25-hydroxyvitamin D	FSV-BH	0.021	0.023	0.008		0.021	0.006
Phytoene	FSV-BS	0.113	*nq*	0.140		*nq*	0.124
Phytofluene	FSV-BS	0.171	0.068	0.296		0.203	0.196
trans-Retinol	FSV-BR	0.650	0.225	0.460		0.440	0.450

Legend

Term	Definition
N	Number of (non-NIST) quantitative values reported for this analyte
Min	Minimum (non-NIST) quantitative value reported
Median	Median (non-NIST) quantitative value reported
Max	Maximum (non-NIST) quantitative value reported
eSD	Adjusted median absolute deviation from the median of the non-NIST results
eCV	Coefficient of Variation for (non-NIST) results: 100*SD/Median
N_{past}	Mean of N(s) from past RR(s)
$Median_{past}$	Mean of Median(s) from past RR(s)
SD_{past}	Pooled SD from past RR(s)
NAV	NIST Assigned Value = (Median + NIST)/2 for analytes reported by NIST = Median for analytes reported by ≥ 5 labs but not NIST
NAU	NIST Assigned Uncertainty: $\sqrt{(S^2 + S_{btw}^2)}$ S is the maximum of (0.05*NAV, SD, SD_{past}, eSD) and S_{btw} is the standard deviation between Median and NIST. The expected long-term SD, eSD, is defined in: Duewer et al., Anal Chem 1997;69(7):1406-1413.
nd	Not detected (i.e., no detectable peak for analyte)
nq	Detected but not quantitatively determined
<x	Concentration at or below the limit of quantification, x
≥x	Concentration greater than or equal to x
!	Discrepant value: damaged sample, interferent, instrument malfunction, etc.
italics	Not explicitly reported but calculated by NIST from reported values

Round Robin LXXIII Laboratory Results

Comparability Summary

Lab	TR	aT	g/bT	bC	tbC	aC	TLy	TbX	TLu	TZ	L&Z
FSV-BA	1	1	1	1	1	1	1	1			1
FSV-BB	1	1	1	1	1	1	1	1	1	1	1
FSV-BC	2										
FSV-BD	2	2									
FSV-BE	1	1	1	1							
FSV-BF	4	2		3							
FSV-BG	1	1	1	1		1	1	1			1
FSV-BH	1	1	1	1		1	2	2	1	1	3
FSV-BJ	1	1	1	2		1	1	1	1		
FSV-BK	1	1									
FSV-BL	1	1									
FSV-BM	2	2									
FSV-BN	1	2		1		1	1	1			1
FSV-BNa	1	1		2	2	1	1	1	1	1	1
FSV-BO	1	1	1	1							
FSV-BP	1	2		4		3	4	4			4
FSV-BQ	1	2									
FSV-BR	1	1									
FSV-BS				4	4	4	4	4	4	4	4
FSV-BT	2	1	1	1	1	1	1	1			1
FSV-BU	3	2	2	1		1	1	1			1
FSV-BV	4	2	1	1		1	2	2			1
FSV-BW	1	1	1	2		3	1				
FSV-CD	1	3	2	4		2	1	2			3
FSV-CE	4	4									
FSV-CG	1	2	1	1	1	1	1	2			2
FSV-CI	1	1	3	1		1			1	1	1
FSV-CO		1	1	1			1				
FSV-CZ	3	2	2	4							
FSV-DD	2										
FSV-DV	2	1									
FSV-EZ	4	1	1	3							
FSV-FK	1	1									
FSV-FZ	3	1	1	2							
n	32	31	18	23	6	16	16	14	6	5	14

	TR	aT	g/bT	bC	tbC	aC	TLy	TbX	TLu	TZ	L&Z
% 1	59	61	78	57	67	75	75	57	83	80	64
% 2	19	32	17	17	17	6	13	29	0	0	7
% 3	9	3	6	9	0	13	0	0	0	0	14
% 4	13	3	0	17	17	6	13	14	17	20	14

Label	Definition
Lab	Participant code
TR	Total Retinol
aT	α-Tocopherol
g/bT	γ/β-Tocopherol
bC	Total β-Carotene
tbC	trans-β-Carotene
aC	Total α-Carotene
TLy	Total Lycopene
TbX	Total β-Cryptoxanthin
TLu	Total Lutein
TZ	Total Zeaxanthin
L&Z	Total Lutein & Zeaxanthin
n	number of participants providing quantitative data
% 1	Percent of CS = 1 (within 1 SD of medians)
% 2	Percent of CS = 2 (within 2 SD of medians)
% 3	Percent of CS = 3 (within 3 SD of medians)
% 4	Percent of CS = 4 (3 or more SD from medians)

"Comparability Score"

The Comparability Score (CS) summarizes your measurement performance for a given analyte relative to the consensus medians in this study. CS is the average distance (in units of standard deviation) of your measurement performance characteristics from the consensus performance. CS is calculated when the number of quantitative values you reported, N_{you}, is at least two and at least six participants reported quantitative values for the analyte.

We define CS as follows:

$$CS = \text{MINIMUM}\left(4, \text{INTEGER}\left(1+\sqrt{C^2+AP^2}\right)\right)$$

$$C = \text{Concordance} = \frac{\sum_{i=1}^{N_{you}} \frac{You_i - Median_i}{NAU_i}}{N_{you}}$$

$$AP = \text{Apparent Precision} = \sqrt{\frac{\sum_{i=1}^{N_{you}} \left(\frac{You_i - Median_i}{NAU_i}\right)^2}{N_{you}-1}}$$

NAU = NIST Assigned Uncertainty

For further details, please see

Duewer DL, Kline MC, Sharpless KE, Brown Thomas J, Gary KT. Micronutrients Measurement Quality Assurance Program: Helping participants use interlaboratory comparison exercise results to improve their long-term measurement performance. Anal Chem 1999;71(9):1870-8.

Appendix D. Representative Individualized Report for RR73

Each participant in RR73 received an "Individualized Report" reflecting their reported results. Each report included a detailed analysis for analytes that were assayed by at least five participants. The following analytes met this criterion:

- Total Retinol
- Retinyl Palmitate
- α-Tocopherol
- γ/β-Tocopherol
- Total β-Carotene
- *trans*-β-Carotene
- Total *cis*-β-Carotene
- Total α-Carotene
- Total Lycopene
- *trans*-Lycopene
- Total β-Cryptoxanthin
- Total Lutein
- Total Zeaxanthin
- Total Lutein & Zeaxanthin
- Coenzyme Q10

The following fourteen pages are the "Individualized Report" for the analytes evaluated by participant FSV-BA.

Individualized Round Robin LXXIII Report: FSV-BA

Summary

	Serum 392			Serum 393			Serum 394a			Serum 394b			Serum 395			Serum 396		
Analyte	You	NAV	n	You	NAV	n	You	NAV	n	You	NAV	n	You	NAV	n	You	NAV	n
Total Retinol	0.724	0.675	31	0.262	0.243	31	0.470	0.470	21		0.317	10	0.452	0.463	31	0.484	0.475	31
Retinyl Palmitate	0.08	0.16	8	0.0	0.0	5	0.0	0.0	7				0.06	0.05	8	0.03	0.02	6
α-Tocopherol	8.53	8.37	31	4.09	4.15	31	6.95	6.88	22		8.40	9	10.78	11.21	31	7.11	7.21	31
γ/β-Tocopherol	4.331	3.913	18	0.839	0.800	18	2.002	1.890	12		2.950	6	1.416	1.387	18	1.897	1.800	18
δ-Tocopherol	0.749	0.704	4	0.040	0.062	4	0.117	0.117	3			2	0.083	0.093	5	0.126	0.109	4
Total β-Carotene	0.299	0.476	21	0.019	0.016	16	0.332	0.328	14		0.294	7	0.636	0.666	21	0.052	0.053	20
trans-β-Carotene	0.286	0.450	6	0.014	0.013	5	0.309	0.301	5			1	0.597	0.612	6	0.045	0.047	6
Total cis-β-Carotene	0.013	0.019	5	0.005	0.005	4	0.023	0.020	4			1	0.039	0.039	5	0.007	0.005	5
Total α-Carotene	0.372	0.421	15	0.004	0.006	11	0.030	0.030	11		0.042	3	0.340	0.355	15	0.020	0.023	14
Total Lycopene	0.299	0.352	15	0.135	0.144	15	0.307	0.332	12		0.513	3	0.260	0.288	15	0.214	0.249	15
trans-Lycopene	0.204	0.246	7	0.071	0.071	7	0.171	0.176	6			1	0.130	0.130	7	0.104	0.120	7
Total β-Cryptoxanthin	0.059	0.058	12	0.011	0.012	11	0.061	0.054	9		0.128	3	0.071	0.067	13	0.101	0.095	13
Total α-Cryptoxanthin	0.046	0.042	4	0.006	0.007	4	0.031	0.024	3			1	0.026	0.024	4	0.014	0.017	4
Total Lutein&Zeaxanthin	0.179	0.216	13	0.033	0.040	13	0.103	0.114	8		0.251	3	0.151	0.165	13	0.105	0.119	13

You : Your reported values for the listed analytes (micrograms/milliliter)
NAV : NIST Assigned Values, here equal to this RR's median
n : Number of non-NIST laboratories reporting quantitative values for this analyte in this serum

D2

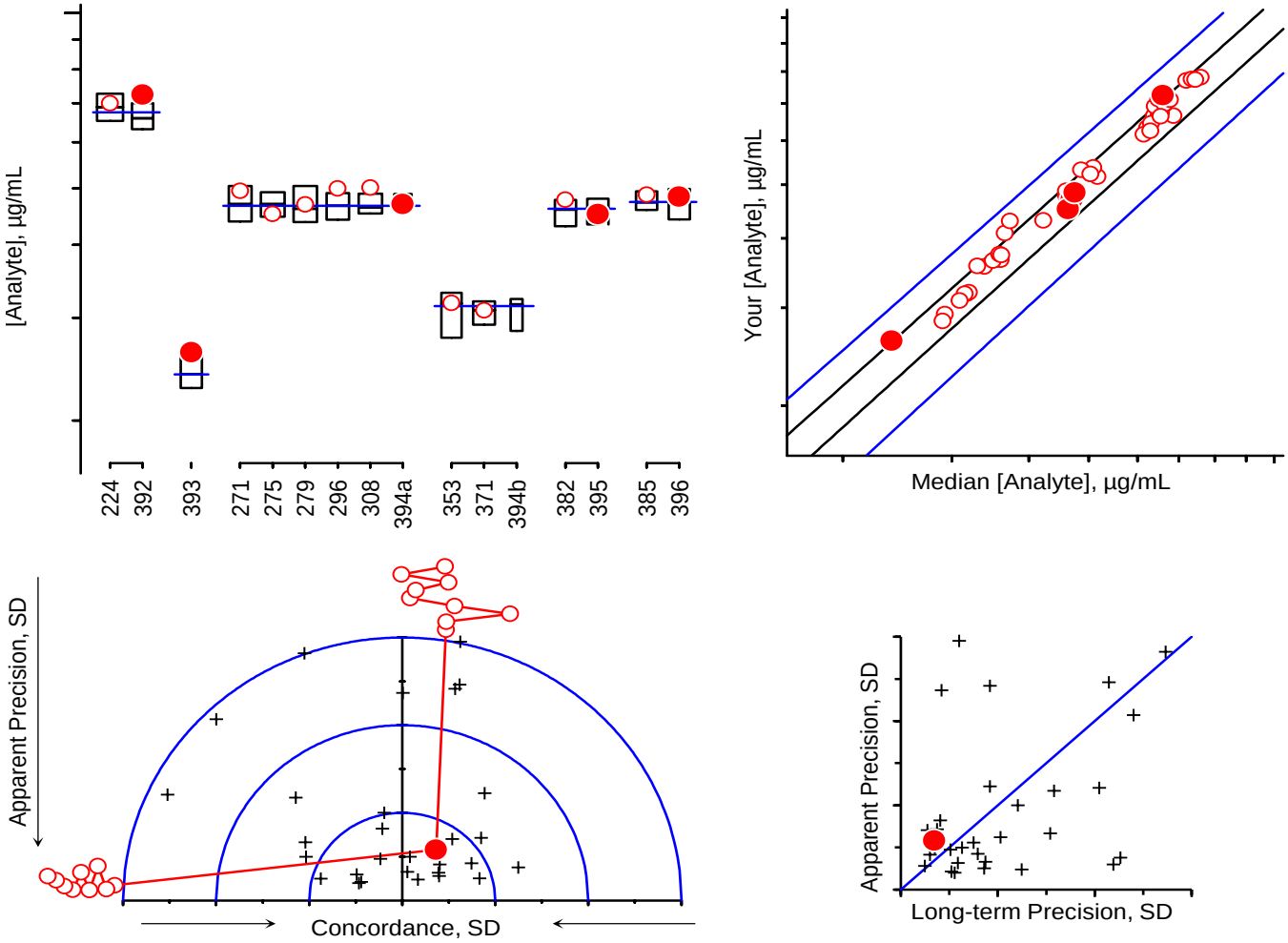
Please check our records against your records. Send corrections and/or updates to...

Micronutrients Measurement Quality Assurance Program
National Institute of Standards and Technology
100 Bureau Drive Stop 8392
Gaithersburg, MD 20899-8392 USA

Tel: (301) 975-3935
Fax: (301) 977-0685
Email: david.duewer@nist.gov

Individualized RR LXXIII Report: FSV-BA

Total Retinol, µg/mL



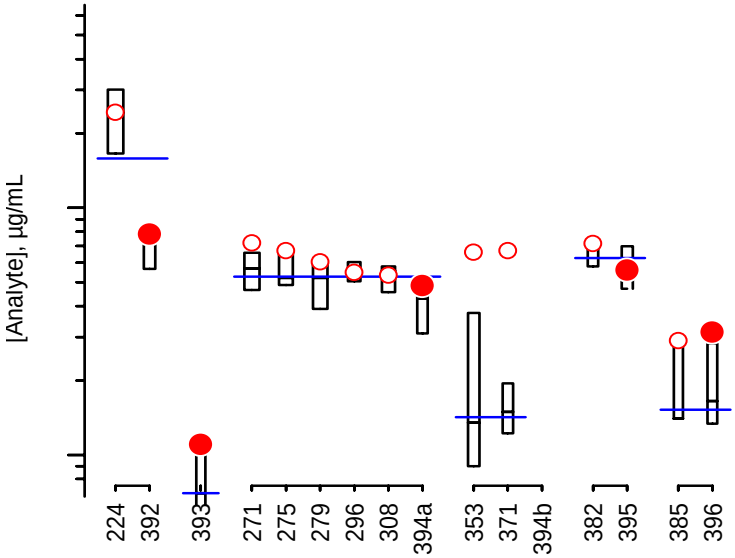
3rd Quartile (75%)
Median (50%)
1st Quartile (25%)
You, this RR
You, past RRs
Expectation
You, ≥x, this RR
You, ≥x, past RRs
Others, this RR

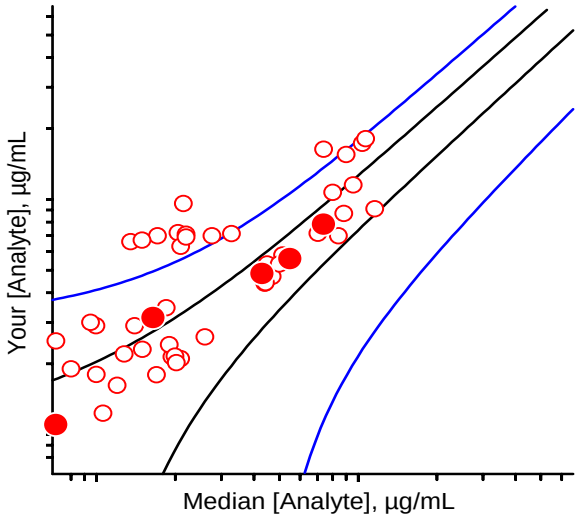
For details of the construction and interpretation of these plots, see:
Duewer, Kline, Sharpless, Brown Thomas, Gary, Sowell. Anal Chem 1999;71(9):1870-8.

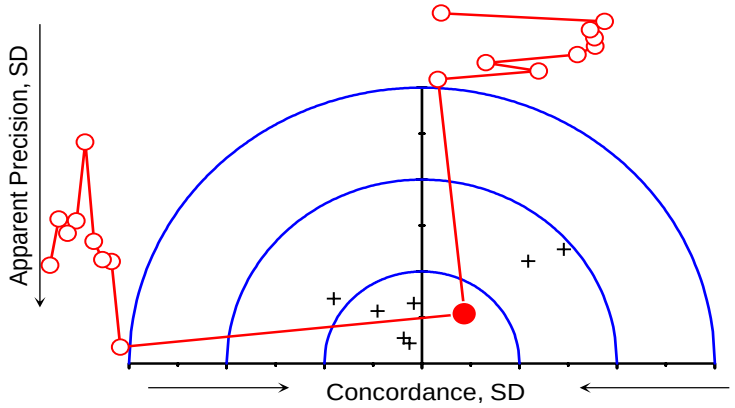
Serum	Comments	History
#392	Lyophilized, augmented, multi-donor	38#224
#393	Fresh-frozen, native, multi-donor	New
#394a	Fresh-frozen, augmented, single-donor	49#271, 50#275, 51#279, 54#296, 56#308
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

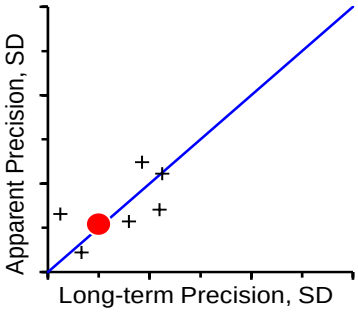
Individualized RR LXXIII Report: FSV-BA

Retinyl Palmitate, µg/mL









3rd Quartile (75%)
Median (50%)
1st Quartile (25%)
You, this RR
You, past RRs
Expectation
You, ≥x, this RR
You, ≥x, past RRs
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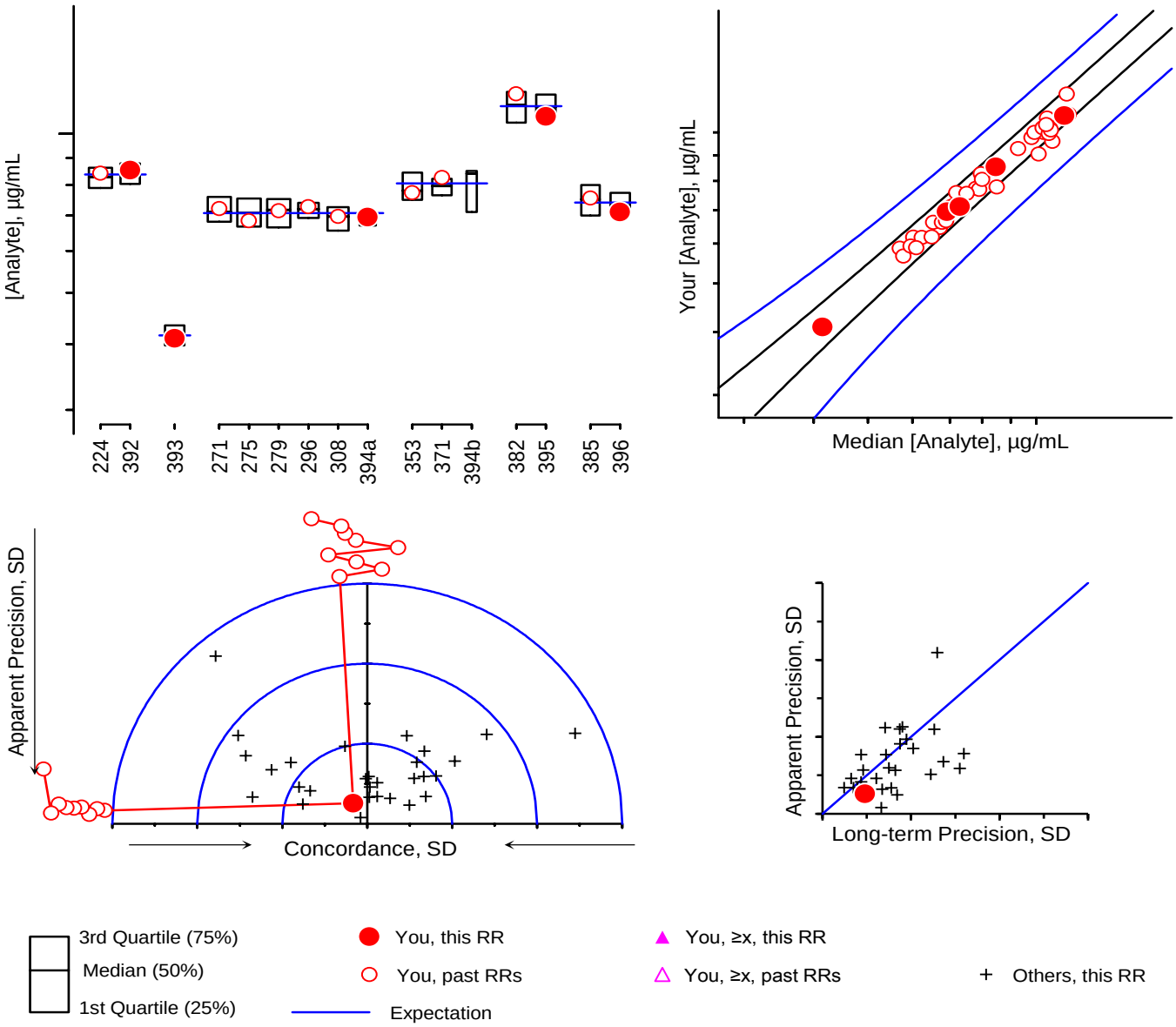
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

α-Tocopherol, µg/mL



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Serum	Comments	History
#392	Lyophilized, augmented, multi-donor	38#224
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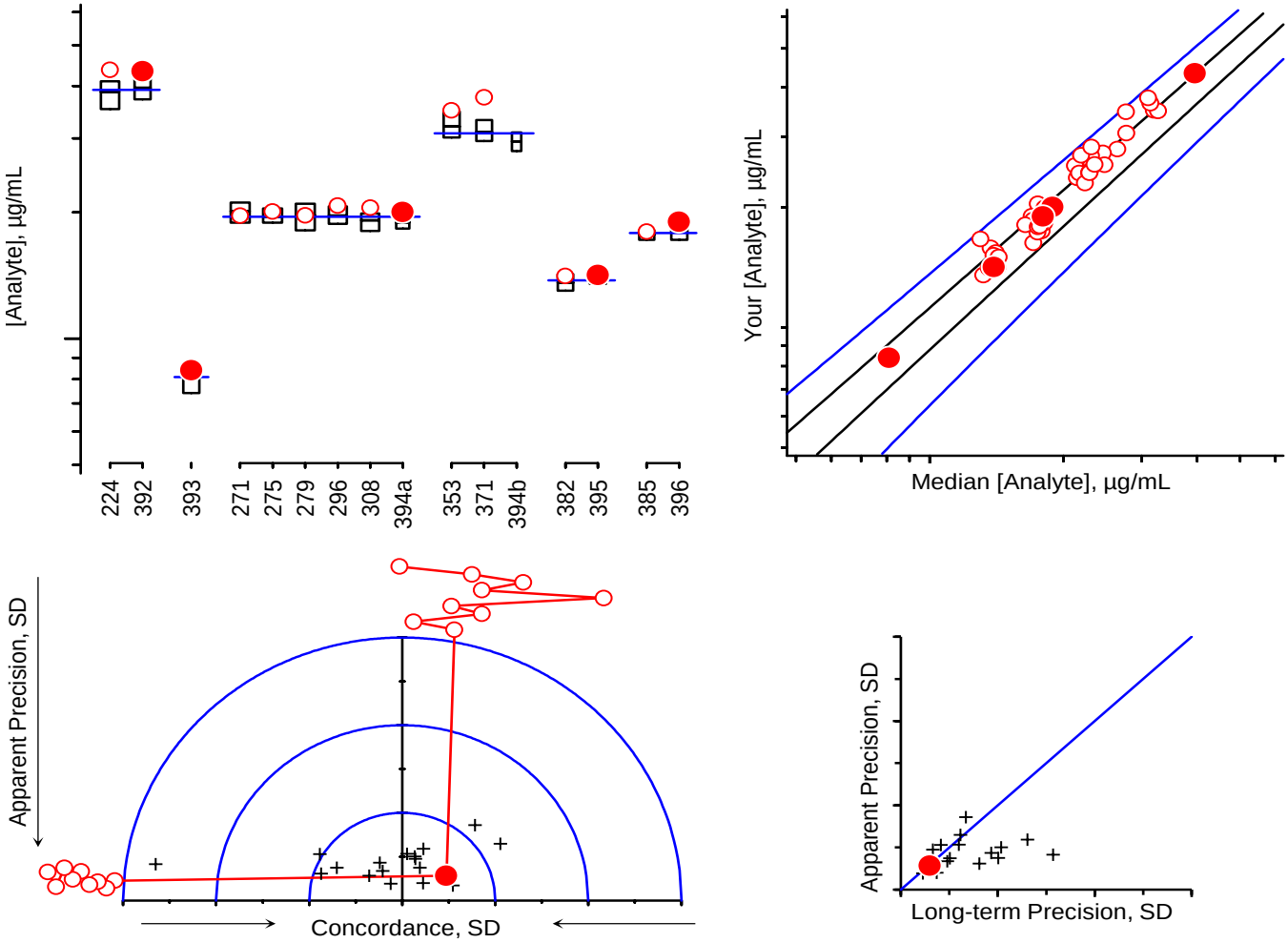
#394a	Fresh-frozen, augmented, single-donor	49#271, 50#275, 51#279, 54#296, 56#308
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

γ/β-Tocopherol, µg/mL



3rd Quartile (75%)
Median (50%)
1st Quartile (25%)
You, this RR
You, past RRs
Expectation
You, ≥x, this RR
You, ≥x, past RRs
Others, this RR

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Duewer, Kline, Sharpless, Brown Thomas, Gary, Sowell. Anal Chem 1999;71(9):1870-8.

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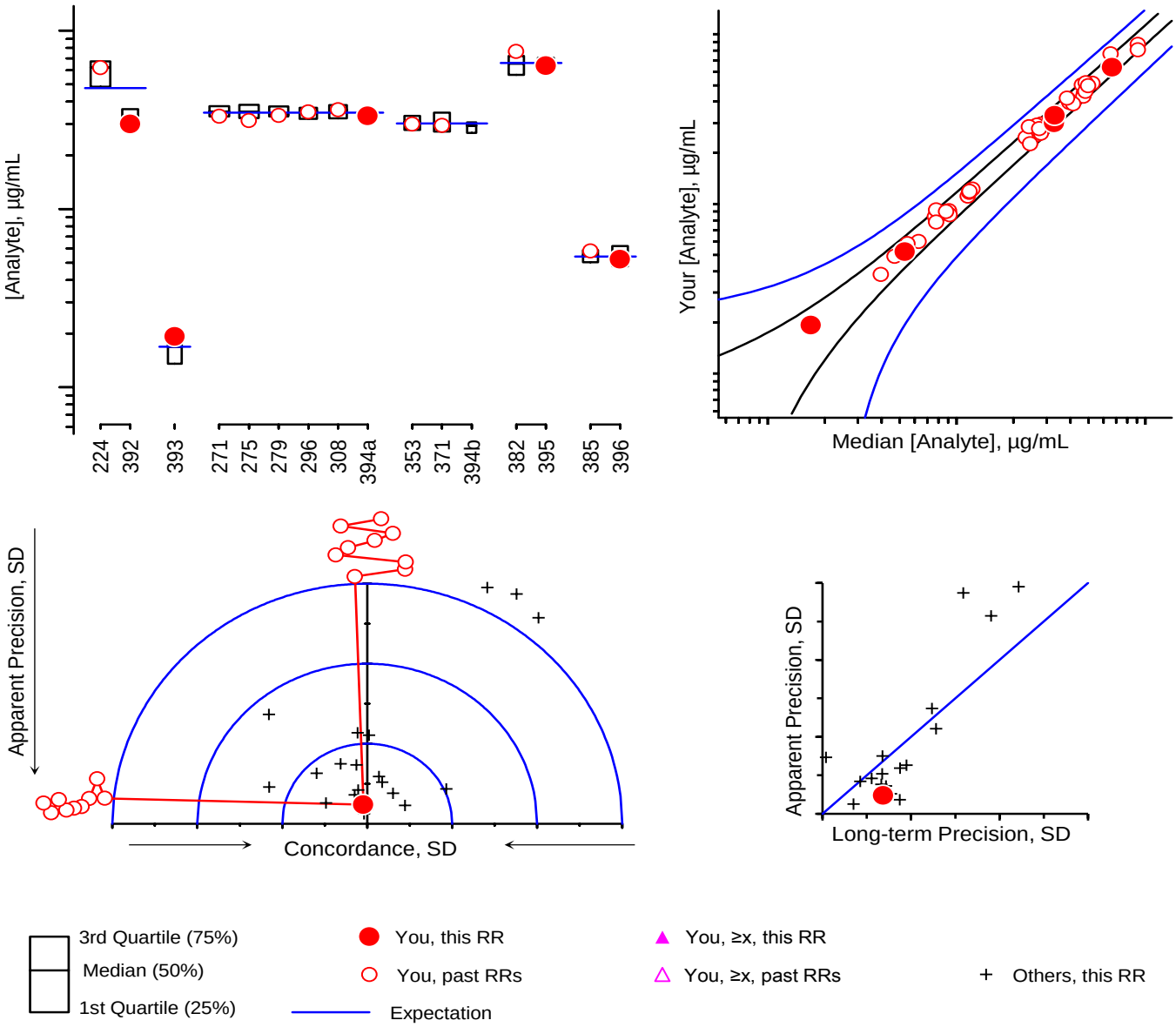
#394a	Fresh-frozen, augmented, single-donor	49#271, 50#275, 51#279, 54#296, 56#308
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

Total β-Carotene, µg/mL



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Serum	Comments	History
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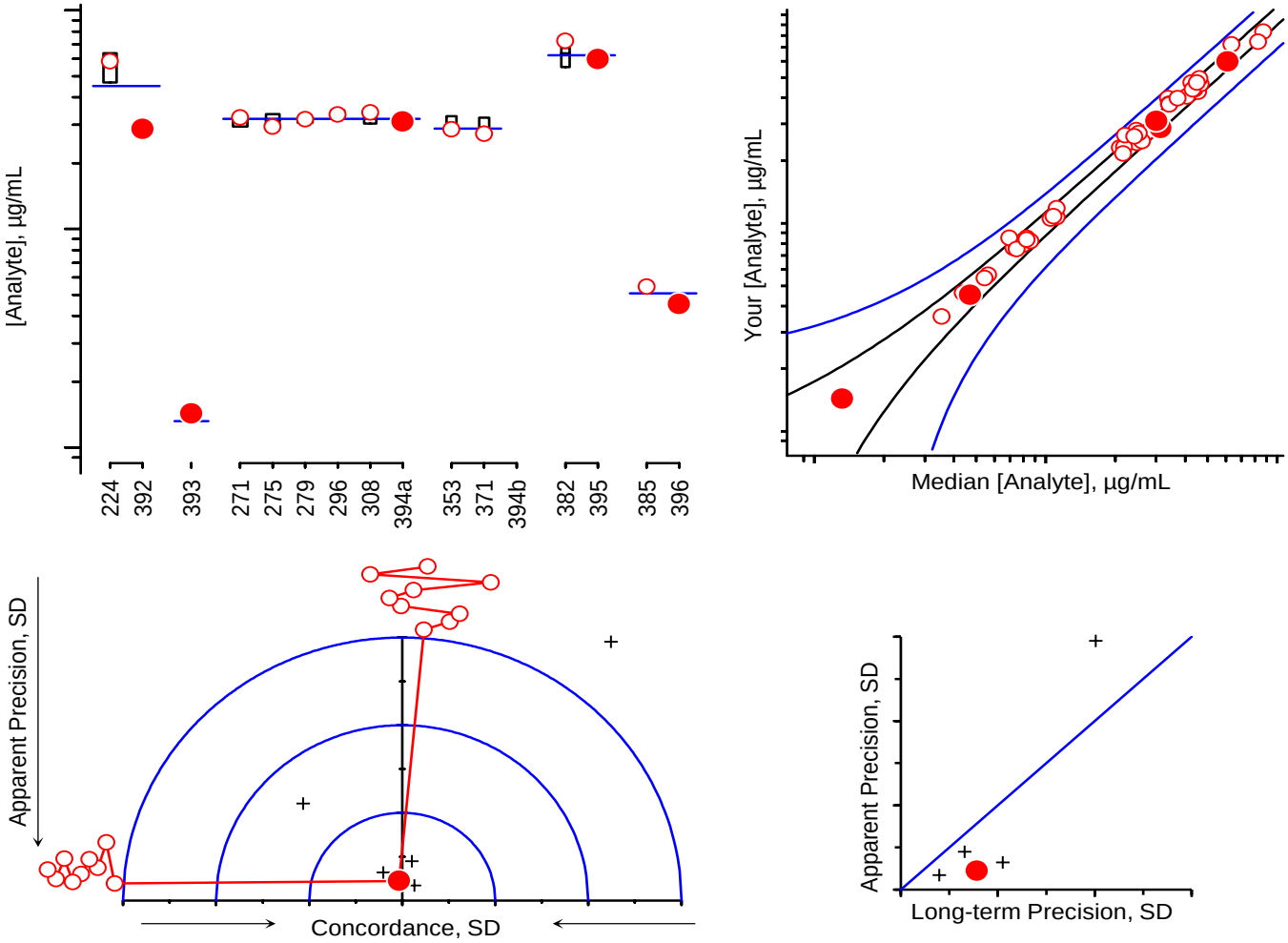
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

trans-β-Carotene, µg/mL



3rd Quartile (75%)
Median (50%)
1st Quartile (25%)
You, this RR
You, past RRs
Expectation
You, ≥x, this RR
You, ≥x, past RRs
Others, this RR

For details of the construction and interpretation of these plots, see:
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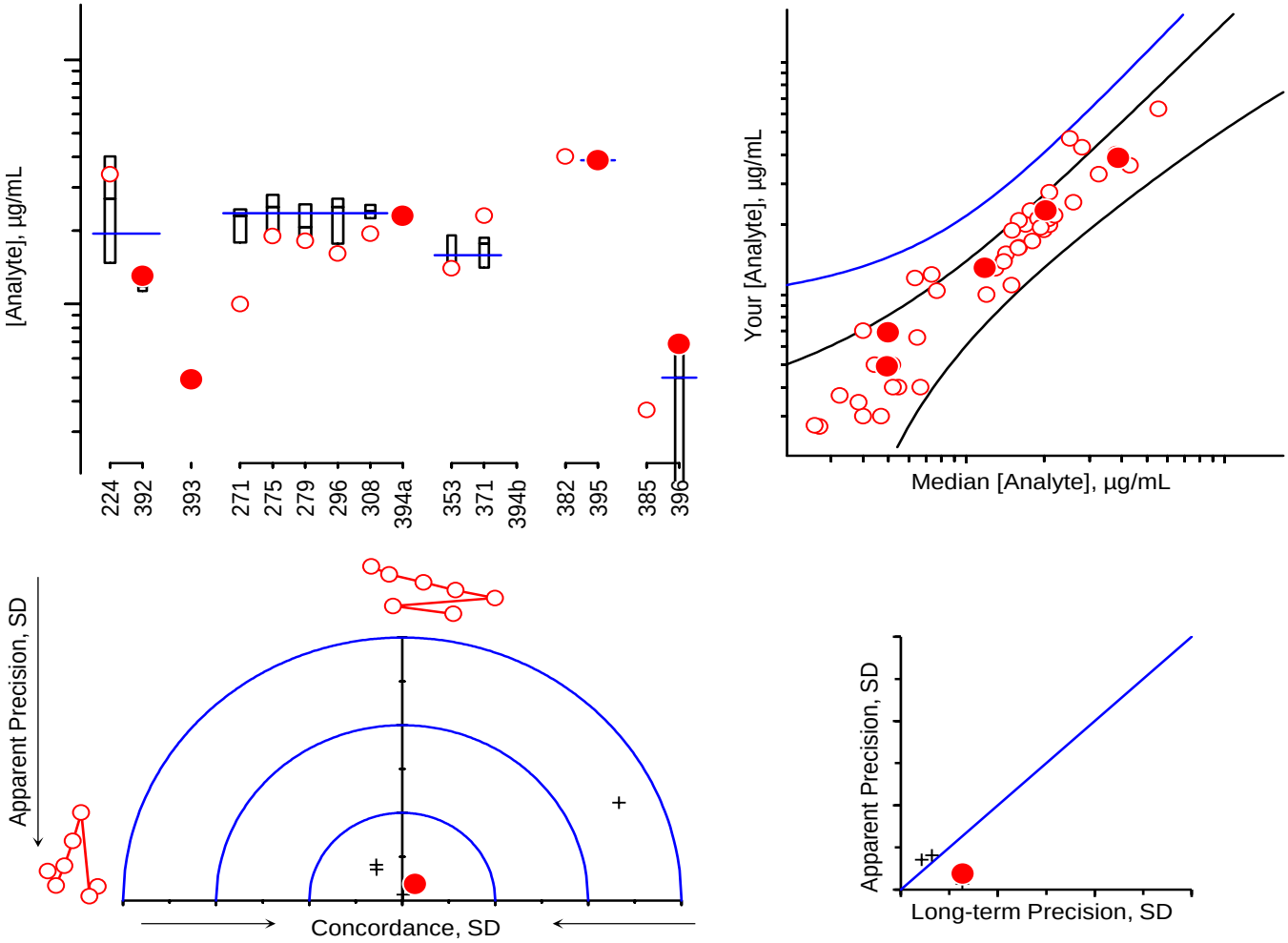
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

Total cis-β-Carotene, µg/mL



3rd Quartile (75%)
Median (50%)
1st Quartile (25%)
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You, past RRs
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You, ≥x, this RR
You, ≥x, past RRs
Others, this RR

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Serum	Comments	History
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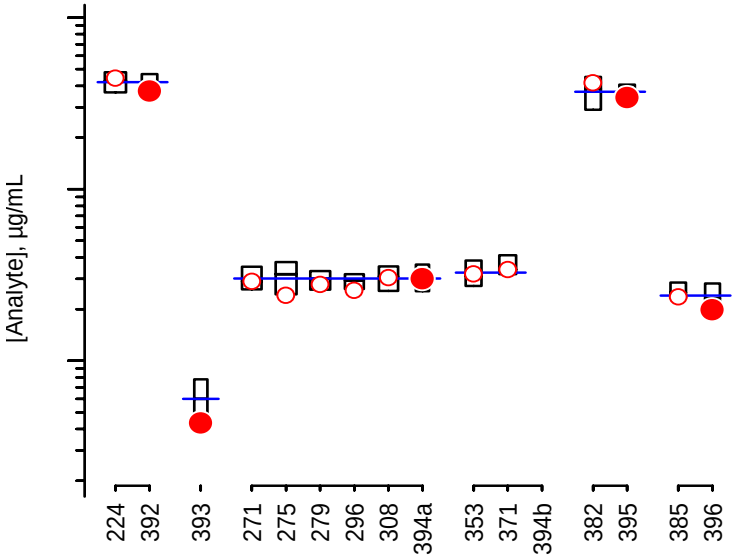
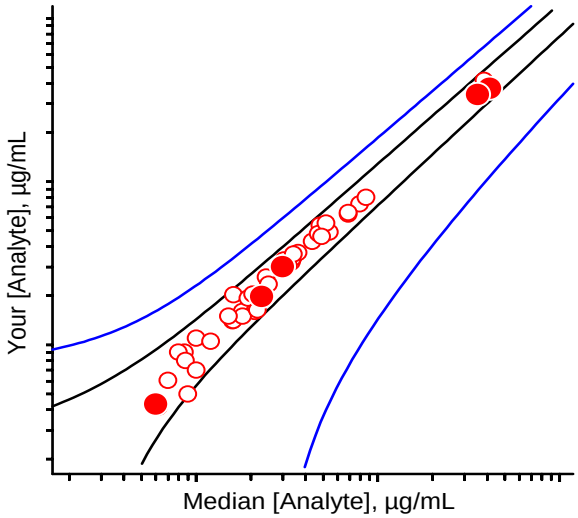
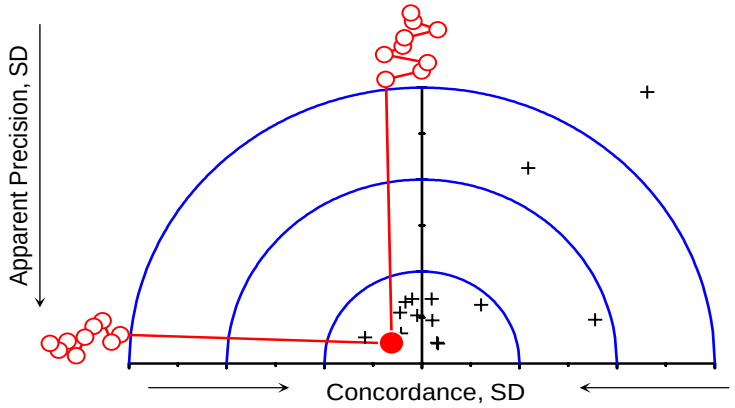
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

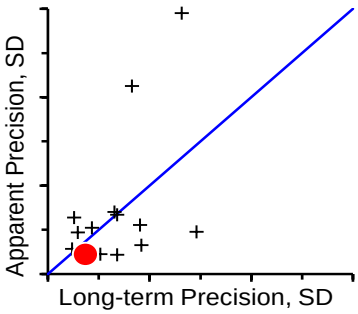
Individualized RR LXXIII Report: FSV-BA

Total α-Carotene, µg/mL









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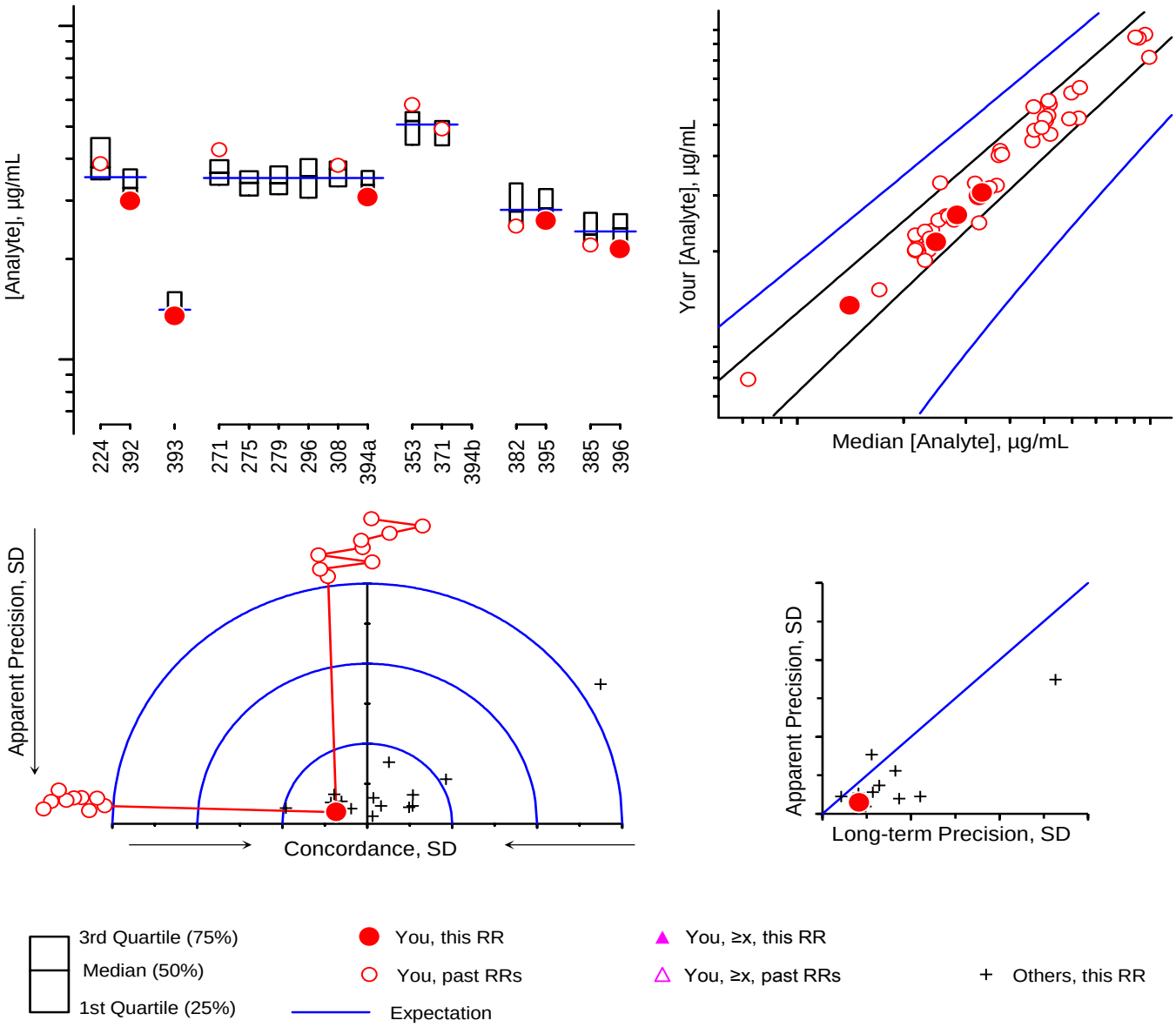
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

Total Lycopene, µg/mL



For details of the construction and interpretation of these plots, see:
Duewer, Kline, Sharpless, Brown Thomas, Gary, Sowell. Anal Chem 1999;71(9):1870-8.

Serum	Comments	History
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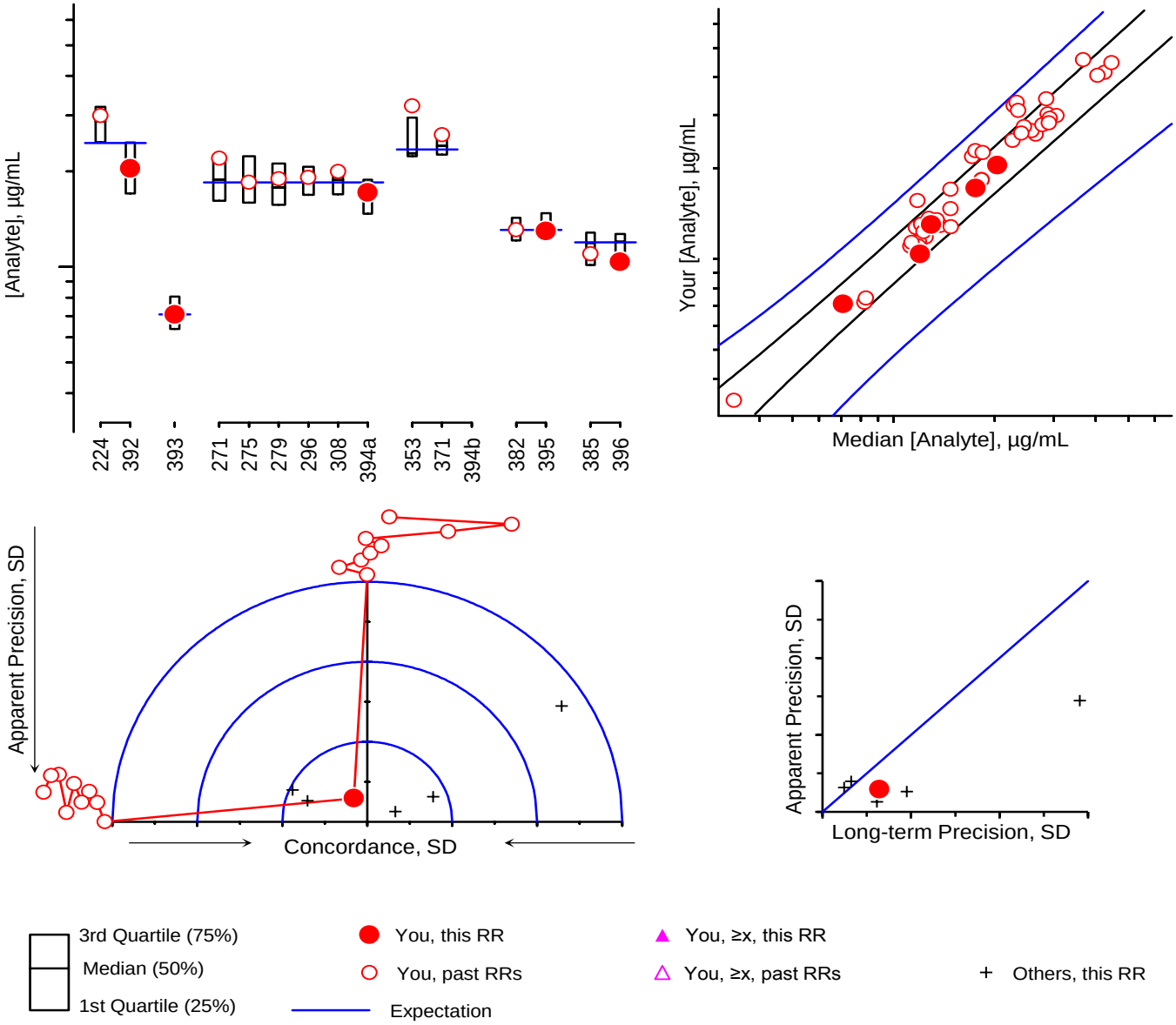
#394a	Fresh-frozen, augmented, single-donor	49#271, 50#275, 51#279, 54#296, 56#308
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

trans-Lycopene, µg/mL

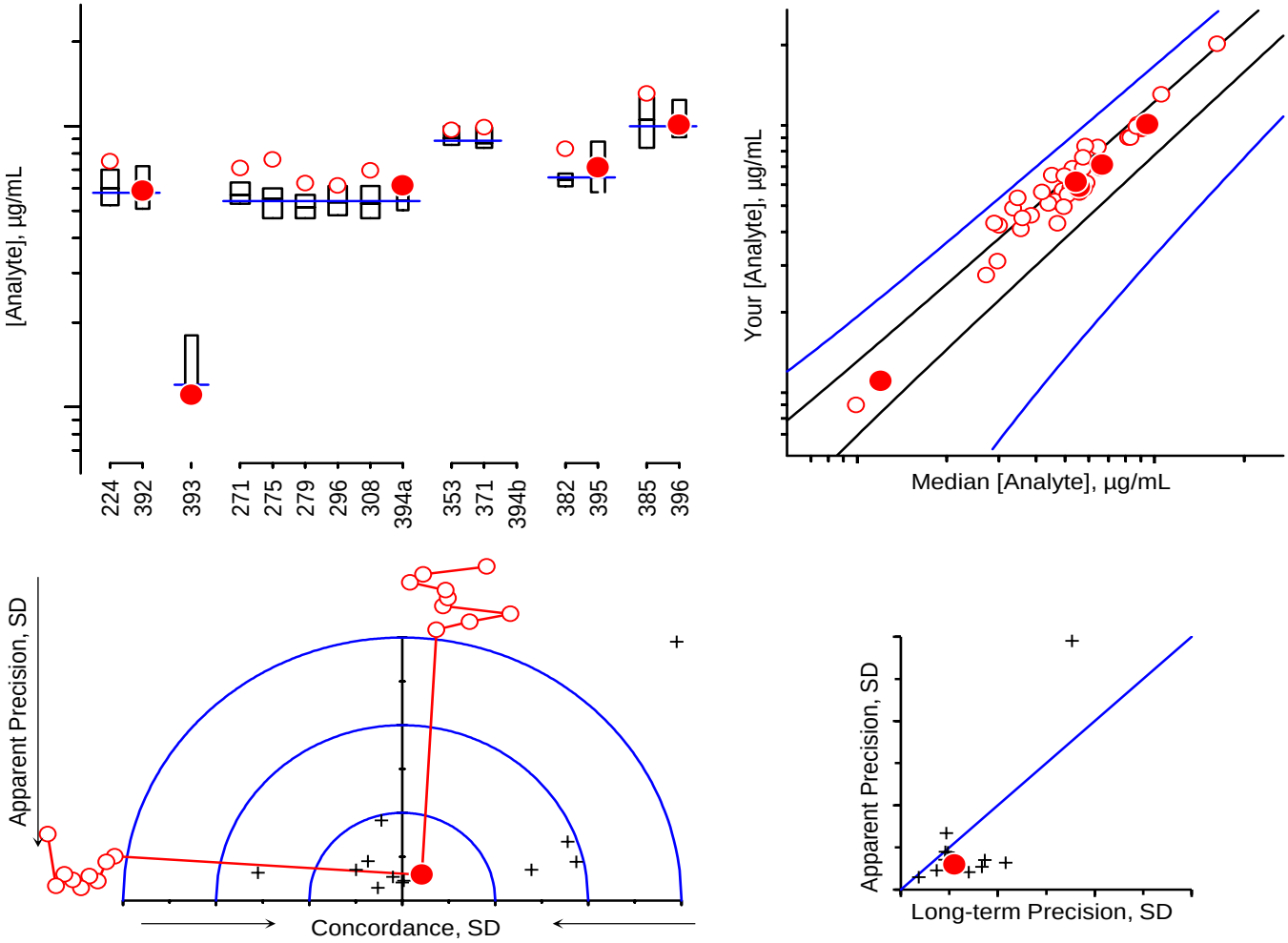


For details of the construction and interpretation of these plots, see:
Duewer, Kline, Sharpless, Brown Thomas, Gary, Sowell. Anal Chem 1999;71(9):1870-8.

Serum	Comments	History
#392	Lyophilized, augmented, multi-donor	38#224
#393	Fresh-frozen, native, multi-donor	New
#394a	Fresh-frozen, augmented, single-donor	49#271, 50#275, 51#279, 54#296, 56#308
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

Total β-Cryptoxanthin, µg/mL



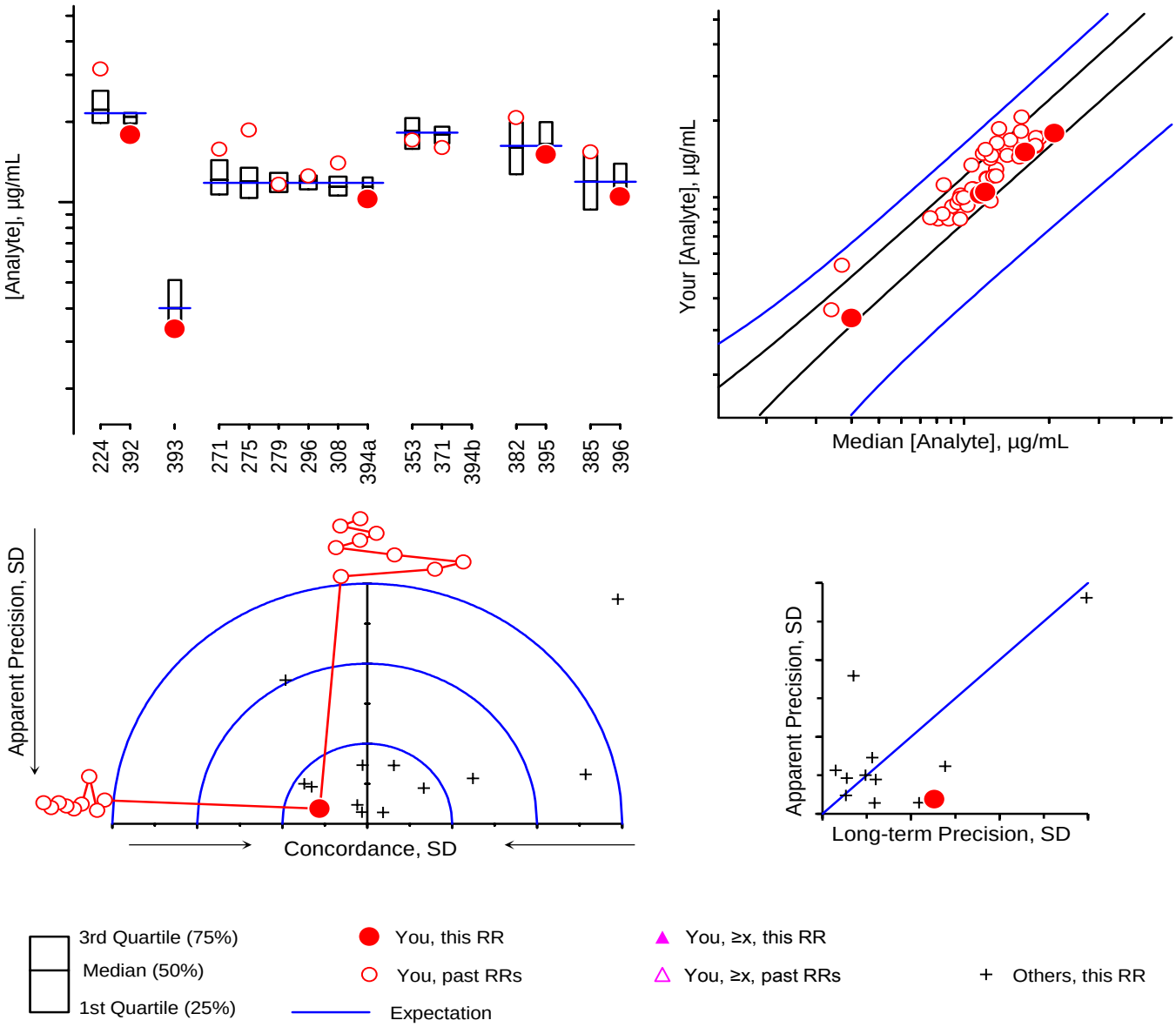
3rd Quartile (75%)
Median (50%)
1st Quartile (25%)
You, this RR
You, past RRs
Expectation
You, ≥x, this RR
You, ≥x, past RRs
Others, this RR

For details of the construction and interpretation of these plots, see:
Duewer, Kline, Sharpless, Brown Thomas, Gary, Sowell. Anal Chem 1999;71(9):1870-8.

Serum	Comments	History
#392	Lyophilized, augmented, multi-donor	38#224
#393	Fresh-frozen, native, multi-donor	New
#394a	Fresh-frozen, augmented, single-donor	49#271, 50#275, 51#279, 54#296, 56#308
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized RR LXXIII Report: FSV-BA

Total Lutein&Zeaxanthin, µg/mL



For details of the construction and interpretation of these plots, see:
Duewer, Kline, Sharpless, Brown Thomas, Gary, Sowell. Anal Chem 1999;71(9):1870-8.

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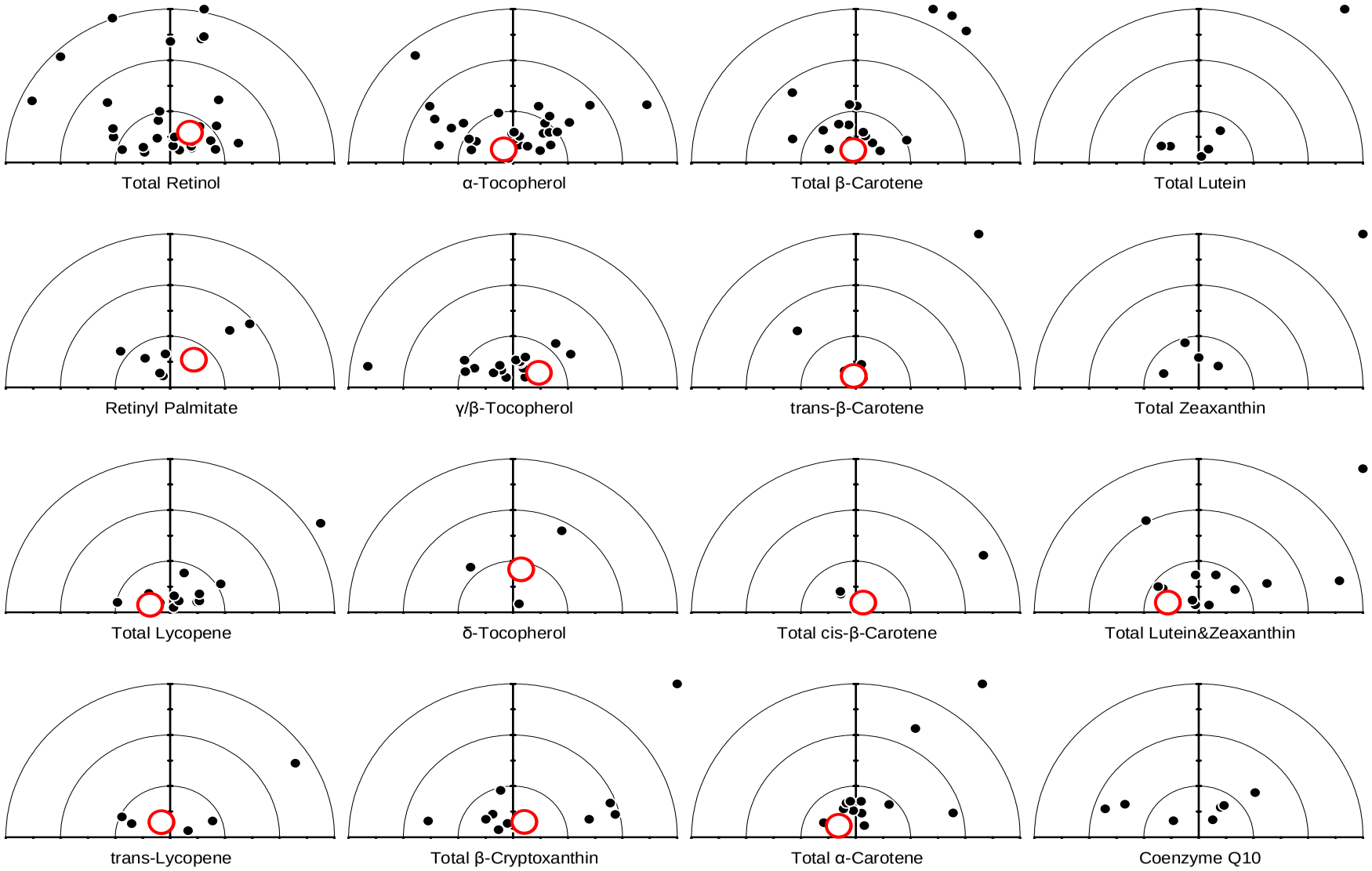
#394b	Fresh-frozen, augmented, multi-donor	65#353, 68#371
#395	Fresh-frozen, native, multi-donor	71#382
#396	Fresh-frozen, native, multi-donor	71#385

Individualized Round Robin LXXIII Report: FSV-BA
Graphical Comparability Summary



D15

Appendix E. Shipping Package Inserts for RR38

The following three items were included in each package shipped to an RR38 participant:

- Cover letter
- Analysis of Control Materials and Test Samples Datasheet
- Packing List and Shipment Receipt Confirmation Form

The cover letter and datasheet were enclosed in a sealed waterproof bag along with the samples themselves. The packing list was placed at the top of the shipping box, between the cardboard covering and the foam insulation.

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

January 21, 2013

Dear Colleague:

The samples within this package constitute Vitamin C Round Robin 38 (RR38) of the 2013 Micronutrients Measurement Quality Assurance Program. RR38 consists of one vial each of four frozen serum *test samples* (#381, #382 #383, and #384) and one vial each of two frozen *control sera* (CS#3 and CS#4). These materials are in sealed ampoules. They were prepared by adding equal volumes of 10% MPA to spiked human serum. We have checked the samples for stability and homogeneity. Only total ascorbic acid is stable. While these samples contain some dehydroascorbic acid, its content is variable. Therefore, only total ascorbic acid should be analyzed and reported.

Please use the *control sera* to validate the performance of your measurement system before you analyze the *test samples*. The target value for CS#3 is (15.5 ±1.6; 13.9 to 17.1) µmol/L and the target for CS#4 is (46.1 ±4.6; 41.5 to 50.7) µmol/L. We expect your results for both of these controls to be within this ±10% target range. If your results are significantly outside this range, your analysis system may not be suited to the analysis of MPA-preserved samples. In this case, please do **not** proceed to the analysis of the *test samples* but contact us at 301-975-3120 or jbthomas@nist.gov.

The *test samples* and *control sera* should be defrosted by warming at 20 °C for not more than 10 min otherwise some irreversible degradation may occur. Please be aware that sample contact with any oxidant-contaminated surface (vials, glassware, etc.) may degrade your measurement system's performance (SA Margolis and E Park, "Stability of Ascorbic Acid in Solutions in Autosampler Vials", *Clinical Chemistry* 2001, *47*(8), 1463-1464). You should suspect such degradation if you observe unusually large variation in replicate analyses.

Please measure the total ascorbic acid in each ampoule in duplicate, reporting in units of µmol/(L sample solution) rather than µmol/(L serum used to prepare the sample). Please email (david.duewer@nist.gov) or fax (301-977-0685) your results to us as soon as possible but no later than **April 1, 2013**.

If you have questions or comments regarding this study, please e-mail me at jbthomas@nist.gov or call me at (301) 975-3120.

Sincerely,

Jeanice Brown Thomas
Program Coordinator/Research Chemist
Analytical Chemistry Division
Chemical Science and Technology Laboratory

Enclosure: RR38 Report Form for Control Material and Test Sample Analyses

NIST

Participant #: _____ Date: _____

Vitamin C Round Robin 38

NIST Micronutrients Measurement Quality Assurance Program

Packing List and Shipment Receipt Confirmation Form

This box contains one vial each of the following **six** VitC M^2QAP samples:

Label	Form
VitC #381	Liquid frozen (1:1 serum:10% MPA)
VitC #382	Liquid frozen (1:1 serum:10% MPA)
VitC #383	Liquid frozen (1:1 serum:10% MPA)
VitC #384	Liquid frozen (1:1 serum:10% MPA)
CS #3	Liquid frozen (1:1 serum:10% MPA)
CS #4	Liquid frozen (1:1 serum:10% MPA)

Please 1) Open the pack immediately
2) Check that it contains one vial each of the above samples
3) Check if the samples arrived frozen
4) Store the samples at -20 ˚C or below until analysis
5) Email (david.duewer@nist.gov) or fax (301-977-0685) us the following information:

1) Date this shipment arrived: _____

2) Are all of the vials intact? Yes | No
If "No", which one(s) were damaged?

3) Was there any dry-ice left in cooler? Yes | No

4) Did the samples arrive frozen? Yes | No

5) At what temperature are you storing the samples? _____ ˚C

6) When do you anticipate analyzing these samples? _____

Your prompt return of this information is appreciated.

The M^2QAP Gang

Mail: M^2QAP
NIST, Stop 6392
Gaithersburg, MD 20899-6392

Fax: 301-977-0685
Email: David.Duewer@NIST.gov

Appendix F. Final Report for RR38

The following three pages are the final report for RR38 as provided to all participants:

- Cover letter.
- An information sheet that:
  - describes the contents of the "All-Lab" report,
  - describes the content of the "Individualized" report,
  - describes the nature of the test samples and details their previous distributions, if any, and
  - summarizes aspects of the study that we believe may be of interest to the participants.

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

May 16, 2013

Dear Colleague:

Enclosed is the summary report of the results for Round Robin 38 (RR38) for the measurement of total ascorbic acid (TAA, ascorbic acid plus dehydroascorbic acid) in human serum. Included in this report are a summary of data for all laboratories and an individualized summary of your laboratory's measurement performance. The robust median is used to estimate the consensus value for all samples, the "adjusted median absolute deviation from the median" (MADe) is used to estimate the expected standard deviation, and we estimate the coefficient of variation (CV) as 100×MADe/median.

RR38 consisted of four test samples (#381, #382,, #383, and #384), one vial each of two frozen control serum control samples (CS #3 and CS #4), and one vial of solid control material (Control) for preparation of TAA control solutions. Details regarding the samples can be found in the enclosed report.

If you have concerns regarding your laboratory's performance, we suggest that you obtain and analyze a unit of Standard Reference Material (SRM) 970 Vitamin C in Frozen Human Serum. SRM 970 can be purchased from the NIST SRM Program at www.nist.gov/srm; phone: 301-975-6776; fax: 301-948-3730. If your measured values do not agree with the certified values, we suggest that you contact us for consultation.

Samples for the second vitamin C round robin (RR39) of the 2013 MMQAP will be shipped **starting June 10, 2013.** Please contact us immediately if this schedule is problematic for your laboratory.

We are currently in the process of providing on-line documentation of data and reports from the MMQAP studies (past and present). The results for Round Robin 71 Fat-Soluble Vitamins and Carotenoids in Human Serum and and Round Robin 36 Ascorbic Acid in Human Serum are available at: http://www.nist.gov/manuscript-publication-search.cfm?pub_id=911458. Click on the DOI link to access the manuscript. Data summaries have been altered to ensure confidentiality of identification codes assigned to laboratories. We will update you as additional documents become available on-line.

If you have questions or concerns regarding this report, please contact David Duewer at david.duewer@nist.gov or me at jbthomas@nist.gov, 301-975-3120, or fax: 301-977-0685.

Sincerely,

Jeanice Brown Thomas, M.B.A .
Research Chemist
Analytical Chemistry Division
Material Measurement Laboratory

David L. Duewer, Ph.D.
Research Chemometrician
Analytical Chemistry Division
Material Measurement Laboratory

Enclosures

cc: L. C. Sander

The NIST MMQAP Vitamin C Round Robin 38 (RR38) report consists of:

Page	"Individualized" Report
1	Summary of your reported values for the two serum control and four serum test samples.
2	Graphical summary of your RR38 measurements.

Page	"All-Lab" Report
1	A tabulation of results and summary statistics for total ascorbic acid [TAA] in the RR38 control and test samples. Results and summary statistics are also presented for the test samples calibrated to the results for the control samples

Serum-Based Samples. Two serum controls and four test samples were distributed in RR38.

CS#3 a (15.4 ±0.4) µmol/L material ampouled in 2009

CS#4 a (46.2 ±1.2) µmol/L material ampouled in 2009

S38:1 an unaugmented material (i.e., the [TAA] content is zero or nearly so), ampouled in 2001, previously distributed in RRs 16, 19, 21, 23, 26, and 29

S38:2 Ampouled in late 2009, previously distributed in RRs 32, 33, and 35

S38:3 Ampouled in late 2009, previously distributed in RRs 32, 35, and 36

S38:4 Ampouled in late 2009, previously distributed in RRs 34 and 36

Results.

1) The reported [TAA] contents of the two control sera, CS#3 and CS#4, are unchanged from the values estimated for these materials when they were distributed as unknowns. The expected [TAA] content and inter-participant standard deviation are estimated with the robust median and adjusted median absolute deviation (eSD) statistics.

2) All participants reported either "zero" or credible limit-of-quantification (LoQ) values for the unaugmented (nominal zero-level) material, S38:1. We regard providing LoQ (i.e., "<*x*") values to be the more informative reporting practice.

3) The reported [TAA] contents of the three non-blank test samples, S38:2 to S38:4, are the same as estimated in previous studies. The robust inter-participant estimated coefficient of variation

$$\text{eCV} = 100*\text{eSD}/\text{Median}$$

pooled over these three materials is 8%.

4) The results for two control sera with well-separated [TAA] levels enable calibration of the reported results for the unknowns to the function:

$$[\text{TAA}]_{\text{reportedCS}} = a + b*[\text{TAA}]_{\text{referenceCS}}$$

where $[\text{TAA}]_{\text{reportedCS}}$ are the reported values for the two control sera and $[\text{TAA}]_{\text{referenceCS}}$ are the established reference values for these materials. The calibrated values for unknown samples are then given by:

$$[\text{TAA}]_{\text{calibrated}} = ([\text{TAA}]_{\text{reported}} - a) / b\ .$$

Figure 1 displays the eSD as a function of the Median values for the test samples distributed in RR37 and RR38 for both the "as reported" and "after calibration" results. While there is as yet too little data to draw strong conclusions, calibration to the control materials appears to improve the pooled eCV of the seven test samples from about 7% to 5%.

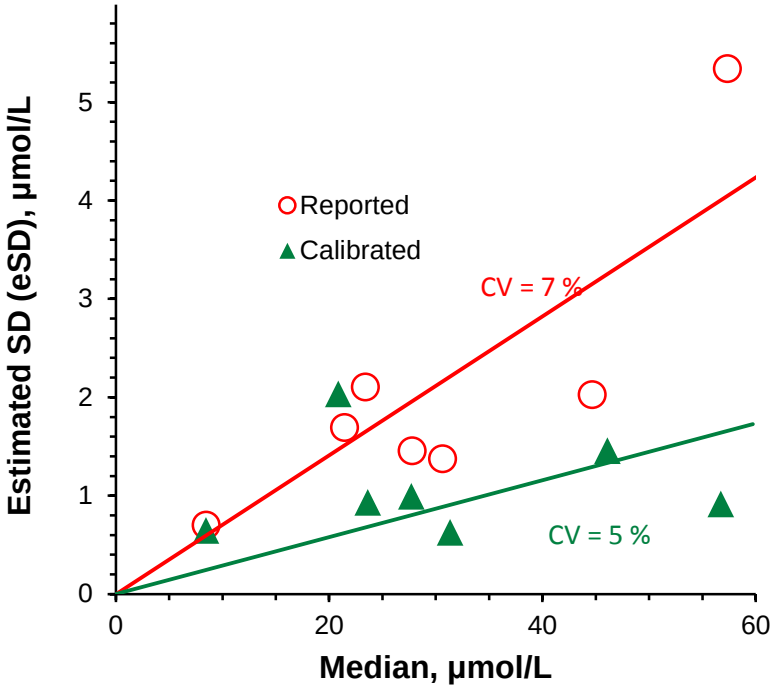


Figure 1: Estimated Standard Deviation as a Function of Median Value

Each symbol represents the summary statistics for one of the four test samples distributed in RR37 or one of the three non-blank test samples distributed in RR38.

Appendix G. "All-Lab Report" for RR38

The following two pages are the "All-Lab Report" for RR38 as provided to all participants, with the following exceptions:

- the participant identifiers (Lab) have been altered.
- the order in which the participant results are listed has been altered.
- the Legend page has been added.

The data summary in the "All-Lab Report" has been altered to ensure confidentiality of identification codes assigned to laboratories.

Micronutrients Measurement Quality Assurance Program for Total Ascorbic Acid
"Round Robin" 38 - Winter 2013

		Samples						Calibrated Results: [TAA]' = ([TAA]-*a*)/*b*					
		Total Ascorbic Acid ([TAA]), µmol/L						Parameters		[TAA]', µmol/L			
Lab	Date	CS#3	CS#4	S38:1	S38:2	S38:3	S38:4	*b*	*a*	S38:1'	S38:2'	S38:3'	S38:4'
VC-MB	27/02/13	13.9	45.4	<5.2	21.7	30.2	57.0	1.03	-2.0	<7.0	23.0	31.3	57.4
VC-MC	15/05/13	16.2	48.3	*nd*	24.0	35.5	57.2	1.05	-0.1	*nd*	22.9	33.9	54.6
VC-MG	03/04/13	15.1	46.6	0.0	23.5	31.1	57.8	1.03	-0.8	0.8	23.7	31.1	57.0
VC-MH	18/03/13	15.7	46.8	<0.9	22.4	29.4	53.9	1.02	-0.1	<0.9	22.0	29.0	53.1
VC-MI	29/03/13	14.6	58.8	<1.4	26.2	38.3	73.3	1.44	-7.8	<6.4	23.6	31.9	56.2
VC-MJ	05/03/13	23.8	53.4	<10	29.7	37.3	62.2	0.97	8.7	<1.3	21.6	29.5	55.2
VC-MN	05/04/13	15.5	43.5	0.0	23.3	31.2	57.7	0.92	1.3	-1.4	24.1	32.6	61.6
VC-NF	28/03/13	15.3	43.7	<1.7	24.0	30.1	53.6	0.93	0.9	<0.9	24.8	31.4	56.7
VC-NM	11/03/13	12.7	42.5	<5.7	21.2	28.3	52.8	0.97	-2.4	<8.4	24.3	31.6	56.7
	N	9	9	2	9	9	9			2	9	9	9
	Average	15.9	47.7	0.0	24.0	32.4	58.4			-0.3	23.3	31.4	56.5
	SD	3.1	5.3	0.0	2.6	3.7	6.3			1.6	1.0	1.5	2.4
	Min	12.7	42.5	0.0	21.2	28.3	52.8			-1.4	21.6	29.0	53.1
	%25	14.6	43.7		22.4	30.1	53.9				22.9	31.1	55.2
	Median	15.3	46.6	0.0	23.5	31.1	57.2			-0.3	23.6	31.4	56.7
	%75	15.7	48.3		24.0	35.5	57.8				24.1	31.9	57.0
	Max	23.8	58.8	0.0	29.7	38.3	73.3			0.8	24.8	33.9	61.6
	eSD	1.1	4.3		1.7	2.6	4.8				0.9	0.8	1.0
	eCV	7	9		7	8	8				4	2	2

G2

Micronutrients Measurement Quality Assurance Program for Total Ascorbic Acid
"Round Robin" 38 - Winter 2013

Legend

Term	Definition
Lab	Participant code
Date	Date results received at NIST
b	Slope and Intercept of the line connecting the expected values
a	for control samples CS#3 and CS#4 with the results reported by each participant
N	Number of quantitative values reported for this analyte
Average	Mean of the reported quantitative values
SD	Standard deviation of the reported quantitative values
Min	Minimum quantitative value reported
%25	First quartile of the reported quantitative values
Median	Median (second quartile) of the reported quantitative values
%75	Third quartile of the reported quantitative values
Max	Maximum quantitative value reported
eSD	Robust standard deviation, estimated using the adjusted median absolute deviation from the median (MADe)
eCV	Robust Coefficient of Variation, estimated as 100*eSD/Median
nd	Not determined
<x	Concentration less than x

G3

Appendix H. Representative "Individualized Report" for RR38

Each participant in RR38 received an "Individualized Report" reflecting their reported results. The following two pages are the "Individualized Report" for participant "VC-MB".

Vitamin C "Round Robin" 38 Report: Participant VC-MB

			[TAA] mmol/Lsample								
Date	RR	Sample	Rep_1	Rep_2	F_{adj}	Mean	SD_{dup}	N	Mean	SD_{repeat}	SD_{reprod}
07/23/10	33	S33:3	13.4	13.4	1.0	13.4	0.0	5	13.8	1.5	1.2
01/14/11	34	S34:2	13.9	13.9	1.0	13.9	0.0				
06/13/11	35	S35:1	15.0	15.5	1.0	15.2	0.4				
08/06/12	37	CS#3	10.3	15.0	1.0	12.6	3.3				
02/27/13	38	CS#3	13.9	13.9	1.0	13.9	0.0				
01/13/10	32	S32:4	45.4	45.9	1.0	45.7	0.4	5	46.1	1.1	1.0
01/14/11	34	S34:3	45.4	45.9	1.0	45.7	0.4				
06/13/11	35	S35:4	47.5	47.5	1.0	47.5	0.0				
08/06/12	37	CS#4	44.9	48.0	1.0	46.5	2.2				
02/27/13	38	CS#4	45.9	44.9	1.0	45.4	0.7				
02/08/02	16	S16:2	3.1	2.0	0.5	1.3	0.4	5	0.9	0.4	1.4
05/01/03	19	S19:1	5.2	7.2	0.5	3.1	0.7				
07/14/04	21	S21:1	<5.2	<5.2	1.0						
05/25/05	23	S23:1	0.0	0.0	1.0	0.0	0.0				
11/26/06	26	S26:1	0.0	0.0	1.0	0.0	0.0				
06/20/08	29	S29:1	0.0	0.0	1.0	0.0	0.0				
01/02/00	38	S38:1	<5.16	<5.16	1.0						
01/13/10	32	S32:2	22.2	22.7	1.0	22.5	0.4	4	22.7	0.4	0.9
07/23/10	33	S33:4	23.2	22.7	1.0	23.0	0.4				
06/13/11	35	S35:2	23.7	23.7	1.0	23.7	0.0				
02/27/13	38	S38:2	21.2	22.2	1.0	21.7	0.7				
01/13/10	32	S32:3	30.5	31.0	1.0	30.7	0.4	4	30.9	0.5	0.7
06/13/11	35	S35:3	32.0	31.5	1.0	31.7	0.4				
03/07/12	36	S36:2	31.5	30.5	1.0	31.0	0.7				
02/27/13	38	S38:3	29.9	30.5	1.0	30.2	0.4				
01/14/11	34	S34:4	56.8	57.3	1.0	57.0	0.4	4	56.8	0.7	0.7
03/07/12	36	S36:1	57.8	56.8	1.0	57.3	0.7				
03/07/12	36	S36:4	56.8	55.2	1.0	56.0	1.1				
02/27/13	38	S38:4	57.3	56.8	1.0	57.0	0.4				

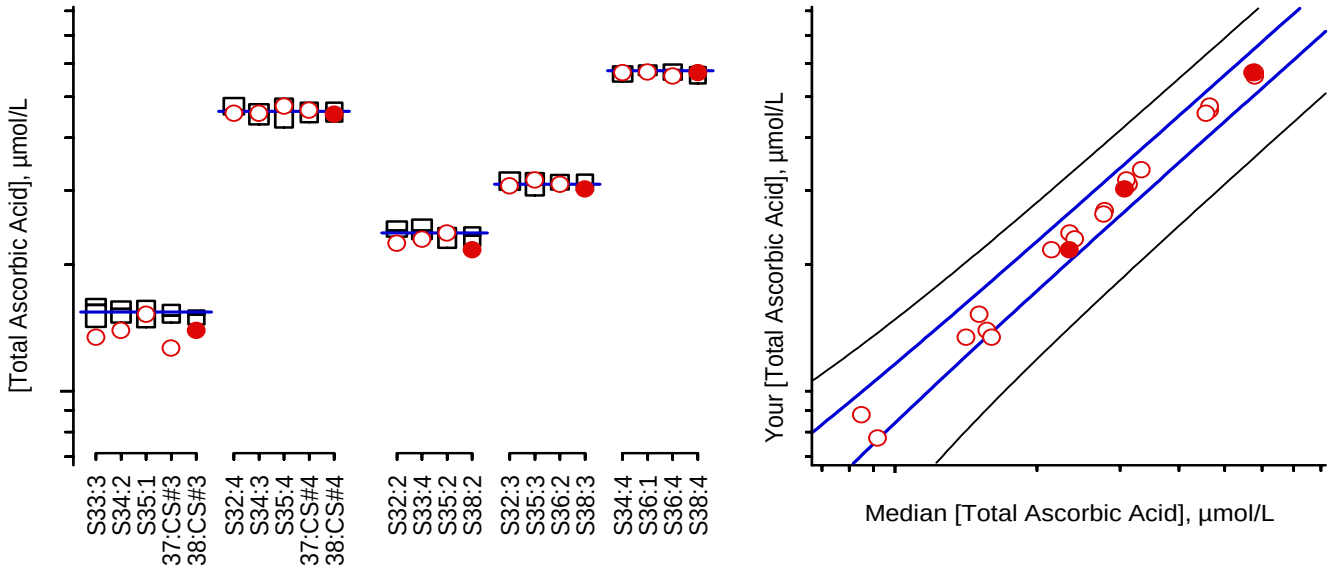
Please check our records against your records. Send corrections and/or updates to...

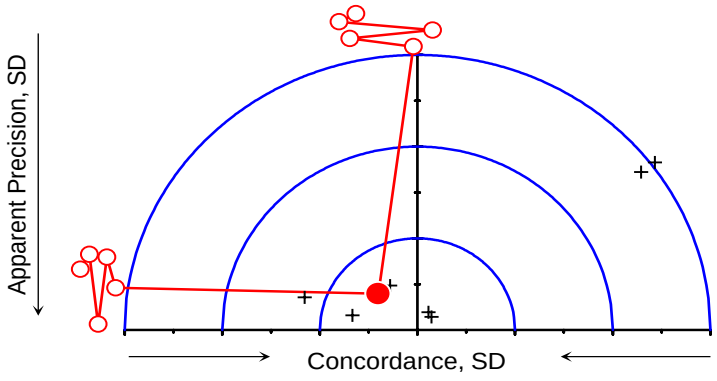
Micronutrients Measurement Quality Assurance Program
National Institute of Standards and Technology
Fax: (301) 977-0685
Email: david.duewer@nist.gov

H2

Vitamin C "Round Robin" 38 Report: Participant VC-MB

Total Ascorbic Acid, µmol/mL





3rd Quartile (75%)
Median (50%)
1st Quartile (25%)

● You, this RR
○ You, past RRs

\+ Others, this RR

For details of the construction and interpretation of these plots, see:
Duewer, Kline, Sharpless, Brown Thomas, Gary, Sowell. Anal Chem 1999;71(9):1870-8.

Sample	Comments
CS#3	Distributed as an unknown in RRs 33, 34, and 35. Distributed as a control in RR37.
CS#4	Distributed as an unknown in RRs 32, 34, and 35. Distributed as a control in RR37.
S38:1	Zero-level control serum, distributed in RRs 16, 19, 21, 23, 26, and 29
S38:2	Distributed in RRs 32, 33, and 35
S38:3	Distributed in RRs 32, 35, and 36
S38:4	Distributed in RRs 34 and 36