Appendix E: Limit of Detection Tables

The analytical limit of detection (LOD) is the level at which the measurement has a 95 percent probability of being greater than zero (Taylor 1987). LOD values may change over time due to changes to analytical methods. We used the highest LOD value when multi-year data were combined.

The tables below provide the LOD for each biochemical indicator by topic area:

Water-soluble vitamins, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Folate (total)	RBC	nmol/L	45	45	45	45	44	44
Folate (total)	Serum	nmol/L	0.23	0.23	0.23	0.23	2	2
5-Methyltetrahydrofolic acid	Serum	nmol/L	---	---	---	---	0.5	0.5
Folic acid	Serum	nmol/L	---	---	---	---	0.3	0.3
Vitamin B_{12}	Serum	pmol/L	11	11	11	11	---	---
Pyridoxal-5'-phosphate	Serum	nmol/L	---	---	---	0.3	0.3	0.3
4-Pyridoxic acid	Serum	nmol/L	---	---	---	0.3	0.3	0.3
Homocysteine	Plasma	µmol/L	0.35	0.35	0.35	0.35	---	---
Methylmalonic acid	Plasma	nmol/L	50	50	50	---	---	---
$3cB_{12}$	Serum	n/a	n/a	n/a	---	---	---	
Vitamin C	Serum	µmol/L	---	---	0.68	0.68	---	---

Abbreviations: $3cB_{12}$, composite score to assess vitamin B_{12} status calculated using the conventional biomarkers serum B_{12}, methylmalonic acid, and homocysteine; RBC, red blood cells; ---, no data; n/a, LOD not applicable because of calculated value.

Water-soluble vitamins, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
Folate (total)	RBC	nmol/L	44	44	44	---
Folate (total; sum of bioactive folate forms)	Serum	nmol/L	n/a	n/a	n/a	---
5-Methyltetrahydrofolic acid	Serum	nmol/L	0.31	0.06	0.13	---
Folic acid	Serum	nmol/L	0.09	0.2	0.14	---
5-Formyltetrahydrofolic acid	Serum	nmol/L	0.30	0.2	0.20	---
Tetrahydrofolic acid	Serum	nmol/L	0.37	0.2	0.25	---
5,10-Methenyltetrahydrofolic acid	Serum	nmol/L	0.34	0.31	0.20	---
MeFox	Serum	nmol/L	0.34	0.08	0.10	---
Vitamin B_{12}	Serum	pmol/L	22.14	22.14	---	---
Methylmalonic acid	Serum	nmol/L	22.1	22.1	---	---
Vitamin C	Serum	µmol/L	---	---	---	1.7

Abbreviations: MeFox, oxidation product of 5-methyltetrahydrofolic acid (pyrazino-s-triazine derivative of 4α-hydroxy-5-methylTHF); RBC, red blood cells; ---, no data; n/a, LOD not applicable because of calculated value.

Water-soluble vitamins, NHANES August 2021–August 2023

Indicator	Matrix	Units	Aug 2021–Aug 2023
Folate (total)	RBC	nmol/L	44
Folate (total; sum of bioactive folate forms)	Serum	nmol/L	n/a
5-Methyltetrahydrofolic acid	Serum	nmol/L	0.13
Folic acid	Serum	nmol/L	0.14
5-Formyltetrahydrofolic acid	Serum	nmol/L	0.20
Tetrahydrofolic acid	Serum	nmol/L	0.25
5,10-Methenyltetrahydrofolic acid	Serum	nmol/L	0.20
MeFox	Serum	nmol/L	0.10
Folate (total; sum of bioactive folate forms)	RBC	nmol/L	n/a
5-Methyltetrahydrofolic acid	RBC	nmol/L	n/a
Folic acid	RBC	nmol/L	n/a
5-Formyltetrahydrofolic acid	RBC	nmol/L	n/a
Tetrahydrofolic acid	RBC	nmol/L	n/a
5,10-Methenyltetrahydrofolic acid	RBC	nmol/L	n/a
MeFox	RBC	nmol/L	n/a

Abbreviations: MeFox, oxidation product of 5-methyltetrahydrofolic acid (pyrazino-s-triazine derivative of 4α-hydroxy-5-methylTHF); RBC, red blood cells; n/a, LOD not applicable because of calculated value.

Vitamins A, E, Carotenoids, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Vitamin A (retinol)	Serum	µg/dL	1.03	1.03	---	1.03	---	---
Retinyl palmitate	Serum	µg/dL	0.2	0.2	---	1.3	---	---
Retinyl stearate	Serum	µg/dL	0.5	0.5	---	0.7	---	---
Vitamin E (*alpha*-tocopherol)	Serum	µg/dL	40.7	40.7	---	40.7	---	---
gamma-Tocopherol	Serum	µg/dL	10.7	10.7	---	10.7	---	---
alpha-Carotene	Serum	µg/dL	0.7	0.7	---	0.7	---	---
trans-beta-Carotene	Serum	µg/dL	0.8	0.8	---	0.8	---	---
cis-beta-Carotene	Serum	µg/dL	0.7	0.7	---	0.7	---	---
beta-Cryptoxanthin	Serum	µg/dL	0.9	0.9	---	0.9	---	---
Lutein/zeaxanthin	Serum	µg/dL	2.4	2.4	---	2.4	---	---
trans-Lycopene	Serum	µg/dL	0.8	0.8	---	0.8	---	---
Total lycopene	Serum	µg/dL	---	---	---	1	---	---

Abbreviations: ---, no data.

Vitamins A and E, and Carotenoids, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
Vitamin A (retinol)	Serum	µg/dL	---	---	---	1.0
Retinyl palmitate	Serum	µg/dL	---	---	---	1.3
Retinyl stearate	Serum	µg/dL	---	---	---	0.7
Vitamin E (*alpha*-tocopherol)	Serum	µg/dL	---	---	---	40
gamma-Tocopherol	Serum	µg/dL	---	---	---	11
alpha-Carotene	Serum	µg/dL	---	---	---	0.7
trans-beta-Carotene	Serum	µg/dL	---	---	---	0.8
cis-beta-Carotene	Serum	µg/dL	---	---	---	0.7
alpha-Cryptoxanthin	Serum	µg/dL	---	---	---	0.2
beta-Cryptoxanthin	Serum	µg/dL	---	---	---	0.9
Lutein/zeaxanthin	Serum	µg/dL	---	---	---	2.4
trans-Lycopene	Serum	µg/dL	---	---	---	0.8
Total lycopene	Serum	µg/dL	---	---	---	1.0

Abbreviations: ---, no data.

Vitamin D, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
25-Hydroxyvitamin D (total)	Serum	nmol/L	---	3.75	3.75	3.75	n/a	n/a
25-Hydroxyvitamin D3	Serum	nmol/L	---	---	---	---	2.23	2.23
25-Hydroxyvitamin D2	Serum	nmol/L	---	---	---	---	2.05	2.05
25-Hydroxyvitamin D3 epimer	Serum	nmol/L	---	---	---	---	1.64	1.64

Abbreviations: ---, no data; n/a, LOD not applicable because of calculated value.

Vitamin D, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
25-Hydroxyvitamin D (total)	Serum	nmol/L	n/a	n/a	n/a	n/a
25-Hydroxyvitamin D2	Serum	nmol/L	2.05	2.05	2.05	2.05
25-Hydroxyvitamin D3	Serum	nmol/L	2.23	2.23	2.23	2.23
25-Hydroxyvitamin D3 epimer	Serum	nmol/L	1.64	1.64	1.64	1.64

Abbreviations: n/a, LOD not applicable because of calculated value.

Vitamin D, NHANES August 2021–August 2023

Indicator	Matrix	Units	Aug 2021–Aug 2023
25-Hydroxyvitamin D (total)	Serum	nmol/L	n/a
25-Hydroxyvitamin D2	Serum	nmol/L	2.216
25-Hydroxyvitamin D3	Serum	nmol/L	0.439
25-Hydroxyvitamin D3 epimer	Serum	nmol/L	0.755

Abbreviations: n/a, LOD not applicable because of calculated value.

Fatty Acids, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Myristic acid (14:0)	Plasma	µmol/L	---	---	1.6	---	---	---
Palmitic acid (16:0)	Plasma	µmol/L	---	---	8.2	---	---	---
Stearic acid (18:0)	Plasma	µmol/L	---	---	23.7	---	---	---
Arachidic acid (20:0)	Plasma	µmol/L	---	---	0.6	---	---	---
Docosanoic acid (22:0)	Plasma	µmol/L	---	---	0.2	---	---	---
Lignoceric acid (24:0)	Plasma	µmol/L	---	---	0.1	---	---	---
Myristoleic acid (14:1n-5)	Plasma	µmol/L	---	---	0.1	---	---	---
Palmitoleic acid (16:1n-7)	Plasma	µmol/L	---	---	0.6	---	---	---
cis-Vaccenic acid (18:1n-7)	Plasma	µmol/L	---	---	0.3	---	---	---
Oleic acid (18:1n-9)	Plasma	µmol/L	---	---	5.2	---	---	---
Eicosenoic acid (20:1n-9)	Plasma	µmol/L	---	---	0.2	---	---	---
Docosenoic acid (22:1n-9)	Plasma	µmol/L	---	---	0.3	---	---	---
Nervonic acid (24:1n-9)	Plasma	µmol/L	---	---	0.4	---	---	---
Linoleic acid (18:2n-6)	Plasma	µmol/L	---	---	2.2	---	---	---
alpha-Linolenic acid (18:3n-3)	Plasma	µmol/L	---	---	0.2	---	---	---
gamma-Linolenic acid (18:3n-6)	Plasma	µmol/L	---	---	0.1	---	---	---
Eicosadienoic acid (20:2n-6)	Plasma	µmol/L	---	---	0.1	---	---	---
homo-gamma-Linolenic acid (20:3n-6)	Plasma	µmol/L	---	---	0.2	---	---	---
Arachidonic acid (20:4n-6)	Plasma	µmol/L	---	---	0.3	---	---	---
Eicosapentaenoic acid (20:5n-3)	Plasma	µmol/L	---	---	0.1	---	---	---
Docosatetraenoic acid (22:4n-6)	Plasma	µmol/L	---	---	0.2	---	---	---
Docosapentaenoic acid (22:5n-3)	Plasma	µmol/L	---	---	0.2	---	---	---
Docosapentaenoic acid (22:5n-6)	Plasma	µmol/L	---	---	0.1	---	---	---
Docosahexaenoic acid (22:6n-3)	Plasma	µmol/L	---	---	0.1	---	---	---

Abbreviations: ---, no data.

Fatty Acids, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
Capric acid (10:0)	Serum	µmol/L	1.59	1.59	---	---
Lauric acid (12:0)	Serum	µmol/L	2.33	2.33	---	---
Myristic acid (14:0)	Serum	µmol/L	4.90	4.90	---	---
Pentadecanoic acid (15:0)	Serum	µmol/L	0.75	0.75	---	---
Palmitic acid (16:0)	Serum	µmol/L	78.1	78.1	---	---
Margaric acid (17:0)	Serum	µmol/L	3.36	3.36	---	---
Stearic acid (18:0)	Serum	µmol/L	39.1	39.1	---	---
Arachidic acid (20:0)	Serum	µmol/L	0.82	0.82	---	---
Docosanoic acid (22:0)	Serum	µmol/L	0.68	0.68	---	---
Tricosanoic acid (23:0)	Serum	µmol/L	0.90	0.90	---	---
Lignoceric acid (24:0)	Serum	µmol/L	1.09	1.09	---	---
Myristoleic acid (14:1n-5)	Serum	µmol/L	0.29	0.29	---	---
Palmitoleic acid (16:1n-7)	Serum	µmol/L	6.56	6.56	---	---
cis-Vaccenic acid (18:1n-7)	Serum	µmol/L	2.31	2.31	---	---
Oleic acid (18:1n-9)	Serum	µmol/L	17.7	17.7	---	---
Eicosenoic acid (20:1n-9)	Serum	µmol/L	0.87	0.87	---	---
Nervonic acid (24:1n-9)	Serum	µmol/L	0.69	0.69	---	---
Linoleic acid (18:2n-6)	Serum	µmol/L	22.6	22.6	---	---
alpha-Linolenic acid (18:3n-3)	Serum	µmol/L	1.54	1.54	---	---
gamma-Linolenic acid (18:3n-6)	Serum	µmol/L	0.42	0.42	---	---
Stearidonic acid (18:4n-3)	Serum	µmol/L	0.24	0.24	---	---
Eicosadienoic acid (20:2n-6)	Serum	µmol/L	0.31	0.31	---	---
homo-gamma-Linolenic acid (20:3n-6)	Serum	µmol/L	1.14	1.14	---	---
Eicosatrienoic acid (20:3n-9)	Serum	µmol/L	0.39	0.39	---	---
Arachidonic acid (20:4n-6)	Serum	µmol/L	7.34	7.34	---	---
Eicosapentaenoic acid (20:5n-3)	Serum	µmol/L	0.79	0.79	---	---
Docosatetraenoic acid (22:4n-6)	Serum	µmol/L	0.31	0.31	---	---
Docosapentaenoic acid (22:5n-3)	Serum	µmol/L	0.55	0.55	---	---
Docosapentaenoic acid (22:5n-6)	Serum	µmol/L	0.24	0.24	---	---
Docosahexaenoic acid (22:6n-3)	Serum	µmol/L	1.84	1.84	---	---

Abbreviations: ---, no data.

Fatty Acids, NHANES August 2021–August 2023

Indicator	Matrix	Units	Aug 2021–Aug 2023
Myristic acid (14:0)	RBC	%	n/a
Palmitic acid (16:0)	RBC	%	n/a
Stearic acid (18:0)	RBC	%	n/a
Arachidic acid (20:0)	RBC	%	n/a
Docosanoic acid (22:0)	RBC	%	n/a
Lignoceric acid (24:0)	RBC	%	n/a
Palmitoleic acid (16:1n-7)	RBC	%	n/a
Oleic acid (18:1n-9)	RBC	%	n/a
Eicosenoic acid (20:1n-9)	RBC	%	n/a
Nervonic acid (24:1n-9)	RBC	%	n/a
Linoleic acid (18:2n-6)	RBC	%	n/a
alpha-Linolenic acid (18:3n-3)	RBC	%	n/a
gamma-Linolenic acid (18:3n-6)	RBC	%	n/a
Eicosadienoic acid (20:2n-6)	RBC	%	n/a
homo-gamma-Linolenic acid (20:3n-6)	RBC	%	n/a
Arachidonic acid (20:4n-6)	RBC	%	n/a
Eicosapentaenoic acid (20:5n-3)	RBC	%	n/a
Docosatetraenoic acid (22:4n-6)	RBC	%	n/a
Docosapentaenoic acid (22:5n-3)	RBC	%	n/a
Docosapentaenoic acid (22:5n-6)	RBC	%	n/a
Docosahexaenoic acid (22:6n-3)	RBC	%	n/a
Omega-3 index	RBC	%	n/a

Abbreviations: omega-3 index, calculated as the sum of eicosapentaenoic acid and docosahexaenoic acid; RBC, red blood cells; n/a, LOD not applicable because of calculated value.

Iron-Status Indicators, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Ferritin	Serum	ng/mL	1.1	1.1	3	3	3	3
Soluble transferrin receptor	Serum	mg/L	---	---	0.5	0.5	0.5	0.5
Body iron index	Serum	mg/kg	---	---	n/a	n/a	n/a	n/a
Iron	Serum	µg/dL	2	---	---	---	---	---
Total iron binding capacity	Serum	µg/dL	6	---	---	---	---	---
Transferrin saturation	Serum	%	n/a	---	---	---	---	---
Erythrocyte protoporphyrin	RBC	µg/dL RBC	1	---	---	---	---	---

Abbreviations: RBC, red blood cells; ---, no data; n/a, LOD not applicable because of calculated value.

Iron-Status Indicators, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
Ferritin	Serum	ng/mL	---	---	0.5	0.5
Soluble transferrin receptor	Serum	mg/L	---	---	0.5	0.5
Body iron index	Serum	mg/kg	---	---	n/a	n/a

Abbreviations: ---, no data; n/a, LOD not applicable because of calculated value.

Iron-Status Indicators, NHANES August 2021–August 2023

Indicator	Matrix	Units	Aug 2021–Aug 2023
Ferritin	Serum	ng/mL	0.5
Soluble transferrin receptor	Serum	mg/L	0.5
Body iron index	Serum	mg/kg	n/a

Abbreviations: n/a, LOD not applicable because of calculated value.

Trace Elements, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Iodine	Urine	ng/mL	---	1	1	1.4	1.4	1.4
Selenium	Serum	ng/mL	8	---	---	---	---	---

Abbreviations: ---, no data.

Trace Elements, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
Iodine	Urine	ng/mL	2.4	2.4	2.4	2.4
Selenium	Serum	µg/L	4.5	4.5	4.5	---
Zinc	Serum	µg/dL	2.9	2.9	2.9	---
Copper	Serum	µg/dL	2.5	2.5	2.5	---

Abbreviations: ---, no data.

Trace Elements, NHANES August 2021–August 2023

Indicator	Matrix	Units	Aug 2021–Aug 2023
Iodine	Urine	ng/mL	Data pending

Phytoestrogens, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Genistein	Urine	µg/L	0.3	0.8	0.3	1	0.2	0.2
Daidzein	Urine	µg/L	0.5	1.6	0.3	0.4	0.4	0.4
Equol	Urine	µg/L	3	3.3	0.3	0.06	0.06	0.06
O-desmethylangolensin	Urine	µg/L	0.2	0.4	0.2	0.2	0.2	0.2
Enterodiol	Urine	µg/L	0.8	1.5	0.3	0.04	0.04	0.04
Enterolactone	Urine	µg/L	0.6	1.9	0.3	0.1	0.1	0.1

Caffeine and metabolites, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Caffeine	Urine	µmol/L	---	---	---	---	---	0.1
Theophylline	Urine	µmol/L	---	---	---	---	---	0.05
Paraxanthine	Urine	µmol/L	---	---	---	---	---	0.1
Theobromine	Urine	µmol/L	---	---	---	---	---	0.05
1-Methylxanthine	Urine	µmol/L	---	---	---	---	---	0.01
3-Methylxanthine	Urine	µmol/L	---	---	---	---	---	0.05
7-Methylxanthine	Urine	µmol/L	---	---	---	---	---	0.05
1,3,7-Trimethyluric acid	Urine	µmol/L	---	---	---	---	---	0.05
1,3-Dimethyluric acid	Urine	µmol/L	---	---	---	---	---	0.05
1,7-Dimethyluric acid	Urine	µmol/L	---	---	---	---	---	0.05
3,7-Dimethyluric acid	Urine	µmol/L	---	---	---	---	---	0.05
1-Methyluric acid	Urine	µmol/L	---	---	---	---	---	0.05
3-Methyluric acid	Urine	µmol/L	---	---	---	---	---	0.1
7-Methyluric acid	Urine	µmol/L	---	---	---	---	---	0.1
5-Acetylamino-6-amino-3-methyluracil	Urine	µmol/L	---	---	---	---	---	0.1

Abbreviations: ---, no data.

Caffeine and metabolites, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
Caffeine	Urine	µmol/L	0.003	0.003	---	---
Theophylline	Urine	µmol/L	0.01	0.01	---	---
Paraxanthine	Urine	µmol/L	0.006	0.006	---	---
Theobromine	Urine	µmol/L	0.004	0.004	---	---
1-Methylxanthine	Urine	µmol/L	0.03	0.03	---	---
3-Methylxanthine	Urine	µmol/L	0.04	0.04	---	---
7-Methylxanthine	Urine	µmol/L	0.02	0.02	---	---
1,3,7-Trimethyluric acid	Urine	µmol/L	0.005	0.005	---	---
1,3-Dimethyluric acid	Urine	µmol/L	0.02	0.02	---	---
1,7-Dimethyluric acid	Urine	µmol/L	0.02	0.02	---	---
3,7-Dimethyluric acid	Urine	µmol/L	0.03	0.03	---	---
1-Methyluric acid	Urine	µmol/L	0.05	0.05	---	---
3-Methyluric acid	Urine	µmol/L	0.1	0.1	---	---
7-Methyluric acid	Urine	µmol/L	0.04	0.04	---	---
5-Acetylamino-6-amino-3-methyluracil	Urine	µmol/L	0.1	0.1	---	---

Abbreviations: ---, no data.

Acrylamide Hemoglobin Adducts, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
Acrylamide-hemoglobin	WB	pmoL/g Hb	---	---	3	3	---	---
Glycidamide-hemoglobin	WB	pmoL/g Hb	---	---	4	4	---	---
Acrylamide/glycidamide ratio	WB	no units	---	---	n/a	n/a	---	---

Abbreviations: WB, whole blood; ---, no data; n/a, LOD not applicable because of calculated value.

Acrylamide Hemoglobin Adducts, NHANES 2011–2018

Indicator	Matrix	Units	2011–2012	2013–2014	2015–2016	2017–2018
Acrylamide-hemoglobin	WB	pmoL/g Hb	---	3.9	3.9	---
Glycidamide-hemoglobin	WB	pmoL/g Hb	---	4.9	4.9	---
Acrylamide/glycidamide ratio	WB	no units	---	n/a	n/a	---

Abbreviations: WB, whole blood; ---, no data; n/a, LOD not applicable because of calculated value.

Trans Fatty Acids, NHANES 1999–2010

Indicator	Matrix	Units	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
trans-9-Hexadecenoic acid	Plasma	µmol/L	0.07	---	---	---	---	0.07
trans-9, *trans*-12-Octadienoic acid	Plasma	µmol/L	0.02	---	---	---	---	0.02
trans-9-Octadecenoic acid	Plasma	µmol/L	0.28	---	---	---	---	0.28
trans-11-Octadecenoic acid	Plasma	µmol/L	0.43	---	---	---	---	0.43
Total *trans* fatty acids	Plasma	µmol/L	n/a	---	---	---	---	n/a

Abbreviations: ---, no data; n/a, LOD not applicable because of calculated value.

Reference

Taylor JK. Quality assurance of chemical measurements. Chelsea (MI): Lewis Publishing; 1987.