Theriome

Tapabrata Biswas

Aristotle® Test Results

Barcode: DB87VFTST

Collection Date:
06/09/2024

Analysis Date:
06/30/2024

Sample Collection Method:
Dried Blood Spot (DBS)

Analytical Platform:
Agilent 1290 UPLC-6490 QQQ-MS

Testing Facility:
Theriome Laboratories
Wexford Innovation Center

Report Reviewed By:
Paniz Jasbi, PhD

(844) 844-2768 | info@therio.me | 850 North 5th Street Suite #504 Phoenix, AZ 85004

Disclaimer. This test is not intended to diagnose, treat, or cure any illness or disease. This report should not be used as the sole basis for diagnosis or treatment decisions. It is recommended that individuals review and discuss the results of this report with their licensed healthcare provider before making any decisions or taking any actions based on the information provided.

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The Aristotle test offers a comprehensive evaluation of your health by providing both a high-level overview and detailed insights into potential health issues. It delves into cellular metabolism at the molecular level, offering a perspective that may not always align with traditional diagnostics or genomic profiles. This means an individual may exhibit a healthy phenotype while having a significantly deregulated metabolism. The sensitive sentinel metabolites identified in this test serve as early indicators of metabolic dysfunction, offering a critical window for intervention and preventive health management.

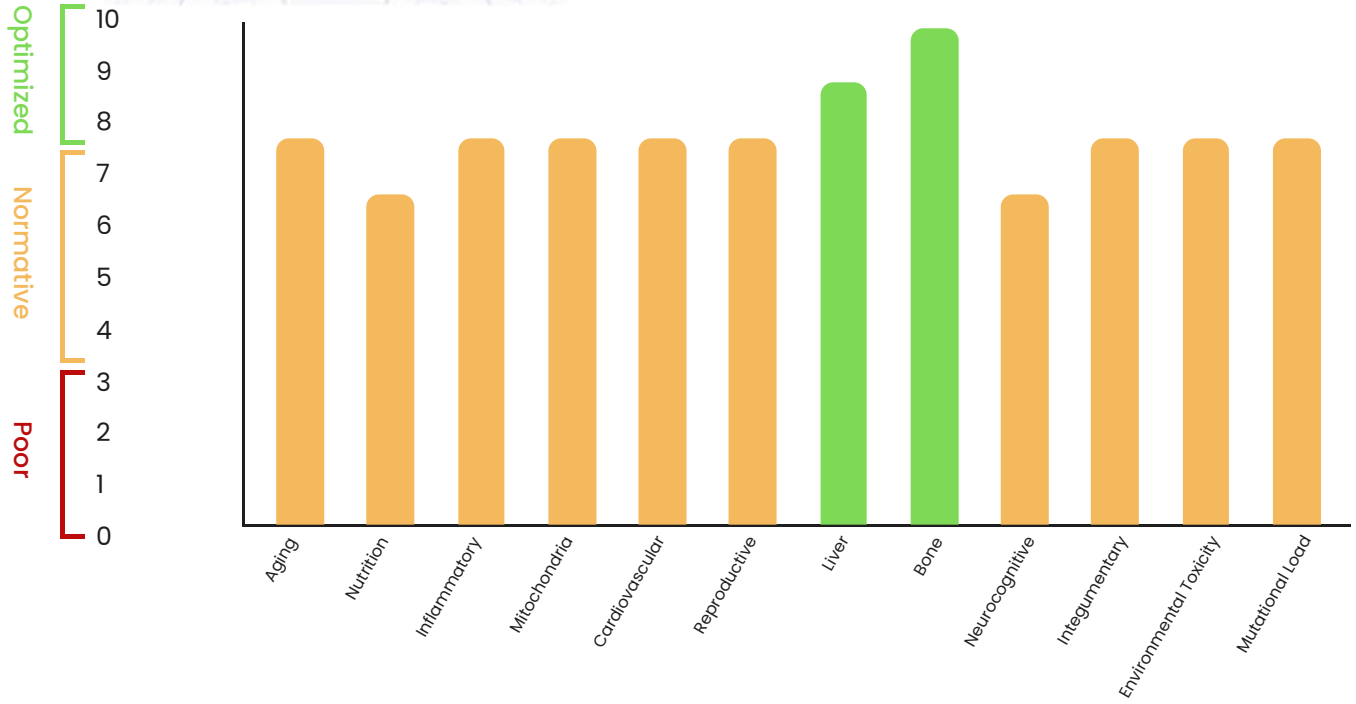
The report aims to empower individuals with a deep molecular understanding of their health, offering actionable insights for lifestyle and dietary adjustments. However, it emphasizes the necessity of consulting with healthcare providers before making significant changes. This document is intended to complement professional medical advice, not replace it, underscoring its role in proactive health management rather than diagnostic purposes.

Tapabrata Biswas, your test results are in.

Thank you for choosing Theriome's deep molecular profiling service. Based on your recent metabolomics panel, we have calculated your health scores across 12 key health domains. Here are your scores:

Your Overall Health Score

71 / 100



Tapabrata Biswas's Next Steps

To improve your health, here are your top recommendations:

1. Supplement

Add 1 cup of cooked leafy greens (such as Swiss chard or beet greens) to your lunch or dinner daily to increase dietary nitrates, supporting endothelial function and electrophysiology.

1. Supplement

Add a daily breakfast smoothie containing spinach, pumpkin seeds, hemp protein, and blueberries to boost micronutrientlinked metabolism and antioxidant status. This targets your low micronutrient metabolism and energy pathways while supporting gut health.

Add 1 tablespoon of extra virgin olive oil to your daily meals to support skin barrier integrity and lipid composition, as well as provide antioxidants for inflammation control.

Introduce 1 tablespoon of ground flaxseed daily to your meals to provide antiinflammatory omega3s and fiber, specifically targeting your low Nutrition and Inflammation subdomain.

Incorporate 1 serving (1/2 cup) of steamed cruciferous vegetables (broccoli, Brussels sprouts, or cauliflower) daily to enhance phase II detoxification and antioxidant processes, addressing your low oxidative stress markers.

1. Environmental

1. Supplement

1. Supplement

AGING INDEX

Your Score

66%

poor *optimal*

Energy and Core Metabolic Intermediates

Fumaric acid	6872 (2516 – 6661)
Niacinamide	8742 (3808 – 6529)
Sarcosine	3584 (5044 – 7312)

Redox Balance and Antioxidant Defense Systems

Glutathione	7107 (3457 – 6886)
Taurine	3575 (2515 – 7277)

Lipid and Membrane Metabolism

Palmitic acid	7770 (4873 – 7704)
Stearic acid	3987 (3812 – 6411)

Polyamine and Cellular Maintenance Pathways

Cadaverine	3112 (3291 – 6830)
Spermidine	6805 (1754 – 5631)

Neurotransmission and Signaling Molecules

Adenosine	8943 (2274 – 8224)
Caffeine	5681 (4247 – 6733)
gamma-Amino butyric acid	4264 (3871 – 6562)
Serotonin	8967 (5084 – 7398)

NUTRITION INDEX

Your Score

59%

poor optimal

Energy Metabolism

Adenine	3638 (3764 – 6776)
Citric acid	1122 (2497 – 7908)
Fumaric acid	6872 (2516 – 6661)
Glucose-6 -phosphate	6815 (2949 – 5314)
Guanosine	7770 (1827 – 7747)
Succinic acid	7073 (3690 – 5083)

Nutrient Sensing

Cyclic AMP	3768 (2598 – 5919)
Fructose 6-phosphate	2175 (2375 – 7448)
Nicotinic acid	2947 (3708 – 7519)
Uridine diphosphate-N-acetylglucosamine	2216 (3104 – 7830)

Gut Microbiome and Digestive Health

Indoleacetic acid	6781 (5022 – 9247)
Taurine	3575 (2515 – 7277)
Tyramine	2720 (2524 – 3503)

Amino Acid Balance and Protein Metabolism

L-Cysteine	9452 (3228 – 7658)
L-Glutamine	1714 (2734 – 8340)
L-Isoleucine	7989 (3382 – 7928)
L-Leucine	1887 (2767 – 7925)
L-Methionine	3101 (3692 – 6878)
L-Tyrosine	7977 (2979 – 8840)
L-Valine	5665 (3233 – 5736)

Lipid and Fatty Acid Metabolism

Linoleic acid	3825 (2708 – 6503)
Oleic acid	8847 (3278 – 8597)
Palmitic acid	7770 (4873 – 7704)

Oxidative Stress and Antioxidant Status

Ferulic acid	7208 (4215 – 8716)
Glutathione	7107 (3457 – 6886)

Micronutrient-Linked Metabolism

alpha-Tocopherol	2080 (2980 – 7522)
Niacinamide	8742 (3808 – 6529)
Pyridoxine	1408 (6186 – 8751)

Metabolic Byproducts and Waste Management

Malonic acid	7067 (4675 – 6732)
Oxalic acid	6627 (5121 – 8808)
Thymine	1209 (3009 – 6873)
Uracil	5126 (3290 – 4705)

Hydration and Electrolyte Regulation

L-Arginine	5489 (2412 – 6553)
Ornithine	7496 (5081 – 7660)

INFLAMMATORY SCORE

Your Score

53%

poor optimal

Immunometabolism

Citric acid	1122 (2497 – 7908)
Guanosine	7770 (1827 – 7747)
L-Isoleucine	7989 (3382 – 7928)
L-Leucine	1887 (2767 – 7925)
L-Valine	5665 (3233 – 5736)
Oleic acid	8847 (3278 – 8597)
Palmitic acid	7770 (4873 – 7704)

Chronic Inflammatory Diseases

gamma-Amino butyric acid	4264 (3871 – 6562)
L-Proline	7008 (2629 – 7691)
L-Tryptophan	9741 (4661 – 9310)

Acute Inflammation

Malic acid	8760 (2691 – 9165)
Succinic acid	7073 (3690 – 5083)
Taurine	3575 (2515 – 7277)

Nutrition and Inflammation

L-Glutamine	1714 (2734 – 8340)
L-Methionine	3101 (3692 – 6878)

Molecular and Cellular Mechanisms

Fumaric acid	6872 (2516 – 6661)
Oxoglutaric acid	2414 (2464 – 5514)
Spermidine	6805 (1754 – 5631)
Spermine	1846 (1885 – 7258)

Therapeutic Interventions

alpha-Tocopherol	2080 (2980 – 7522)
Glutathione	7107 (3457 – 6886)
Glycine	8852 (3675 – 6277)
Ibuprofen	4556 (2505 – 7566)

Viral Inflammation

Adenosine	8943 (2274 – 8224)
Cyclic AMP	3768 (2598 – 5919)
Histamine	7152 (4956 – 8948)
L-Arginine	5489 (2412 – 6553)
Niacinamide	8742 (3808 – 6529)
Nicotinic acid	2947 (3708 – 7519)
Putrescine	1639 (3749 – 7484)
Quinolinic acid	8818 (5258 – 9195)

MITOCHONDRIAL HEALTH

Your Score

59%

poor *optimal*

Energy and Signaling

Adenine	3638 (3764 – 6776)
Adenosine	8943 (2274 – 8224)

Oxidative Stress Marker

2-Hydroxy butyric acid	4995 (3258 – 6913)

TCA Cycle Intermediates

Fumaric acid	6872 (2516 – 6661)
Isocitric acid	1388 (5835 – 7673)
Succinic acid	7073 (3690 – 5083)

Glycolysis and Mitochondrial Respiration

Citric acid	1122 (2497 – 7908)
Malic acid	8760 (2691 – 9165)

Amino Acid Metabolism and TCA Cycle Entry

L-Glutamine	1714 (2734 – 8340)
L-Glutamic acid	2552 (3517 – 5461)

Fatty Acid Oxidation

Methylmalonic acid	5481 (3506 – 5215)
Oleic acid	8847 (3278 – 8597)
Palmitic acid	7770 (4873 – 7704)
Stearic acid	3987 (3812 – 6411)

TCA Cycle and Redox Balance

Oxoglutaric acid	2414 (2464 – 5514)

NAD+/NADH Cycle

Niacinamide	8742 (3808 – 6529)

Membrane Health and Mitochondrial Signaling

Glutathione	7107 (3457 – 6886)
L-Cystathionine	4260 (3162 – 8182)
L-Methionine	3101 (3692 – 6878)
L-Cysteine	9452 (3228 – 7658)

CARDIOVASCULAR HEALTH

Your Score

58%

poor — optimal

Growth Factor Signaling (VEGF, EGF, PDGF)

Cadaverine	3112 (3291 – 6830)
Putrescine	1639 (3749 – 7484)
Spermidine	6805 (1754 – 5631)
Spermine	1846 (1885 – 7258)

Mitochondrial Function (fusion-fission cycling, genomic stability, energy production)

cis-Aconitic acid	5674 (3380 – 5817)
Citric acid	1122 (2497 – 7908)
Fructose 6 -phosphate	2175 (2375 – 7448)
Fumaric acid	6872 (2516 – 6661)
Glucose 6 -phosphate	6815 (2949 – 5314)
Glutathione	7107 (3457 – 6886)
Isocitric acid	1388 (5835 – 7673)
L-Glutamic acid	2552 (3517 – 5461)
L-Glutamine	1714 (2734 – 8340)
Malic acid	8760 (2691 – 9165)
Oxoglutaric acid	2414 (2464 – 5514)
Succinic acid	7073 (3690 – 5083)

Apoptosis (cell functions, death mechanisms)

Adenine	3638 (3764 – 6776)
Adenosine	8943 (2274 – 8224)
Deoxyadenosine	2558 (3803 – 8148)
Dihydrouracil	6609 (4943 – 6560)
Guanosine	7770 (1827 – 7747)
Hypoxanthine	2681 (3236 – 9006)
Inosine	5661 (2714 – 5432)
Thymine	1209 (3009 – 6873)
Uracil	5126 (3290 – 4705)

Fibrosis (collagen deposition fibroblast activation)

4-Hydroxyproline	3040 (5044 – 7312)
L-Proline	7008 (2629 – 7691)

Thrombosis (coagulation process)

alpha-Linolenic acid	9741 (2540 – 6378)
L-Cystathionine	4260 (3162 – 8182)
L-Methionine	3101 (3692 – 6878)
Linoleic acid	3825 (2708 – 6503)
Niacinamide	8742 (3808 – 6529)
Nicotinic acid	2947 (3708 – 7519)
Oleic acid	8847 (3278 – 8597)
Palmitic acid	7770 (4873 – 7704)
Serotonin	8967 (5084 – 7398)

Ion Channel Trafficking

Cyclic AMP	3768 (2598 – 5919)

Electrophysiology (ion channel inhibition)

gamma-Amino butyric acid	4264 (3871 – 6562)
Taurine	3575 (2515 – 7277)

Contractility (eNOS signaling, calcium cycling)

L-Arginine	5489 (2412 – 6553)

ENDOCRINE METABOLISM

Your Score

61%

poor *optimal*

Androgenic Metabolism

Inosine	5661 (2714 – 5432)
Spermidine	6805 (1754 – 5631)
Spermine	1846 (1885 – 7258)
Taurine	3575 (2515 – 7277)

Estrogenic Metabolism

alpha-Linolenic acid	9741 (2540 – 6378)
Hypoxanthine	2681 (3236 – 9006)
Linoleic acid	3825 (2708 – 6503)
Oleic acid	8847 (3278 – 8597)
Palmitic acid	7770 (4873 – 7704)

Integrated Metabolism

Adenine	3638 (3764 – 6776)
Caffeine	5681 (4247 – 6733)
Cyclic AMP	3768 (2598 – 5919)
Glutathione	7107 (3457 – 6886)
myo-Inositol	7729 (3010 – 7337)
Putrescine	1639 (3749 – 7484)
Serotonin	8967 (5084 – 7398)

Your Score

67%

poor optimal

Amino Acid Metabolism

L-Cystathionine	4260 (3162 – 8182)
L-Cysteine	9452 (3228 – 7658)
L-Methionine	3101 (3692 – 6878)
Ornithine	7496 (5081 – 7660)

Urea Cycle Function

Ornithine	7496 (5081 – 7660)
L-Arginine	5489 (2412 – 6553)

Lipid Metabolism

Linoleic acid	3825 (2708 – 6503)
Oleic acid	8847 (3278 – 8597)
Palmitic acid	7770 (4873 – 7704)

Energy Metabolism and Citric Acid Cycle

Citric acid	1122 (2497 – 7908)
Malic acid	8760 (2691 – 9165)
Succinic acid	7073 (3690 – 5083)

Antioxidant and Detoxification Processes

Glutathione	7107 (3457 – 6886)

Bile Acid Synthesis and Transport

Glycine	8852 (3675 – 6277)
Taurine	3575 (2515 – 7277)

Carbohydrate Metabolism

Fructose 6 -phosphate	2175 (2375 – 7448)
Glucose 6 -phosphate	6815 (2949 – 5314)

Oxidative Stress Markers

Fumaric acid	6872 (2516 – 6661)
Oxoglutaric acid	2414 (2464 – 5514)

BONE HEALTH

Your Score

56%

poor optimal

Bone Collagen Turnover

4-Hydroxyproline	3040 (2608 – 7923)
Glycine	8852 (3675 – 6277)
L-Arginine	5489 (2412 – 6553)
L-Cysteine	9452 (3228 – 7658)
L-Cystine	5625 (2632 – 5186)
L-Lysine	1804 (2337 – 7320)

Bone Mineralization

Citric acid	1122 (2497 – 7908)
Malic acid	8760 (2691 – 9165)
Oxoglutaric acid	2414 (2464 – 5514)

Bone Remodeling and Inflammation

alpha-Linolenic acid	9741 (2540 – 6378)
Linoleic acid	3825 (2708 – 6503)
Oleic acid	8847 (3278 – 8597)
Palmitic acid	7770 (4873 – 7704)
Stearic acid	3987 (3812 – 6411)

Bone Growth and Repair

Spermidine	6805 (1754 – 5631)
Spermine	1846 (1885 – 7258)

Bone Density and Resorption

Niacinamide	8742 (3808 – 6529)
Pyridoxine	1408 (6186 – 8751)

Calcium and Phosphate Regulators

Fructose 6 -phosphate	2175 (2375 – 7448)
Glucose 6 -phosphate	6815 (2949 – 5314)
Succinic acid	7073 (3690 – 5083)

Oxidative Stress and Bone Health

Glutathione	7107 (3457 – 6886)
Taurine	3575 (2515 – 7277)

NEUROCOGNITIVE INDEX

Your Score

62%

poor — optimal

Neurotransmission and and Synaptic Plasticity

Cadaverine	3112 (3291 – 6830)
gamma-Amino butyric acid	4264 (3871 – 6562)
Glycine	8852 (3675 – 6277)
Homocarnosine	7550 (2401 – 6893)
L-Dopa	8748 (4160 – 8316)
L-Glutamic acid	2552 (3517 – 5461)
L-Phenyl alanine	7532 (3262 – 6793)
L-Tryptophan	9741 (4661 – 9310)
L-Tyrosine	7977 (2979 – 8840)
Putrescine	1639 (3749 – 7484)
Spermidine	6805 (1754 – 5631)
Spermine	1846 (1885 – 7258)
Tryptamine	7452 (3553 – 7854)

Energy Metabolism and Mitochondrial Function

Adenine	3638 (3764 – 6776)
Citric acid	1122 (2497 – 7908)
Fructose 6 -phosphate	2175 (2375 – 7448)
Fumaric acid	6872 (2516 – 6661)
Glucose 6 -phosphate	6815 (2949 – 5314)
Isocitric acid	1388 (5835 – 7673)
Malic acid	8760 (2691 – 9165)
Oxoglutaric acid	2414 (2464 – 5514)
Succinic acid	7073 (3690 – 5083)

Second Messengers and Signaling Molecules

Adenosine	8943 (2274 – 8224)
Cyclic AMP	3768 (2598 – 5919)
myo-Inositol	7729 (3010 – 7337)

Structural Integrity and Antioxidant Mechanisms

alpha-Linolenic acid	9741 (2540 – 6378)
Glutathione	7107 (3457 – 6886)
L-Serine	5072 (5083 – 8874)
Linoleic acid	3825 (2708 – 6503)
Taurine	3575 (2515 – 7277)

Amino Acids and Cofactors in Neurotransmitter Synthesis

L-Cysteine	9452 (3228 – 7658)
L-Homoserine	7444 (3087 – 7353)
L-Methionine	3101 (3692 – 6878)
Nicotinic acid	2947 (3708 – 7519)
Pyridoxamine	6814 (5087 – 7520)
Pyridoxine	1408 (6186 – 8751)

Compounds Linked to Mood and Arousal Regulation

Caffeine	5681 (4247 – 6733)
Histamine	7152 (4956 – 8948)
Serotonin	8967 (5084 – 7398)

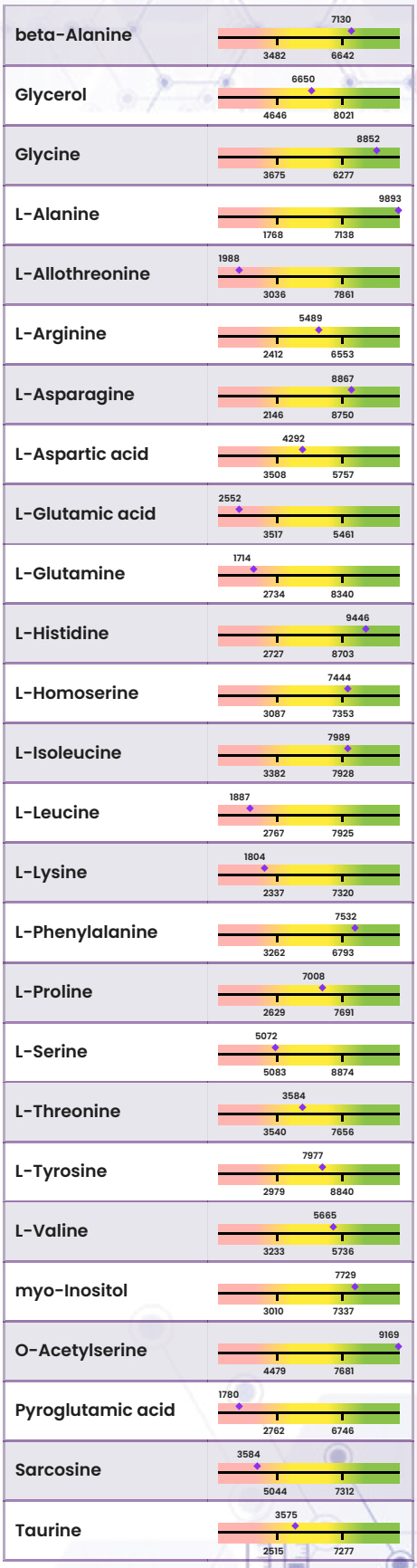
INTEGUMENTARY HEALTH

Your Score

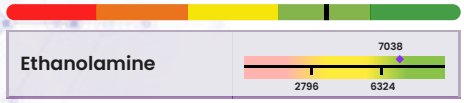
65%

poor *optimal*

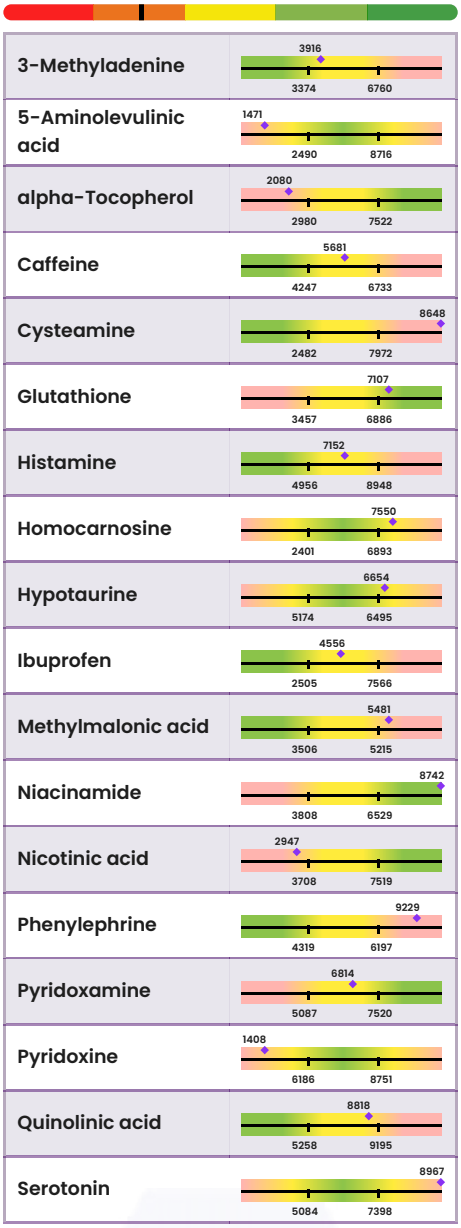
Natural Moisturizing Factors(NMFs)



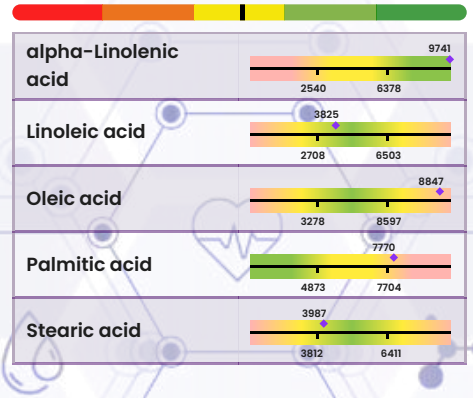
Skin Barrier Integrity and Lipid Composition



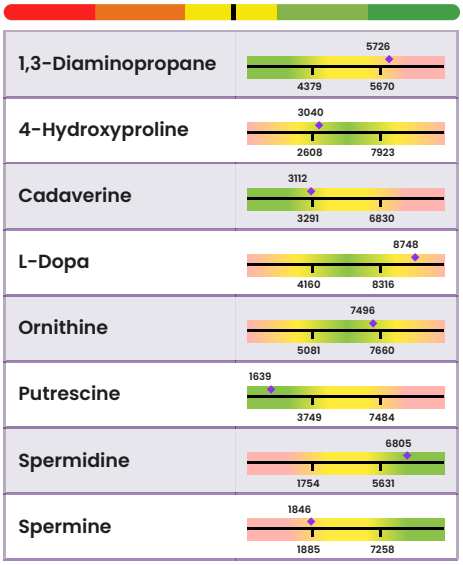
Inflammation & Oxidative Stress Markers



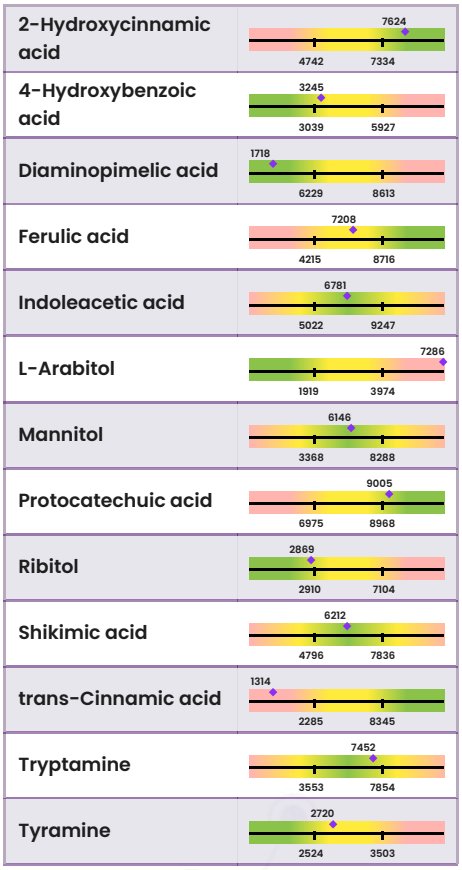
Sebum Composition and Sebaceous Gland Function



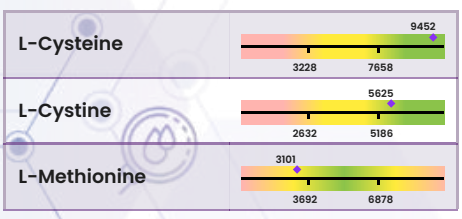
Wound Healing and Tissue Remodeling



Microbiome-Associated Metabolites



Hair and Nail Health Indicators



ENVIRONMENTAL TOXIN EXPOSURE INDEX

Your Score

47%

poor *optimal*

Heavy Metals

Glutathione	7107 (3457 – 6886)
L-Cysteine	9452 (3228 – 7658)

Volatile Organic Compounds (VOCs)

Quinolinic acid	8818 (5258 – 9195)

Pesticides

Shikimic acid	6212 (4796 – 7836)

Industrial Chemicals

1,3-Diaminopropane	5726 (4379 – 5670)

Plastics and Synthetic Polymer Toxins

Cadaverine	3112 (3291 – 6830)
gamma-Aminobutyric acid	4264 (3871 – 6562)
Linoleic acid	3825 (2708 – 6503)
Palmitic acid	7770 (4873 – 7704)

Air Pollutants

p-Hydroxyphenylacetic acid	1253 (3637 – 8047)

Endocrine Disruptors

Adenosine	8943 (2274 – 8224)

Consumer Products

4-Hydroxybenzoic acid	3245 (3039 – 5927)

Mycotoxins

2-Hydroxybutyric acid	4995 (3258 – 6913)

Pharmaceuticals and Illicit Drugs

Phenylephrine	9229 (4319 – 6197)

Radiation Exposure

Adenine	3638 (3764 – 6776)

MUTATIONAL LOAD

Your Score

54%

poor *optimal*

Oxidative Stress

Cyclic AMP	3768 (2598 – 5919)
L-Tyrosine	7977 (2979 – 8840)
Sucrose	5569 (3314 – 7727)

Mutagenesis

3-Methyladenine	3916 (3374 – 6760)
Dihydrouracil	6609 (4943 – 6560)
Uracil	5126 (3290 – 4705)

DNA Repair

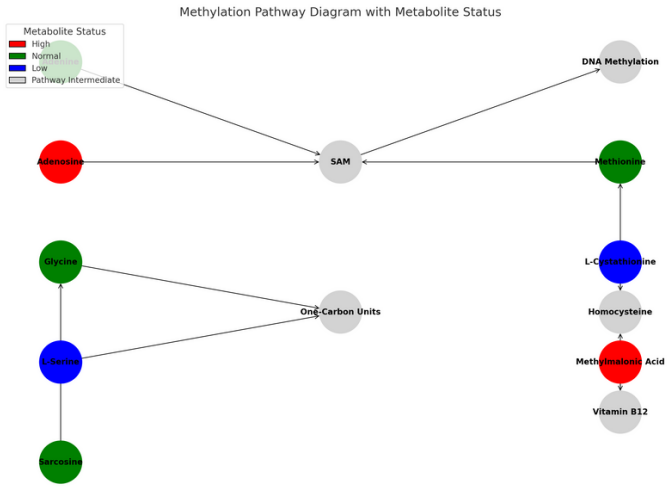
Adenine	3638 (3764 – 6776)
Adenosine	8943 (2274 – 8224)
Deoxyadenosine	2558 (3803 – 8148)
Guanosine	7770 (1827 – 7747)
Thymine	1209 (3009 – 6873)
Uridine	1471 (2379 – 7449)
Uridine diphosphate-N-acetylglucos amine	2216 (3104 – 7830)

Tapabrata Biswas, here is your methylation profile.

Thank you for choosing Theriome's comprehensive methylation analysis service. Based on your recent metabolomics panel, we have conducted a detailed analysis focusing on key metabolites involved in DNA methylation. The accompanying pathway diagram visually represents how these metabolites interact and influence your methylation processes. Below, you'll find personalized insights and recommendations based on this analysis.

Your Methylation Efficiency Index (MEI)

71 / 100



What is the methylome?

The methylome refers to the complete set of DNA methylation modifications in an organism's genome, which play a crucial role in regulating gene expression, genomic stability, and cellular function.

DNA methylation silences genes; SAM, Adenosine, and Adenine are monitored for their roles in gene regulation.

Methylation affects immune response; Glycine, L-Serine, and Adenine are tracked for immune system functioning.

Methylation regulates the cell cycle; Sarcosine, Adenosine, and Adenine are monitored for cell cycle control.

Methylation stabilizes DNA and prevents transposable elements; Methionine, L-Cystathionine, and Adenine help monitor this process.

Methylation maintains chromosomal stability; Methylmalonic Acid and Adenine reflect methylation status affecting chromosomes.

Methylation changes with age; Methylmalonic Acid, SAM, and Adenine assess methylation's role in aging.

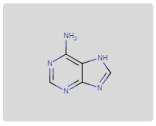
MEI

Your Score: 60%

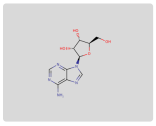
Poor — Optimal

The Methylation Efficiency Index (MEI) is a measure of how effectively your body's DNA methylation processes are functioning, which is crucial for maintaining cellular health and regulating gene expression. It considers various methylation-related biomarkers, including levels of key metabolites that influence methylation pathways, such as SAM, homocysteine, and methylmalonic acid.

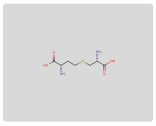
By assessing your MEI, you can gain a comprehensive understanding of how well your methylation processes are supporting your overall health and identify specific areas where you may need to focus on optimizing methylation efficiency. This index is especially valuable for individuals looking to proactively manage their health, prevent potential epigenetic imbalances, and support long-term wellness.



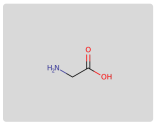
Adenine: Adenine is a key component of DNA and RNA that contributes to the synthesis of S-adenosylmethionine (SAM), the primary methyl donor in methylation processes.



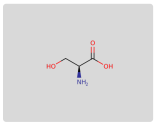
Adenosine: Adenosine, formed by the breakdown of ATP, influences the availability of SAM for methylation reactions and is involved in energy transfer and cellular signaling.



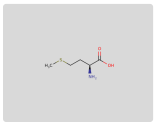
L-Cystathionine: L-Cystathionine is an intermediate in the transsulfuration pathway, crucial for converting homocysteine to cysteine, thus regulating homocysteine levels and supporting methylation.



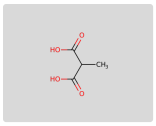
Glycine: Glycine is a simple amino acid that provides one-carbon units necessary for the synthesis of SAM, playing a critical role in the one-carbon metabolism pathway.



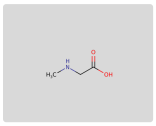
L-Serine: L-Serine is essential for one-carbon metabolism, contributing to the synthesis of glycine and 5-methyltetrahydrofolate, both of which are critical for effective methylation.



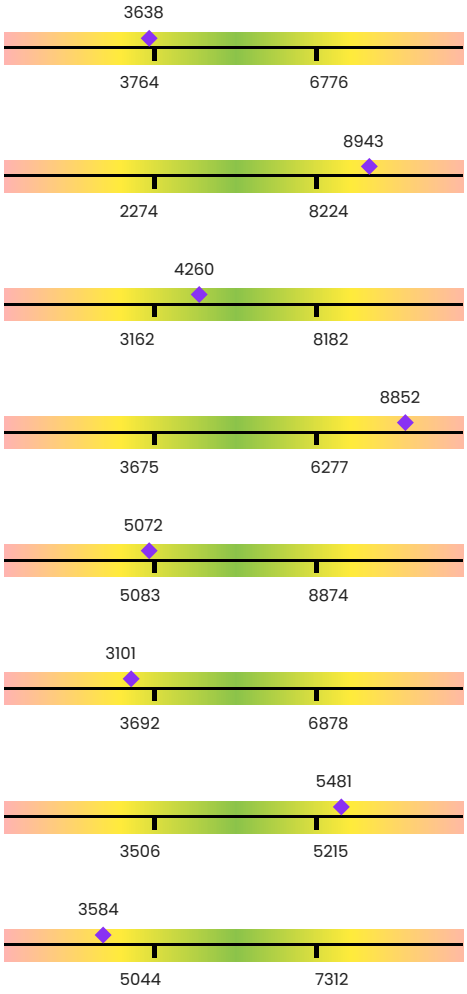
L-Methionine: Methionine is an essential amino acid and a direct precursor to SAM, making it vital for maintaining adequate methylation processes across the genome.



Methylmalonic acid: Methylmalonic acid is a metabolite that accumulates in the case of vitamin B12 deficiency, indirectly affecting methylation by disrupting the conversion of homocysteine to methionine.



Sarcosine: Sarcosine, also known as N-methylglycine, is involved in the methylation of glycine and serves as an indicator of methylation activity, reflecting SAM utilization.



Next Steps :

*Find a detailed protocol addressing your Methylation Efficiency Index and underlying metabolites of the methylome in the **Aging, Inflammation, Environmental Toxin, and Mutational Load** of your digital twinning protocol on pages 18–24.*

Digital Twinning Personal Protocol

Next Steps ?
Re-test in: Months

We're excited to present health recommendations uniquely tailored just for you! The insights you're about to read are derived from our cutting-edge "Digital Twinning" in silico experimental platform, where a digital counterpart of your biological self is created to simulate various health scenarios. To ensure the highest accuracy and relevance to your individual needs, each recommendation undergoes 1,000 iterations, incorporating elements of randomness at every stage. This process is akin to testing out 1,000 slightly different versions of an intervention in a virtual setting to find the optimal health strategies. It's the future of healthcare—personalized, predictive, and precisely tailored. By leveraging such advanced computational methodologies, we're not only predicting your health needs today but engineering your health trajectory into the future.

As you navigate through your report, know that you're experiencing the next frontier in biomedical care, where science meets personalization to empower your health journey.

AGING Index

- Supplement: Take 900 mg of acetyl-L-carnitine daily in the morning to support your low Energy and Core Metabolic Intermediates and Neurotransmission pathways. Acetyl-L-carnitine enhances mitochondrial energy production and neurotransmitter synthesis, directly targeting your metabolic inefficiencies.
- Dietary: Incorporate 2 servings daily of polyamine-rich foods such as wheat germ, mushrooms, and green peas to support Polyamine and Cellular Maintenance Pathways. These foods help promote cellular repair and longevity, addressing your suboptimal polyamine metabolism.
- Behavioral: Practice 10 minutes of moderate-intensity interval walking 3 times daily, spaced throughout the day, to stimulate lipid metabolism and improve redox balance. This approach is especially important given your current lack of regular exercise and low scores in lipid and antioxidant defense systems.

Digital Twinning Personal Protocol

NUTRITIONAL Index

- Dietary: Add a daily breakfast smoothie containing spinach, pumpkin seeds, hemp protein, and blueberries to boost micronutrient-linked metabolism and antioxidant status. This targets your low micronutrient metabolism and energy pathways while supporting gut health.
- Supplement: Take a high-potency multivitamin with methylated B vitamins and chelated minerals (including magnesium, zinc, and selenium) once daily with your largest meal to address broad micronutrient insufficiencies and support nutrient sensing.
- Behavioral: Increase daily water intake to at least 8 cups (2 liters), distributed evenly throughout the day, to improve hydration, electrolyte regulation, and metabolic waste management, as your current intake is inadequate.

INFLAMMATORY Score

- Dietary: Introduce 1 tablespoon of ground flaxseed daily to your meals to provide anti-inflammatory omega-3s and fiber, specifically targeting your low Nutrition and Inflammation subdomain.
- Supplement: Take 500 mg of curcumin phytosome (with piperine for enhanced absorption) twice daily with meals to modulate acute and molecular inflammation and support immunometabolism.
- Behavioral: Implement a daily 10-minute guided mindfulness or breathing exercise in the evening to reduce stress-driven inflammation, which is relevant given your high job stress score and chronic inflammatory risk.

Digital Twinning Personal Protocol

MITOCHONDRIAL Health

- Supplement: Take 200 mg of ubiquinol (the active form of CoQ10) with breakfast to support TCA cycle function and redox balance, directly addressing your low TCA cycle and oxidative stress markers.
- Dietary: Consume 2 servings per week of wild-caught fatty fish (such as salmon or sardines) to supply essential omega-3s and carnitine precursors, supporting mitochondrial membrane health and fatty acid oxidation.
- Exercise: Begin a gentle, progressive resistance training routine 2–3 times per week (using bodyweight or light resistance bands), focusing on large muscle groups to stimulate mitochondrial biogenesis and glycolytic pathways, which are currently underactive.

CARDIOVASCULAR Health

- Dietary: Add 1 cup of cooked leafy greens (such as Swiss chard or beet greens) to your lunch or dinner daily to increase dietary nitrates, supporting endothelial function and electrophysiology.
- Supplement: Take 400 mg of magnesium glycinate in the evening to support ion channel trafficking, contractility, and reduce arrhythmogenic risk; magnesium also synergizes with B vitamins for cardiac mitochondrial support.

Digital Twinning Personal Protocol

REPRODUCTIVE Health

- Behavioral: Prioritize a consistent sleep schedule, aiming for 7–8 hours of sleep nightly, and maintain a dark, cool sleeping environment to optimize androgenic and integrated hormone signaling, as sleep disruption impairs endocrine balance.
- Dietary: Include 2 Brazil nuts daily as a selenium source to support thyroid hormone metabolism and antioxidant defense, which is important for integrated reproductive and endocrine health.

LIVER Health

- Dietary: Incorporate 1 serving (1/2 cup) of steamed cruciferous vegetables (broccoli, Brussels sprouts, or cauliflower) daily to enhance phase II detoxification and antioxidant processes, addressing your low oxidative stress markers.
- Behavioral: Avoid alcohol and minimize processed food intake, as both can strain hepatic metabolism and detoxification pathways, which is particularly important given your moderate scores in energy and carbohydrate metabolism.

Digital Twinning Personal Protocol

GUT Health

- Supplement: Take 2,000 IU of vitamin D3 daily with your largest meal to support bone mineralization and repair, given your low bone mineralization and density scores.
- Dietary: Add 1 cup of plain, unsweetened Greek yogurt or a calcium-fortified plant-based alternative to your daily diet to improve calcium and phosphate regulation and support bone collagen turnover.

NEUROCOGNITIVE Index

- Supplement: Take 300 mg of alpha-GPC (L-alpha glycerylphosphorylcholine) in the morning to support neurotransmitter synthesis and synaptic plasticity, targeting your low energy metabolism and mood regulation subdomains.
- Behavioral: Dedicate 20 minutes daily to a cognitively stimulating activity (such as a new language app or complex puzzles) to enhance neuroplasticity and mood regulation, aligning with your high motivation and mood scores.

Digital Twinning Personal Protocol

INTEGUMENTARY Health

- Dietary: Add 1 tablespoon of extra virgin olive oil to your daily meals to support skin barrier integrity and lipid composition, as well as provide antioxidants for inflammation control.
- Environmental: Use a gentle, fragrance-free moisturizer containing ceramides after showering to support natural moisturizing factors and skin barrier repair, especially important for your low inflammation/oxidative stress skin markers.

ENVIRONMENTAL TOXIN EXPOSURE Index

- Environmental: Install a certified water filter (NSF/ANSI 53 or 58) for drinking and cooking water to reduce exposure to heavy metals, plastics, and VOCs, which are elevated in your toxin profile.
- Behavioral: Avoid the use of plastic food containers and wraps, especially with hot foods, to minimize plastics and endocrine disruptor exposure, which is a significant concern in your toxin subdomain.

MUTATIONAL LOAD

- Supplement: Take 500 mg of liposomal glutathione daily in the morning to support DNA repair and reduce oxidative stress, directly addressing your low DNA repair and oxidative stress subdomains.
- Dietary: Increase intake of colorful vegetables (red peppers, carrots, purple cabbage) to at least 3 servings per day to provide polyphenols and carotenoids, supporting mutagenesis defense and antioxidant status.

SUMMARY OF RESULTS

The Aristotle test is a novel blood-based diagnostic tool that measures the levels of 126 metabolites in the blood. This test provides a comprehensive overview of an individual's metabolic state and can be used to identify potential health issues or to monitor the progress of a disease. The results of the test are analyzed using machine learning algorithms and presented in an easy-to-understand report that can be used by healthcare professionals to develop personalized treatment plans for their patients. The test has the potential to revolutionize the field of personalized medicine by providing a more complete picture of an individual's health and allowing for earlier and more accurate diagnosis of diseases. A full summary of all 126 monitored metabolites is appended below, along with sample concentration ratios, ratio ranges, confidence estimates, as well as metabolite descriptions and implications of high and low levels.

Metabolite	Relative Abundance (RA)	Low RA	High RA
1-Methylhistamine	**5148**	4330	9384
Description	1-Methylhistamine is a type of chemical compound found in all living organisms and is involved in histidine metabolism in humans (DOI: 10.1021/acs.analchem.0c02008). It can be produced by the body through a process called biosynthesis and can be converted into another compound called methylimidazole acetaldehyde. It is also known as H137.		
Implications of low value	1-Methylhistamine is a product of the degradation of histamine, and histamine has many functions in the body, including acting as a neurotransmitter and a mediator of inflammation (DOI: 10.1016/s0378-4347(97)00122-9). Abnormal levels of histamine, including low levels, can contribute to various medical conditions, such as allergies, asthma, and gastric ulcers.		
Implication of High Value	High levels of 1-methylhistamine may be potentially toxic (DOI: 10.1016/s0378-4347(97)00122-9).		
1,3-Diaminopropane	**5726**	4379	5670
Description	1,3-Diaminopropane is a compound that belongs to a class of substances called monoalkylamines (DOI: 10.1002/bmc.898). It is a liquid that is flammable and absorbs moisture easily. It is a byproduct of the breakdown of a compound called spermidine and a building block for other compounds. It can be toxic if ingested, inhaled, or contacts skin. It has been found in some foods such as cassava, shiitakes, oyster mushrooms, muscadine grapes, and cinnamons, thus it can potentially be a marker for consumption of these foods.		
Implications of low value	1,3-diaminopropane, also known as trimethylenediamine, is not a commonly studied biomolecule, it is more likely to be used in chemical synthesis (DOI: 10.1002/bmc.898).		
Implication of High Value	High levels of 1,3-diaminopropane in blood or urine may be an indication of exposure to certain industrial chemicals or cleaning agents, such as certain types of carpet cleaners or industrial solvents (DOI: 10.1016/s0731-7085(96)02048-1). Elevated levels of 1,3-diaminopropane in biological samples may also be an indication of certain health conditions or diseases such as multiple myeloma.		
2-Aminobenzoic acid	**5262**	2271	5375
Description	2-Aminobenzoic acid is a chemical compound that can be found in some foods (DOI: 10.1021/acs.analchem.0c02008). It is involved in the metabolism of tryptophan in humans. It can also cause changes in mental status like confusion and seizures. It is a potential biomarker for the consumption of some foods like mamey sapotes, prairie turnips, and hyacinth beans.		
Implications of low value	It is a relatively uncommon metabolite and research on its role in human health is limited (DOI: 10.1006/abbi.1998.0861).		
Implication of High Value	It is also a uremic toxin, meaning it can have negative effects on the body when present in high levels (DOI: 10.1681/ASN.2011121175). This can lead to conditions such as kidney damage and cardiovascular disease.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
2-Hydroxybutyric acid	**4995**	3258	6913
Description	2-Hydroxybutyric acid (alpha-hydroxybutyrate) is an organic acid that comes from the breakdown of another compound called alpha-ketobutyrate (DOI: 10.1371/journal.pone.0010883). It is produced by the body during the breakdown of certain amino acids and the formation of a compound called glutathione. It is formed as a byproduct and is typically found in the liver. It can also be found in patients with lactic acidosis and ketoacidosis. alpha-Hydroxybutyrate also been found to be an early marker of type 2 diabetes.		
Implications of low value	Low levels of 2-OHB may indicate a state of glucose utilization and carbohydrate metabolism (DOI: 10.1371/journal.pone.0010883). Lower levels of 2-OHB may indicate that the body is using glucose as its primary energy source, rather than fatty acids. This could be due to a diet that is high in carbohydrates, or it could be indicative of other conditions such as an overactive thyroid, certain cancers, or certain genetic disorders.		
Implication of High Value	Elevated levels of 2-hydroxybutyric acid in the urine or blood can be an early marker for insulin resistance, impaired glucose regulation, and certain inherited metabolic diseases (DOI: 10.1016/j.aca.2008.11.058). In general, high levels of 2-Hydroxybutyric acid (2-OHB) can indicate a state of ketosis. The body produces 2-OHB when it breaks down fatty acids for energy, and it's typically found in higher concentrations in people who are following a low-carbohydrate or ketogenic diet or in people with uncontrolled diabetes. However, high levels of 2-OHB can also be indicative of other conditions such as liver disease, kidney disease, and metabolic disorders.		
2-Hydroxycinnamic acid	**7624**	4742	7334
Description	2-coumaric acid is a type of compound found in plants (DOI: 10.1021/acs.analchem.0c02008). It is a hydroxycinnamic acid, which means it is a cinnamic acid with a hydroxyl group. There are three forms of coumaric acid, which differ by the location of the hydroxyl group on the phenyl ring. It is found in small amounts in certain foods such as corn, wheat, olives, pomegranates, cranberries and peanuts. It is also found in all living organisms, including humans.		
Implications of low value	There is limited information available on 2-hydroxycinnamic acid, and more research is needed to determine its possible roles in health and disease (DOI: 10.3945/jn.109.113613).		
Implication of High Value	2-Hydroxycinnamic acid is not a commonly measured substance in the human body and information on its levels and health effects is limited (DOI: 10.3945/jn.109.113613).		
3-Methyl-2-oxovaleric acid	**5085**	3246	5851
Description	3-Methyl-2-oxovaleric acid is a harmful chemical that forms when the body can't properly break down certain amino acids (DOI: 10.1093/jn/135.6.1531S).		
Implications of low value	The information on the effects of specific metabolites or metabolic markers is complex and often context-specific (DOI: 10.1007/BF00711898). The levels of this molecule can be influenced by many factors, including genetic factors, diet, lifestyle, and underlying health conditions.		
Implication of High Value	The medical significance of high levels of 3-methyl-2-oxovaleric acid (MOV) is not well established (DOI: 10.1021/acs.analchem.0c02008). Some studies have suggested that elevated levels of MOV may be a biomarker for certain metabolic disorders, such as isovaleric acidemia. However, more research is needed to fully understand the clinical implications of high levels of MOV.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
3-Methyladenine	**3916**	3374	6760
Description	3-Methyladenine is a chemical compound found in small amounts in some foods such as garlic, bayberries, fish, and tea (DOI: 10.1021/acs.analchem.0c02008). It is part of a group of compounds called 6-aminopurines, which have an amino group at position 6. It's also recognized and excised by a specific enzyme called 3-methyladenine DNA glycosylase.		
Implications of low value	We don't have information on the health implications of low levels of 3-methyladenine in humans (DOI: 10.1016/j.clinbiochem.2005.08.002). It is a naturally occurring molecule and its levels in the body are not commonly measured or studied in the context of human health.		
Implication of High Value	There is limited information available on the health implications of high levels of 3-methyladenine (DOI: 10.1021/ac300829f). The available information suggests that high levels of 3-methyladenine may be associated with various biological processes, including DNA damage and cancer development. However, more research is needed to determine the precise health implications of elevated levels of this substance.		
3,4-Dihydroxybenzeneacetic acid	**4870**	4227	7983
Description	3,4-Dihydroxyphenylacetic acid (DOPAC) is a chemical found in the human body that is a metabolite of dopamine (DOI: 10.1002/0470867196.ch5).		
Implications of low value	Low levels of DOPAC may indicate decreased dopamine metabolism, which can be associated with certain neurological conditions such as Parkinson's disease (DOI: 10.1021/acs.analchem.0c02008). However, it is important to note that the interpretation of metabolite levels in the body is complex and can be influenced by a variety of factors including diet, genetics, and overall health.		
Implication of High Value	High levels of 3,4-dihydroxybenzeneacetic acid in biological samples are associated with diseases such as multiple sclerosis and Parkinson's disease (DOI: 10.2174/156802661866180102153044).		
4-Hydroxybenzoic acid	**3245**	3039	5927
Description	4-Hydroxybenzoic acid is a chemical compound found in various foods and plants such as coconut, green tea, wine, vanilla,mushrooms, and berries (DOI: 10.1006/enrs.1997.3782). It's also present in some microorganisms. It's used in the production of ubiquinone, which is a type of antioxidant, and it has also estrogenic activity. It's a white crystalline solid that has a nutty and phenolic taste, it's slightly soluble in water and more soluble in polar solvents like alcohols and acetone. It's commonly used as a food additive, and it is generally considered safe.		
Implications of low value	4-Hydroxybenzoic acid is a metabolite that is produced during the breakdown of certain compounds in the body, but it is not clear what impact low levels of this metabolite would have on human health (DOI: 10.1093/jn/133.6.1806). More research is needed to determine the significance of low levels of 4-hydroxybenzoic acid.		
Implication of High Value	4-hydroxybenzoic acid is a common metabolic intermediate, but its levels in the human body are not typically measured or monitored as a diagnostic tool (DOI: 10.1016/j.chroma.2009.07.058). In some cases, high levels of 4-hydroxybenzoic acid may indicate an increased exposure to or consumption of certain foods or substances that contain the acid, such as tea, coffee, wine, or certain fruits and vegetables.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
4-Hydroxyphenylpyruvic acid	**7117**	4384	8500
Description	4-Hydroxyphenylpyruvic acid (4-HPPA) is a product formed during the breakdown of the amino acid tyrosine in the body (DOI:10.1006/mgme.2000.3085). It can also be converted to a compound called homogentisic acid, which is involved in the formation of a pigment called ochronotic pigment. A deficiency in an enzyme called 4-hydroxyphenylpyruvic acid dioxygenase can lead to a disorder called tyrosinemia type III, which is characterized by elevated levels of tyrosine in the blood and the excretion of tyrosine derivatives in the urine. 4-HPPA can also be associated with phenylketonuria, another inborn error of metabolism. There are two different versions of HPPA, 4HPPA and 3HPPA, with 4HPPA being the most common. 4-HPPA is also found in certain types of bacteria.		
Implications of low value	Low levels of 4-Hydroxyphenylpyruvic acid have not been specifically associated with any particular health condition (DOI:10.1016/s0378-4347(96)00411-2).		
Implication of High Value	High levels of 4-Hydroxyphenylpyruvic acid (4-HPPA) have been associated with phenylketonuria (PKU), an inherited disorder in which the body is unable to process phenylalanine, an essential amino acid (DOI: 10.1021/acs.analchem.0c02008). When phenylalanine is not metabolized properly, it accumulates in the blood and is converted to 4-HPPA. Elevated levels of 4-HPPA can be detected in the urine and blood of individuals with PKU. Treatment for PKU involves a diet that is low in phenylalanine, which helps to control the levels of 4-HPPA in the body.		
4-Hydroxyproline	**3040**	2608	7923
Description	4-Hydroxyproline (Hydroxyproline or Hyp) is an amino acid that is mostly found in the protein collagen (DOI: 10.1016/0009- 8981(79)90216-x). It is created by a process that modifies proline. Hydroxyproline helps to keep collagen stable and is also found in a protein called elastin. It is a useful indicator for measuring the amount of collagen and/or gelatin in samples of tissue or biological fluids. Hydroxyproline is also associated with certain metabolic disorders. Trans-4-Hydroxy-L-proline is a biomarker for the consumption of processed meat.		
Implications of low value	A deficiency of vitamin C can also affect the formation of hydroxyproline (DOI: 10.1248/bpb.23.101).		
Implication of High Value	Increased levels of hydroxyproline have been found in certain diseases and conditions such as Paget's disease, muscle damage, depression, stress and Alzheimer's disease (DOI: 10.1080/15438627.2011.608046).		
5-Aminolevulinic acid	**1471**	2490	8716
Description	5-Aminolevulinic acid is a chemical compound found in all living organisms (DOI: 10.1021/acs.analchem.0c02008). It is involved in a metabolic process and can be produced from other substances in the body. It can also be found in small amounts in certain foods such as fish, berries, and some plants. It's also used in medical treatment in combination with light therapy to treat skin conditions.		
Implications of low value	Low levels of 5-aminolevulinic acid (ALA) have not been consistently linked to any specific medical condition or disease (DOI:10.1539/joh.45.209). ALA is a natural substance in the body that is involved in the synthesis of heme, which is a component of hemoglobin. Low levels of ALA may be seen in individuals with vitamin B6 or iron deficiency, but more research is needed to establish a clear link.		
Implication of High Value	High levels of 5-aminolevulinic acid (ALA) have been associated with various diseases and conditions, including: 1. Porphyrias: ALA is the first intermediate in the biosynthesis of heme, the iron-containing molecule in hemoglobin. Elevated levels of ALA can lead to the overproduction of porphyrins and cause porphyria, a group of inherited metabolic disorders. 2. Lead toxicity: Lead exposure can increase ALA levels by disrupting the heme biosynthesis pathway. 3. Certain cancers: Elevated ALA levels have been observed in some types of cancer, such as prostate and bladder cancer, although the significance of this association is not well understood. 4. Acute intermittent porphyria (AIP): AIP is a genetic disorder that can cause elevated ALA levels during an attack.It's important to note that the presence of high levels of ALA in the body does not necessarily indicate the presence of a disease, as other factors, such as diet, medications, and alcohol consumption, can also affect ALA levels (DOI: 10.1046/j.1464-410x.2003.04182.x).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Adenine	**3638**	3764	6776
Description	Adenine is a chemical compound that belongs to a class of compounds called 6-aminopurines (DOI:10.1021/acs.analchem.0c02008). It is a building block of a compound called adenosine and a modified form called adenosine triphosphate (ATP) which is important in energy transfer within cells. It is found in all living species, and it can be used to help identify certain heart conditions. It is also involved in the metabolism of a nutrient called riboflavin and it's a component of certain coenzymes. Adenine is one of four nitrogenous bases that make up the structure of nucleic acids. It's important to note that high amount of adenine can be toxic.		
Implications of low value	It is a chemical compound present in DNA and RNA and it is not associated with any diseases or metabolic disorders (DOI:10.1007/BF00965000).		
Implication of High Value	As a purine base, adenine it not typically found in a metabolomics panel (DOI: 10.1007/BF00965000). Since we have it confirmed in ours, we can say that high levels of adenine are a sign low DNA synthesis and repair.		
Adenosine	**8943**	2274	8224
Description	Adenosine is a compound composed of adenine and a sugar called D-ribose (DOI: 10.1016/s0378-4347(00)80367-9). It plays many important roles in the body, such as being a component of DNA and RNA, as well as being involved in energy transfer as adenosine triphosphate (ATP) and adenosine diphosphate (ADP). It also plays a role in signaling, acting as a neurotransmitter and blood vessel widener. It is a precursor of deoxyadenosine which is linked to an increase in S-adenosylhomocysteine, which can cause toxicity to immature lymphocytes.		
Implications of low value	Low levels of adenosine in the body can be associated with a number of conditions, including: Deficiencies in the enzymes involved in the production of adenosine, such as adenosine kinase or adenosine deaminase. Decreased availability of the precursors needed to produce adenosine, such as adenine or adenosine triphosphate (ATP). Increased consumption of adenosine by cells or tissues, as can occur in certain inflammatory conditions. Genetic disorders that affect the metabolism of adenosine, such as adenosine deaminase deficiency (DOI: 10.1016/s0378-4347(00)80367-9).		
Implication of High Value	High levels of adenosine can be used as a medication, but they can lead to symptoms such as chest pain, feeling faint, shortness of breath, and tingling of the senses, along with serious side effects (DOI: 10.1016/s0378-4347(00)84113-4). In high levels, it can be harmful to the immune system and interfere with DNA synthesis, affecting the proper function of immune cells.		
alpha-Hydroxyisobutyric acid	**1330**	4280	7924
Description	alpha-Hydroxyisobutyric acid is a chemical substance produced when the body breaks down methyl tert-butyl ether (MTBE), which is found in some fuels and air pollution (DOI: 10.1371/journal.pone.0016957). It can be found in the body of people exposed to high levels of MTBE. The body quickly gets rid of MTBE, mostly through breathing out, and converts it into other substances like formaldehyde and t-butyl alcohol. alpha-Hydroxyisobutyric acid is also used as an aerial bactericide.		
Implications of low value	The health implications of low levels of alpha-hydroxyisobutyric acid in humans are not well established in the scientific literature (DOI: 10.1007/BF00711898). This metabolite is not commonly studied, and its biological significance is not well understood.		
Implication of High Value	High levels of alpha-hydroxyisobutyric acid are not commonly measured or studied in clinical settings, and its role in human health is not well understood (DOI: 10.1155/2015/183624). More research is needed to determine the health effects of elevated levels of this metabolite.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
alpha-Lactose	**1336**	3846	6790
Description	Lactose is a sugar found in milk, serving as the main energy source for newborn mammals and regulating lactation (DOI: 10.1051/rnd:2002012). Many adult mammals cannot digest lactose properly, leading to lactose intolerance, which is common in many people, especially in certain ethnic groups. Symptoms include stomach pain, bloating, and diarrhea. This condition can be managed by avoiding lactose-containing foods or taking lactase enzyme supplements. People with lactose intolerance should also ensure adequate calcium intake.		
Implications of low value	There are no specific health conditions directly associated with low levels of alpha-lactose (DOI: 10.1046/j.1365-2036.2002.01321.x). As a type of sugar present in milk, it serves as an energy source, but the health effects of low levels are not well documented.		
Implication of High Value	High levels of alpha-lactose are generally linked to increased intake or production of milk and dairy products (DOI: 10.1093/oxfordjournals.jbchem.a124560). It could also indicate lactose intolerance or malabsorption. In some cases, it might suggest an underlying metabolic disorder or a side effect of certain medications like antibiotics.		
alpha-Linolenic acid	**9741**	2540	6378
Description	alpha-Linolenic acid (ALA) is an essential fatty acid important for health (DOI: 10.1007/s11745-006-5014-9). Found in foods like nuts and vegetable oils, ALA, an omega-3 fatty acid, plays a role in maintaining cell membrane structure and function. It may help regulate genes that control metabolism and inflammation. It is an essential nutrient that must be obtained through diet and is associated with isovaleric acidemia.		
Implications of low value	Low levels of alpha-linolenic acid (ALA) are associated with increased risk of cardiovascular disease, neurodegenerative disorders, and certain cancers (DOI: 10.1007/s11745-006-5014-9). ALA is essential and must be obtained from the diet. Low levels may also lead to poor skin and hair health and increased risk of depression and anxiety. Adequate ALA intake can be achieved through sources like flaxseeds, chia seeds, walnuts, and soybeans.		
Implication of High Value	High levels of alpha-linolenic acid (ALA) in the blood are not specifically associated with medical conditions (DOI: 10.1007/s11745-006-5014-9). ALA is important for overall health, found in foods like flaxseeds and walnuts. High levels can occur due to increased dietary intake or supplementation, rather than due to specific health conditions.		
alpha-Tocopherol	**2080**	2980	7522
Description	Vitamin E, a powerful antioxidant found in foods like vegetable oils, nuts, and seeds, is present as alpha-Tocopherol in humans (DOI: 10.1016/j.jada.2008.11.033). It is measured in international units (IU) and was traditionally assessed by its ability to prevent spontaneous abortions in rats. There are eight forms of vitamin E, including tocopherols and tocotrienols. Good sources include vegetable oils, nuts, and seeds.		
Implications of low value	Low levels of alpha-tocopherol (vitamin E) are linked to increased oxidative stress, cardiovascular disease risk, cognitive decline, and age-related macular degeneration (DOI: 10.1016/j.jada.2008.11.033). Low levels of this form of vitamin E might differ from overall vitamin E deficiency, and further research is needed to understand its specific health impacts.		
Implication of High Value	High levels of alpha-tocopherol are associated with higher intake from dietary sources and supplements (DOI: 10.1093/jn/134.4.927). Elevated levels do not necessarily indicate adverse health outcomes, but further research is needed to clarify the relationship between high alpha-tocopherol levels and health effects.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Aminocaproic acid	**4243**	4544	7898
Description	Aminocaproic acid is a medication used to stop bleeding caused by certain conditions (DOI: 10.1016/0091-6749(85)90773-0). It works by preventing the breakdown of blood clots and is derived from lysine. It is used to treat bleeding disorders and is sold under the brand name Amicar.		
Implications of low value	Low levels of aminocaproic acid may indicate a deficiency or decreased effectiveness in treating excessive bleeding (DOI: 10.3109/00016489609137846).		
Implication of High Value	High levels of aminocaproic acid can be associated with recent use of the drug and may cause side effects such as nausea, vomiting, diarrhea, and headache (DOI: 10.3109/00016489609137846).		
beta-Alanine	**7130**	3482	6642
Description	beta-Alanine is a naturally occurring amino acid used to produce compounds like carnosine, anserine, and pantothenic acid (DOI: 10.1016/j.nutres.2006.03.002). It is commonly used as a dietary supplement to improve exercise performance and endurance. It is found in foods like chicken and beef and is considered important for muscle function and overall health.		
Implications of low value	Low levels of beta-alanine can affect exercise performance and may be linked to conditions like beta-alanine deficiency syndrome (DOI: 10.1016/j.nutres.2006.03.002). This syndrome can lead to impaired muscle function and endurance.		
Implication of High Value	High levels of beta-alanine are typically associated with its supplementation and may cause side effects such as tingling or flushing (DOI: 10.1016/j.nutres.2006.03.002). Elevated levels are usually not associated with specific health conditions but may indicate excessive supplementation.		
Cadaverine	**3112**	3291	6830
Description	Cadaverine is a chemical found in dead animals and certain types of bacteria, which causes a bad smell (DOI: 10.1007/10_2016_34). It's made from the breakdown of a protein called lysine and is also found in small amounts in mammals, like urine and semen. In large amounts, cadaverine can be toxic.		
Implications of low value	Recent research has shown cadaverine to be a reliable indicator of biological age (DOI: 10.1007/s11357-023-00823-4). Cadaverine has been shown to be elevated in older individuals, and low levels may reflect slowed aging.		
Implication of High Value	High levels of cadaverine can be found in the urine of people with certain metabolic disorders (DOI: 10.1021/acs.analchem.0c02008).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Caffeine	**5681**	4247	6733
Description	Caffeine is a natural stimulant found in coffee, tea, and various other beverages (DOI: 10.1016/j.bbi.2009.03.003). It can enhance cognitive performance, mood, and physical performance by blocking adenosine receptors in the brain. It is commonly consumed worldwide and is also used in some medications to treat headaches and drowsiness.		
Implications of low value	Low levels of caffeine are not commonly studied, as it is usually associated with consumption (DOI: 10.1016/j.bbi.2009.03.003). However, low caffeine intake may be linked to reduced cognitive alertness and energy levels.		
Implication of High Value	High levels of caffeine can cause symptoms such as jitteriness, insomnia, rapid heartbeat, and digestive issues (DOI: 10.1016/j.bbi.2009.03.003). Long-term excessive intake may lead to dependence or other health issues, so moderation is advised.		
cis-Aconitic acid	**5674**	3380	5817
Description	cis-Aconitic acid is a compound that is found in many living organisms and it's a type of carboxylic acid that has three carboxyl groups (DOI: 10.1021/acs.analchem.0c02008). It can be found in highest concentration in cow's milk, but it is also found in other foods such as plantains, yams, horse radishes, sweet potatoes, and persimmons. In humans, it plays a role in the metabolic disorder and cancer pathway. It can also be used as a biomarker for the consumption of those foods. cis-Aconitic acid is considered a secondary metabolite and it plays a role as a defense or signaling molecule.		
Implications of low value	The measurement of cis-aconitic acid levels in blood is not a routine part of medical testing, and the information is not widely available (DOI: 10.1038/nature07762).		
Implication of High Value	cis-Aconitic acid is a tricarboxylic acid that is involved in the tricarboxylic acid cycle (TCA) and can be produced by the isomerization of isocitrate, which is a key step in the TCA cycle (DOI: 10.1515/CCLM.2003.248). High levels of cis-aconitic acid can be caused by a variety of factors, including genetic mutations, enzyme deficiencies, or certain metabolic disorders. In some cases, high levels of cis-aconitic acid can also be caused by certain medications or environmental toxins.		
Citric acid	**1122**	2497	7908
Description	Citric acid is a type of organic acid that can be found in all living organisms, from bacteria to plants to animals (DOI: 10.1073/pnas.1009219107). It's an important intermediate in the TCA cycle, which produces energy for all living organisms. Citric acid is found in citrus fruits and is used as a preservative and a sour taste in foods and drinks. It can also be used to remove limescale and as an anticoagulant but can cause intolerance in some people.		
Implications of low value	Low levels can be affected by factors such as genetics, lifestyle, and medication use (DOI: 10.1021/pr2006796).		
Implication of High Value	High levels of citrate in blood samples have been associated with metabolic disorders such as obesity and type 2 diabetes (DOI: 10.1046/j.1523-1755.1998.00891.x). Elevated levels of citrate have also been found in individuals with renal disease, as well as in some cancers, such as prostate cancer. It also can be related to high citrate diet or high citrate supplement intake.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Cyclic AMP	**3768**	2598	5919
Description	Cyclic AMP (cAMP) is a chemical compound found in all organisms and it plays a role in signaling within cells (DOI: 10.1111/j.1468-2982.2003.00712.x). It's synthesized from another compound called ATP by an enzyme called adenylate cyclase. cAMP works as a mediator, a kind of messenger, for several hormones and activates certain proteins, including some ion channels like the HCN channels. In the human body, cAMP plays a key role in intracellular regulation and helps to transfer the effects of hormones like adrenaline and glucagon into the cell.		
Implications of low value	Low levels of cyclic AMP (cAMP) have been associated with a number of conditions and diseases (DOI: 10.1111/j.1468-2982.2003.00712.x). cAMP is a signaling molecule that is involved in a wide range of cellular processes, including cell proliferation, differentiation, and survival. It is also involved in the regulation of various hormones and neurotransmitters. Low levels of cAMP have been associated with decreased insulin sensitivity, which can lead to diabetes. Additionally, low levels of cAMP have also been observed in some types of cancer, such as breast and colon cancer. This is because cAMP signaling plays a role in cell proliferation and differentiation, and low levels of cAMP can contribute to the uncontrolled cell growth that is characteristic of cancer. In addition, Low levels of cAMP can also be associated with certain inherited genetic disorders such as cAMP-dependent protein kinase deficiency, which can cause a wide range of symptoms such as developmental delays, muscle weakness, and growth failure. It's important to note that one single low level of cAMP doesn't necessarily imply any disease, it would need a thorough analysis with other markers and symptoms to have a more clear picture.		
Implication of High Value	High levels of cAMP can be found in certain medical conditions but it's also an important compound for many physiological processes such as heart and brain activity (DOI: 10.1513/pats.2306015).		
Cysteamine	**8648**	2482	7972
Description	Cysteamine is a chemical found in the body that is produced from the breakdown of a coenzyme called coenzyme A (DOI: 10.1074/jbc.M703089200). It helps form a chemical called hypotaurine, which is further converted to taurine. It is not greatly affected by diet. It is used to treat disorders related to the excretion of cystine and may also have potential as a treatment for Huntington's disease and as a radiation protective agent. It can be given through injection or orally.		
Implications of low value	Low levels of cysteamine in the blood have been associated with a genetic disorder called cystinuria, which is characterized by the abnormal excretion of the amino acid cystine in the urine, leading to the formation of kidney stones (DOI: 10.1021/acs.analchem.0c02008).		
Implication of High Value	Elevated levels of cysteamine can indicate recent or ongoing exposure to the chemical (DOI: 10.1074/jbc.M703089200). Cysteamine is a naturally occurring amino acid derivative that is used in a number of industrial applications, including the production of certain chemicals and as a component of some food additives and animal feed supplements.		
D-Mannose	**5456**	3378	6370
Description	D-Mannose is a type of sugar that is similar to glucose and can be found in small amounts in fruits and in the body (DOI: 10.1016/j.bbrc.2014.06.021). It is not essential, meaning it can be produced by the body and is not needed in the diet. It is found in plants, animals, and microbes. Mannose is mostly used as a nutritional supplement, called 'D-mannose,' to prevent urinary tract infections. It works by preventing bacteria from attaching to the urinary tract by binding to the bacteria instead of the urinary tract cells. It is consumed in sufficient amounts, absorbed quickly and excreted by the urinary tract.		
Implications of low value	Low levels of mannose in the blood may indicate a dysfunction in the metabolism of this sugar, which could result from various underlying conditions such as inherited genetic disorders, infections, or certain types of cancers (DOI: 10.1016/j.bbrc.2014.06.021).		
Implication of High Value	High mannose status might reflect overconsumption of some fruits and vegetables or excessive intake of dietary supplements (DOI: 10.1016/j.bbrc.2014.06.021).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
D-Ribose	**8188**	5016	8355
Description	D-Ribose is a natural sugar that is found in all living cells (DOI: 10.1007/s11932-007-0041-8). It is important because it is a component of DNA, RNA, ATP, ADP, and AMP. It can be found in small amounts in fruits, vegetables and Brewer's yeast, it is also a component of some dietary supplements and energy drinks. D-ribose helps in regenerating the level of adenine nucleotides, which helps in restoring the energy potential in muscles. It has been studied for its potential to improve exercise performance and has shown promising results in some studies.		
Implications of low value	Low levels of ribose in the blood are not associated with a specific condition or disease (DOI: 10.1086/383204). The concentration of ribose in the blood can be influenced by various factors such as dietary intake, metabolism, and overall health. It is not a commonly measured substance in routine blood tests.		
Implication of High Value	There is no established medical condition associated with elevated levels of ribose (DOI: 10.1086/383204). It is important to note that levels of ribose in the body can be influenced by a variety of factors, including dietary intake, metabolic processes, and overall health status.		
D-Ribose 5-phosphate	**5929**	1685	8692
Description	D-Ribose 5-phosphate is a type of sugar molecule called a pentose phosphate (DOI: 10.1021/acs.analchem.0c02008). It plays a role in a process called the pentose phosphate pathway in the body, which produces energy and helps in making DNA. It is found in all living organisms and can be made from other sugars in the body. It is also used in the purine metabolism pathway, which helps in the production of important compounds like DNA and RNA.		
Implications of low value	Information about the association of low levels of D-ribose 5-phosphate with any particular condition or disease state is currently lacking in the scientific literature (DOI: 10.1186/1742-4682-2-18). Further research is needed to determine if there is any such association.		
Implication of High Value	More research is needed in this area to determine any potential health implications of high levels of this substance (DOI: 10.1186/1742-4682-2-18).		
Deoxyadenosine	**2558**	3803	8148
Description	Deoxyadenosine is a component of DNA, it's missing an oxygen in the sugar component (DOI: 10.1016/s0378-4347(98)00402-2).		
Implications of low value	It is possible that low levels of deoxyadenosine may be related to certain health conditions or metabolic disorders, but further research is needed (DOI: 10.1007/BF00296762).		
Implication of High Value	High levels of it can harm the immune system and is associated with a genetic condition called ADA deficiency (DOI: 10.1007/978-1-4615-9140-5_69). This condition harms the immune system, making people vulnerable to serious infections. The symptoms include pneumonia, diarrhea, and skin rashes. Additionally, it can prevent cells from dividing and reproducing, causing difficulties in the growth and activity of important immune cells.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Diaminopimelic acid	**1718**	6229	8613
Description	Diaminopimelic acid (DAPA) is a type of amino acid found in the cell walls of certain types of bacteria, particularly in gram-negative bacteria (DOI: 10.1021/acs.analchem.0c02008). DAPA is a key component of the peptidoglycan, which makes up the cell wall of these bacteria. DAPA is also the attachment point for a protein called Braun's lipoprotein (BLP), which is found in the cell walls of gram-negative bacteria and helps to hold the cell wall together. DAPA may be found in human urine or feces due to the breakdown of certain types of gut bacteria.		
Implications of low value	Diamonipimelic acid is not a commonly studied compound and there is limited information available on its role in the human body (DOI: 10.1099/ijs.0.63282-0).		
Implication of High Value	This compound is not commonly measured in clinical settings and its role in human health is not well understood (DOI: 10.1016/0304-4165(81)90042-8).		
Dihydrouracil	**6609**	4943	6560
Description	Dihydrouracil is a chemical compound that is formed in the body from the breakdown of uracil (DOI: 10.1016/s1570-0232(02)00009-0). It is a part of a multi-step process that produces beta-alanine.		
Implications of low value	Dihydrouracil is a naturally occurring metabolite and its levels can be affected by a variety of factors such as genetics, diet, and lifestyle (DOI: 10.1016/s1570-0232(02)00009-0).		
Implication of High Value	High levels of dihydrouracil may be associated with a genetic disorder called dihydropyrimidinase deficiency which can cause neurological and gastrointestinal problems in some people, including intellectual disability, seizures, weak muscle tone, small head size, and autistic behaviors, as well as recurrent episodes of vomiting and stomach acid backflow (DOI: 10.1016/s1570-0232(02)00009-0).		
Ethanolamine	**7038**	2796	6324
Description	Ethanolamine is a liquid with a smell similar to ammonia (DOI: 10.1073/pnas.1809611115). It is used for buffering and preparing emulsions in the pharmaceutical industry and to regulate pH in cosmetics. Ethanolamine is a precursor for the production of phospholipids and other compounds that play a role in various physiological processes like seed germination, plant-pathogen interactions, chloroplast development and flowering. Ethanolamine is found in all living species and can be found in certain foods like cattails, mung beans, blackcurrants, white cabbages, and bilberries.		
Implications of low value	As far as we know, there are no established medical conditions that are specifically associated with low levels of ethanolamine (DOI: 10.1021/acs.analchem.0c02008). It is a naturally occurring compound that is involved in a variety of physiological processes in the body, but its exact role and the effects of changes in its levels are not well understood. However, low levels of ethanolamine can be an indication of malnutrition or a deficiency in certain nutrients.		
Implication of High Value	High levels of ethanolamine have been associated with certain conditions such as liver disease, cancer, and certain types of infections (DOI: 10.1023/a:1024255208563). Elevated levels of ethanolamine have also been observed in the brain of patients with Alzheimer's disease.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Ferulic acid	**7208**	4215	8716
Description	Ferulic acid is a naturally occurring chemical that is found in high levels in plant cell walls (DOI: 10.2741/2130). It is mostly found in seeds and leaves and is used as an antioxidant in food supplements. It can be found in high levels in wheat bran, sugar-beet pulp, corn kernel and other foods. It can be absorbed by the body and excreted through urine. It is often used as a nutritional approach to reduce oxidative damage in Alzheimer disease. Ferulic acid is also found in some microorganisms such as Pseudomonas and Saccharomyces.		
Implications of low value	Ferulic acid is a naturally occurring compound that is found in many foods, including fruits, vegetables, grains, and spices (DOI: 10.1016/0891-5849(92)90184-i). It is sometimes used as a dietary supplement and has been investigated for its potential health benefits, including antioxidant and anti-inflammatory effects. However, more research is needed to determine the effects of low levels of ferulic acid on human health.		
Implication of High Value	Ferulic acid is a naturally occurring organic compound found in a variety of plants, including cereals, coffee, and some fruits and vegetables (DOI: 10.1021/jf0351164). It is commonly used as a dietary supplement and is thought to have antioxidant properties, although more research is needed to determine the health effects of consuming high levels of ferulic acid.		
Fructose 6-phosphate	**2175**	2375	7448
Description	Fructose 6-phosphate (F6P) is a chemical compound found in all living organisms that is made from fructose and a phosphate group (DOI: 10.1038/nature07762). It is important in a metabolic process called glycolysis, which turns glucose into a chemical called pyruvic acid. This process also creates ATP and NADH. F6P can also be produced from other chemicals such as glucosamine 6-phosphate and can be converted into other compounds like glucosamine 6-phosphate.		
Implications of low value	Low levels of fructose 6-phosphate may be indicative of an underlying metabolic disorder or a deficiency of the enzymes involved in its metabolism (DOI: 10.1186/1742-4682-2-18). It may also occur due to a decreased intake of fructose or other sugars. In some cases, low levels of fructose 6-phosphate may also be a result of certain genetic conditions, such as fructose intolerance or glycogen storage diseases.		
Implication of High Value	The information regarding the association of high levels of fructose 6-phosphate with a specific medical condition or disease is limited (DOI: 10.1177/000456329202900507). Fructose 6-phosphate is a naturally occurring intermediate in carbohydrate metabolism and its levels are regulated by various enzymatic processes. An increase in the levels of fructose 6-phosphate may occur in certain metabolic disorders such as liver diseases or inborn errors of metabolism.		
Fumaric acid	**6872**	2516	6661
Description	Fumaric acid is a type of acid that is involved in a biological process called the Krebs cycle (DOI: 10.1007/BF00711898). It is created by the body and can be found in higher levels in cancerous tumors. It has been found to inhibit certain enzymes that may lead to the development of cancer. It can also be found in a fungus called Aspergillus.		
Implications of low value	It's difficult to give a specific answer about what low levels of fumaric acid might be associated with, as fumaric acid is a metabolite that can be involved in a number of different metabolic pathways and its levels can be influenced by a variety of factors (DOI: 10.1021/acs.analchem.0c02008). However, fumaric acid is an intermediate in the citric acid cycle, thus, low levels of fumaric acid could be associated with a deficiency in the enzymes involved in this cycle or a blockage in the citric acid cycle. Also, it could be associated with certain disease or condition like some genetic disorder, mutations or inborn errors of metabolism, kidney disease, and liver disease.		
Implication of High Value	High levels of fumaric acid have been linked to metabolic disorder (DOI: 10.1021/pr500443c).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
gamma-Aminobutyric acid	**4264**	3871	6562

Description	GABA (gamma-aminobutyric acid) is a chemical that is present in the nervous system and acts as a neurotransmitter to help inhibit nerve activity (DOI: 10.1046/j.1440-1681.1999.03151.x). It has a calming effect and helps regulate anxiety and seizures. It is found in all living organisms, including humans. There are three types of receptors that respond to GABA: GABA-A, GABA-B and GABA-C. These receptors are located on the surface of nerve cells and when activated they can change the nerve cell's activity which can result in inhibition of neurotransmitter release. This inhibition can cause hyperpolarization which leads to nerve cell inhibition. The GABA-A receptor also has binding sites for benzodiazepines and barbiturates, and certain drugs that stimulate GABA-A receptors, such as benzodiazepines and barbiturates have calming and anti-seizure effects.
Implications of low value	GABA can be found deficient in many neurological disorders such as epilepsy, spasticity and hypertension (DOI: 10.1046/j.1440-1681.1999.03151.x).
Implication of High Value	High levels of GABA (gamma-aminobutyric acid) have been associated with several conditions and states, including: neurological disorders such as seizures, migraines, and Parkinson's disease, anxiety and depression, substance abuse and addiction, pregnancy, and certain types of tumors (DOI: 10.1046/j.1440-1681.1999.03151.x). Some studies have suggested that GABA supplementation may have a positive effect on mood and anxiety, however more research is needed to confirm the effectiveness and safety of GABA supplements.

Glucose 6-phosphate	**6815**	2949	5314

Description	Glucose 6-phosphate (G6P) is a sugar that is formed when glucose enters the cell and is immediately phosphorylated by the enzyme hexokinase (DOI: 10.1021/acs.analchem.0c02008). G6P can be used in two metabolic pathways, glycolysis and pentose phosphate pathway. It can also be stored as glycogen in the liver if there is an excess of glucose in the blood. G6P can also be converted to fructose 6-phosphate and then to fructose 1,6-bisphosphate, which is then used in the glycolysis process to produce energy. G6P can also be used to make glycogen, a form of glucose storage in the liver, which is activated by G6P but inhibited when there is high stress or low blood glucose levels.
Implications of low value	Low levels of glucose 6-phosphate can be associated with insulin resistance and type 2 diabetes, as well as liver and kidney disease (DOI: 10.1186/1742-4682-2-18). In some cases, low levels of glucose 6-phosphate can also result from decreased glucose intake or decreased glucose production by the liver. It can also occur as a result of an enzyme deficiency in the glucose 6-phosphate pathway, which is involved in the production of energy in the body. However, low levels of glucose 6-phosphate can also be due to normal variation.
Implication of High Value	High levels of glucose 6-phosphate are generally associated with increased glucose metabolism, particularly in the context of glycolysis, which is the metabolic pathway that breaks down glucose to generate energy (DOI: 10.1055/s-2003-39501). Elevated levels of glucose 6-phosphate can indicate an increase in insulin resistance or glucose intolerance, which can be a hallmark of conditions such as type 2 diabetes or metabolic syndrome. However, it is important to note that elevated levels of glucose 6-phosphate can have other causes as well, such as liver disease or certain types of tumors.

Glutaric acid	**6787**	2670	8330

Description	Glutaric acid is a chemical compound that is produced naturally in the body during the metabolism of some amino acids (DOI: 10.3171/ped.2007.106.3.222).
Implications of low value	Low levels of glutaric acid have been associated with several health conditions and metabolic disorders, including: Mitochondrial disorders: Glutaric acid is a byproduct of several metabolic pathways, including those involved in energy production in the mitochondria. Low levels of glutaric acid have been associated with mitochondrial disorders, which can cause a wide range of symptoms, including muscle weakness, developmental delays, and seizures. Chronic fatigue syndrome (CFS): Low levels of glutaric acid have been found in some patients with CFS, although the significance of this finding is not yet clear. It is important to note that low levels of glutaric acid in the blood can also be a result of normal metabolic processes and are not always indicative of an underlying health condition (DOI: 10.1023/B:BOLI.0000045775.03183.48).
Implication of High Value	High levels of this acid can cause health problems and is associated with certain metabolic disorders (DOI: 10.1016/j.enzmictec.2018.07.002). These disorders can cause symptoms such as brain damage, large head size, weak muscle tone, and seizures. Treatment for these disorders typically involves limiting certain types of food and supplementing with carnitine. High levels are also associated with glutaric acidemia type I (GA1), a rare genetic disorder that results from a deficiency of the enzyme glutaryl-CoA dehydrogenase, which is responsible for breaking down glutaric acid. As a result, glutaric acid accumulates in the body and can cause damage to the brain and other organs.

Metabolite	Relative Abundance (RA)	Low RA	High RA
Glutathione	**7107**	3457	6886
Description	Glutathione is a natural compound found in the body that helps with detoxifying chemicals and protecting cells from damage (DOI: 10.1161/01.cir.100.22.2244). It is made from the amino acid cysteine and is present in all living organisms. It has many roles including working as an antioxidant, being a coenzyme in various enzymatic reactions, and helping with blood cell formation and the immune system. It is also used in medical treatments such as preventing oxygen toxicity, treating heavy metal poisoning, and reversing cataracts. It can also help in detoxifying a toxic by-product of metabolism called methylglyoxal.		
Implications of low value	It is often depleted by overdose of certain medication (DOI: 10.1161/01.cir.100.22.2244). In such cases, N-acetylcysteine can be administered to renew the usable amount of glutathione in the body.		
Implication of High Value	High levels of glutathione can be associated with a variety of conditions and situations (DOI: 10.1016/s0006-291x(75)80062-3). Glutathione is an antioxidant that is naturally produced in the body and plays a role in protecting cells from damage. High levels of glutathione can be seen in individuals with a diet rich in fruits and vegetables, which are sources of glutathione precursors. High levels of glutathione can also be seen in individuals who take supplements that increase glutathione levels, such as N-acetylcysteine (NAC) or glutathione. High levels of glutathione can also be seen in certain disease states, such as cancer, where cancer cells may have increased levels of glutathione to protect themselves from the toxic effects of chemotherapy. High levels of glutathione can also be seen in individuals who are exposed to toxins or pollutants, as the body may increase its production to counteract the effects.		
Glycerol	**6650**	4646	8021
Description	Glycerol, also known as glycerin, is a sweet-tasting and mostly non-toxic liquid that is commonly used in food and medicine (DOI: 10.1021/pr2006796). It is an important component of fats and oils in the body. When the body uses stored fat for energy, glycerol and fatty acids are released and the glycerol can be converted into glucose for cellular energy.		
Implications of low value	Low levels of glycerol can be associated with a variety of conditions, depending on the context (DOI: 10.1021/acs.analchem.0c02008). In the context of metabolism, low levels of glycerol can be seen in certain genetic disorders, such as glycerol kinase deficiency, and in other conditions that affect the body's ability to produce or process this compound. Low levels of glycerol can also be seen in conditions that lead to dehydration, such as severe diarrhea or burns. However, it's important to note that low levels of glycerol in the blood can also be seen in a healthy person who has fasted or is dehydrated. In such cases, it would be important to look at other metabolic markers and the clinical context to make any conclusions.		
Implication of High Value	High levels of glycerol in the blood over a long period of time is associated with a condition called hyperglycerolemia, which can cause acidosis, development delay and kidney, liver and heart problems (DOI: 10.1152/ajpendo.00294.2001). The severe form of this condition is called glycerol kinase deficiency (GKD) and symptoms vary in severity among infants, children and adults.		
Glycine	**8852**	3675	6277
Description	Glycine is an amino acid found in all living organisms (DOI: 10.1007/s10545-005-0033-x). It is used in the biosynthesis of proteins and helps in the production of DNA, hemoglobin, and collagen. It also plays a role in the release of energy in the body. It's often used in skin care products as it can penetrate skin. It's also an inhibitory neurotransmitter in the central nervous system.		
Implications of low value	Low levels of glycine can be associated with various conditions, depending on the context in which the measurement is taken (DOI: 10.1371/journal.pone.0016957). In general, low levels of glycine may indicate a deficiency or imbalance in the metabolism of this amino acid. For example, low levels of glycine have been observed in individuals with inborn errors of metabolism such as nonketotic hyperglycinemia, a rare genetic disorder that affects the metabolism of glycine. Low levels of glycine have also been observed in individuals with liver disease and in individuals with certain types of cancer, such as lung cancer. Additionally, low levels of glycine have been observed in individuals with certain types of kidney disease, such as nephrotic syndrome.		
Implication of High Value	Deficiency of enzyme activity can lead to increased glycine in plasma, urine, and cerebrospinal fluid (DOI: 10.1007/s10545-010-9249-5). High levels of glycine in combination with a deficiency of the enzyme can lead to nonketotic hyperglycinemia.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Glycolic acid	**8805**	2841	7831
Description	Glycolic acid is a type of acid used in skin care products to improve the appearance of the skin (DOI: 10.1271/bbb.65.2265). It can reduce wrinkles, acne scarring, and dark spots on the skin. It works by breaking down the bonds that hold dead skin cells together, allowing the outer layer of skin to be removed revealing the new skin. It can be applied as a chemical peel and can also inhibit the formation of skin pigmentation. High doses of glycolic acid can cause irritation and if consumed orally, it can damage the kidneys and lead to respiratory, thymus and liver damage. It can be found in some foods and can be produced by certain microorganisms.		
Implications of low value	There is limited information on the normal levels of glycolic acid in the blood (DOI: 10.1016/j.copbio.2015.08.022). Some studies have measured glycolic acid levels in the blood as a marker of glycolysis, which is a metabolic pathway that converts glucose into energy. However, the normal levels of glycolic acid in the blood may vary depending on factors such as age, health status, and diet. To our knowledge, there is no information suggesting that low levels of glycolic acid in the blood are associated with any specific health conditions.		
Implication of High Value	High levels of glycolic acid in the body could be due to excessive use of skincare products containing glycolic acid, or from occupational exposure in the manufacturing of such products (DOI: 10.1139/m55-059).		
Guanosine	**7770**	1827	7747
Description	Guanosine is a chemical compound found in all living organisms (DOI: 10.3390/cells8121630). It is a component of RNA and is involved in intracellular signal transduction. It also has neuroprotective effects and is used in the treatment of Parkinson's and Alzheimer's diseases. It also prevents the damage due to reactive oxygen species (ROS).		
Implications of low value	It is difficult to say for certain what specific conditions or diseases may be associated with low levels of guanosine, as it is a nucleoside that is found in many types of cells and plays a role in various cellular processes (DOI: 10.14336/AD.2016.0208). Guanosine is a building block of RNA, and low levels of guanosine in certain types of RNA could lead to issues in protein synthesis, which could affect the function of many different organ systems.		
Implication of High Value	High levels of guanosine in the blood or urine are not typically associated with any specific medical condition or disease (DOI: 10.14336/AD.2016.0208). Guanosine is a naturally occurring purine nucleoside that is involved in various cellular processes. The levels of guanosine in the blood and urine can vary depending on various factors, such as diet, drugs, and medical conditions. In some cases, high levels of guanosine may be seen in individuals with certain genetic disorders that affect purine metabolism.		
Histamine	**7152**	4956	8948
Description	Histamine is a chemical found in certain foods and produced by the body (DOI: 10.4315/0362-028x-69.10.2509). It can cause symptoms such as stomach upset, constriction of airways, and increased blood flow. It is found in small amounts in some foods like spinach and oats, and large amounts of histamine in food can cause allergies in some people. Histamine has also been found in certain bacteria.		
Implications of low value	Low levels of histamine are associated with a condition called histamine deficiency, which can result in symptoms such as fatigue, depression, poor appetite, and poor sleep (DOI: 10.1021/acs.analchem.0c02008). However, this condition is relatively rare, and most often low histamine levels are seen in combination with other health problems. Other causes of low histamine levels include some medications, such as H1-antihistamines and certain antidepressants, and certain medical conditions, such as anemia or liver disease.		
Implication of High Value	High levels of histamine in the blood, also known as histamine intolerance or histaminemia, can be associated with several conditions (DOI: 10.1136/jcp.44.3.243). The most common causes of elevated histamine levels are an allergic reaction, an infection, and the consumption of certain foods that are high in histamine or that trigger the release of histamine in the body. Other potential causes of high histamine levels include: Histamine N-methyltransferase (HNMT) deficiency, a genetic condition that affects the body's ability to break down histamine. Mast cell activation syndrome (MCAS), a condition in which mast cells release too much histamine and other chemicals in response to triggers such as stress, heat, or cold. Chronic autoimmune disorders such as systemic lupus erythematosus (SLE). High histamine levels can cause symptoms such as skin redness, itching, hives, flushing, low blood pressure, stomach pain, diarrhea, and difficulty breathing. The severity of symptoms can vary depending on the cause and individual factors.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Homocarnosine	**7550**	2401	6893
Description	Homocarnosine is a normal chemical found in the human brain, made of two amino acids, GABA and histidine (DOI: 10.1111/j.1600-0404.1976.tb04348.x). It is found in higher levels in some inherited disorders and certain brain conditions, like familial spastic paraplegia and certain tumors. It is also found to increase in brain tissue after injury or trauma.		
Implications of low value	There is limited information available on the health implications of low levels of homocarnosine (DOI: 10.1111/j.1600-0404.1977.tb05636.x). Further research is needed to determine what low levels of homocarnosine may be associated with in humans.		
Implication of High Value	Homocarnosine is a naturally occurring dipeptide composed of beta-alanine and histidine (DOI: 10.1007/BF00965207). It has been detected in various tissues, including the brain, but its function is not well understood. Further research is needed to determine the potential health implications of elevated levels of homocarnosine.		
Hypotaurine	**6654**	5174	6495
Description	Hypotaurine is a compound found in all living organisms (DOI: 10.1038/nature07762). It is a sulfinic acid and is made in the body from the amino acid cysteamine. It plays a role in the metabolism of taurine and hypotaurine.		
Implications of low value	Lowered levels of hypotaurine are implicated in reduced metabolism of taurine, dysregulation of oxidative stress pathways, and the reduced modulation of the immune system (DOI: 10.1023/b:nere.0000010437.81860.d5).		
Implication of High Value	Hypotaurine is a naturally occurring amino acid derivative, and information on its levels in the human body is limited (DOI: 10.1023/b:nere.0000010439.99991.cf). Research is ongoing.		
Hypoxanthine	**2681**	3236	9006
Description	Hypoxanthine is a type of chemical called a purine, which is found in all living things, from bacteria to humans (DOI: 10.1002/art.11058). It is involved in the metabolism of other chemicals like adenosine and in the formation of nucleic acids. It can be found in small amounts in some foods, and it can be made in the body in several different ways. It's also a product of a metabolic disorder called purine nucleoside phosphorylase deficiency, which can cause recurrent infections, neurologic symptoms and autoimmune disorders.		
Implications of low value	Low levels of hypoxanthine have not been associated with any specific disease or health condition (DOI: 10.1021/acs.analchem.0c02008). Hypoxanthine is a purine derivative that is produced as a breakdown product of adenosine monophosphate (AMP) and is further metabolized to xanthine and then to uric acid. In healthy individuals, hypoxanthine levels are typically low in blood and urine.		
Implication of High Value	It is important to note that high levels of hypoxanthine can be associated with some genetic disorders such as Lesch-Nyhan syndrome, but also with some environmental factors such as high purine diet, alcohol consumption or smoking (DOI: 10.1681/ASN.2011121175). In some disease states, such as gout and kidney disease, hypoxanthine levels may be elevated.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Ibuprofen	**4556**	2505	7566
Description	Ibuprofen is a medication used to relieve pain, reduce fever, and reduce inflammation (DOI: 10.1021/acs.analchem.0c02008). It is commonly known by brand names such as Advil and Motrin. It works by blocking the production of certain chemicals in the body that cause inflammation and pain. It is available over the counter and commonly used for headaches, muscle aches, menstrual cramps and fever. It may also have some side effects such as stomach pain or bleeding.		
Implications of low value	Low levels of ibuprofen are not associated with any specific health condition or state (DOI: 10.1016/0378-4347(93)80229-w). Ibuprofen is a commonly used over-the-counter pain reliever and anti-inflammatory drug, and the levels of ibuprofen in the blood are typically low when it has been metabolized and eliminated from the body after use. In general, low levels of ibuprofen in the blood are not a cause for concern, but a doctor should be consulted if an individual is experiencing symptoms that they suspect may be related to their ibuprofen use.		
Implication of High Value	High levels of ibuprofen in the blood are associated with toxicity due to overdose or prolonged use (DOI: 10.1016/j.jconrel.2004.06.005). Signs and symptoms of ibuprofen toxicity include nausea, vomiting, abdominal pain, dizziness, headache, tinnitus, hearing loss, and ringing in the ears. In severe cases, ibuprofen toxicity can lead to complications such as kidney failure, low blood pressure, and damage to the digestive system. If you think you may have taken an overdose of ibuprofen, it is important to seek medical attention immediately.		
Indoleacetic acid	**6781**	5022	9247
Description	Indoleacetic acid (IAA) is a compound that is produced by the breakdown of tryptophan and is commonly found in bacteria in the gut (DOI: 10.1086/341914). IAA is also found in small amounts in some mammal tissues and is known as a plant hormone that helps in growth and development. It has also been identified as a uremic toxin and it has potential applications in cancer therapy.		
Implications of low value	In animals and humans, IAA can be found at very low levels and its role is not well understood (DOI: 10.1086/341914). Some studies have suggested that it may have an effect on the immune system and may be involved in some physiological processes, but more research is needed to fully understand its role.		
Implication of High Value	Elevated levels of IAA have been found in the urine of some patients with a genetic disorder called phenylketonuria (DOI: 10.1094/MPMI-20-6-0619).		
Inosine	**5661**	2714	5432
Description	Inosine is a compound that is found in all living species, including humans (DOI: 10.1038/sj.sc.3101878). It is an intermediate in the breakdown of purines and nucleosides to uric acid, as well as being an intermediate in the purine salvage pathway. It plays a role in the translation of genetic code in certain transfer RNA molecules and has potential benefits in certain conditions like spinal cord injury, stroke and multiple sclerosis. It is found in gut bacteria and has some benefits in regulating immune response and gut barrier function. Inosine can also be used as a feed stimulant for farmed fish.		
Implications of low value	Inosine is a naturally occurring purine nucleoside, and it plays a role in the metabolism of nucleotides, which are the building blocks of DNA and RNA (DOI: 10.1073/pnas.132076299). It is also involved in the production of adenosine triphosphate (ATP), which is the primary energy currency of cells. Low levels of inosine would be considered as normal physiological range, unless in a certain disease or pathological conditions.		
Implication of High Value	High levels of inosine are associated with several conditions and diseases, but they are not well understood and there is limited research on this subject (DOI: 10.1089/acm.2008.0513). Some studies have suggested that high levels of inosine may be associated with certain neurological disorders, such as multiple sclerosis and Alzheimer's disease, but more research is needed to confirm these findings. Additionally, high levels of inosine may be associated with the breakdown of purines, which are found in certain foods and can accumulate in the body in certain metabolic disorders such as gout and Lesch–Nyhan syndrome.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Isocitric acid	**1388**	5835	7673
Description	Isocitric acid, also known as isocitrate, is a type of organic acid that is involved in the citric acid cycle in the body (DOI: 10.1007/BF00711898). It is made from citrate and broken down into other compounds by an enzyme called aconitase. Isocitrate is also used in the food industry as a food additive and preservative. It is found in small amounts in fruits and vegetables, and its ratio to other acids can indicate whether juice has been tampered with or adulterated.		
Implications of low value	Low levels of isocitric acid may indicate an issue with the citric acid cycle, which is an important process in the body's metabolism of carbohydrates and fats (DOI: 10.1021/acs.analchem.0c02008).		
Implication of High Value	High levels of isocitric acid are typically associated with certain genetic disorders such as isocitrate dehydrogenase deficiency, which is a genetic disorder that affects the way the body metabolizes certain nutrients (DOI: 10.1007/BF00711898). Additionally, high levels of isocitrate acid may be seen in certain cancers, especially brain tumors and some cases of leukemia. Other conditions such as kidney and liver disease may also be associated with elevated levels of isocitric acid.		
Ketoleucine	**4762**	3292	6991
Description	Ketoleucine is a substance that comes from the incomplete breakdown of certain amino acids in the body (DOI: 10.1093/jn/135.6.1531S). It's harmful in high levels and is associated with a disease called maple syrup urine disease (MSUD). MSUD is a metabolic disorder caused by a deficiency of an enzyme that leads to a buildup of certain amino acids and their toxic by-products in the blood and urine. Symptoms of MSUD can lead to severe brain damage if not treated and may present at different ages depending on the severity of the disease. Untreated, it can lead to a variety of symptoms such as abnormal behavior, hallucinations, weight loss, seizures and coma.		
Implications of low value	Information on the health implications of low levels of this substance is not readily available (DOI: 10.1007/BF00711898).		
Implication of High Value	There is limited research available on this substance and its effects on human health (DOI: 10.1371/journal.pone.0158568). Further studies are needed to determine the health implications of high levels of ketoleucine in the blood.		
L-Alanine	**9893**	1768	7138
Description	Alanine is a type of amino acid found in all living organisms, used in protein synthesis (DOI: 10.1021/pr300459d). It is non-essential, synthesized from pyruvate or other amino acids, and is concentrated in muscle tissue. Alanine plays a role in glucose metabolism, energy production, and immune function. It is found in high-protein foods and helps dissolve kidney stones. Deficiencies in vitamin B6 can impact alanine metabolism.		
Implications of low value	Low levels of alanine may be associated with liver disease, malnutrition, or metabolic disorders (DOI: 10.1186/1750-1172-8-192). However, low levels can also occur in healthy individuals and may not always indicate a problem.		
Implication of High Value	High levels of alanine can be linked to liver disease, high-protein diets, or certain metabolic disorders such as maple syrup urine disease (DOI: 10.1021/acs.analchem.0c02008). Elevated levels may also be a normal response to stress or exercise.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Allothreonine	**1988**	3036	7861
Description	L-Allothreonine is a rare amino acid found in some plants and produced in small amounts in human diets (DOI: 10.1021/bi000032z). It is formed from the enzyme serine hydroxymethyltransferase 1 (SHMT), involved in converting serine and glycine.		
Implications of low value	Information on low levels of allothreonine is limited and not widely studied (DOI: 10.1021/ac991142i).		
Implication of High Value	There is limited research on the health effects of high levels of allothreonine (DOI: 10.1021/acs.analchem.9b02977). Further research is needed to understand its implications.		
L-Arabitol	**7286**	1919	3974
Description	L-Arabitol is a sugar alcohol found in various foods and biofluids such as urine and saliva (DOI: 10.1016/s1096-7192(02)00125-7). It is formed from arabinose or lyxose reduction and is associated with certain medical conditions, including Alzheimer's disease and metabolic disorders.		
Implications of low value	Low levels of arabitol may be linked to liver disease or genetic disorders, but more research is needed to establish a clear relationship (DOI: 10.1046/j.1523-1755.2003.00924.x).		
Implication of High Value	High levels of arabitol can indicate fungal infections, as it is a byproduct of fungal metabolism (DOI: 10.1086/383204). Elevated levels are often found in the urine of individuals with fungal infections, but dietary intake may also affect levels.		
L-Arginine	**5489**	2412	6553
Description	L-Arginine is an amino acid found in all organisms, used in protein synthesis and important for various physiological functions (DOI: 10.1093/ndt/17.3.413). It plays a role in N-linked glycosylation and is linked to acrylamide formation when foods containing asparagine are heated. The presence of asparagine can cause changes in urine odor.		
Implications of low value	Low levels of asparagine are not typically associated with specific conditions but may indicate dietary protein deficiencies or metabolic issues (DOI: 10.1021/acs.analchem.0c02008).		
Implication of High Value	High levels of asparagine may be related to liver disease, type 2 diabetes, and cancer, although the exact relationship is not well understood (DOI: 10.1016/s0899-9007(02)00780-3). Factors like diet, medications, and health conditions can influence asparagine levels.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Asparagine	**8867**	2146	8750
Description	Asparagine (Asn) is an amino acid that is found in all organisms and is used in the biosynthesis of proteins(DOI: 10.1093/ndt/17.3.413). It is not essential for humans, as it can be produced by the body from other substances. Asparagine is often found near the beginning and end of protein structures and also plays a role in N-linked glycosylation, a process that adds carbohydrates to proteins. Heating food at high temperatures can produce a chemical called acrylamide in food containing asparagine and sugar. Asparagine was first isolated from asparagus juice in 1806, which is where it gets its name from. Some people may have a different smell in their urine after consuming asparagus and it may be caused by a byproduct of asparagine metabolism, but this is debated among scientists.		
Implications of low value	Low levels of asparagine are not typically associated with a specific condition or disease (DOI: 10.1021/acs.analchem.0c02008). However, low levels of asparagine, along with other amino acids, may indicate a deficiency in dietary protein intake or an underlying health issue affecting the body's ability to absorb or metabolize nutrients.		
Implication of High Value	High levels of asparagine can be associated with various conditions, including liver disease, type 2 diabetes, and cancer (DOI:10.1016/s0899-9007(02)00780-3). However, the exact relationship between asparagine levels and these conditions is not well understood, and more research is needed to fully understand the role of asparagine in these diseases. Additionally, the levels of asparagine can also be affected by factors such as diet, medications, and medical conditions, so it is important to consider these factors when interpreting results.		
L-Aspartic acid	**4292**	3508	5757
Description	Aspartic acid, also known as L-aspartic acid or aspartate, is an amino acid found in all organisms (DOI: 10.1021/acs.analchem.0c02008). It is a nonessential amino acid which is derived from glutamic acid and is used in the biosynthesis of proteins. Aspartic acid acts as a neurotransmitter, is involved in the urea cycle, and helps in the production of energy. It's mostly found in oysters, luncheon meats, wild game, avocado, asparagus, young sugarcane and molasses from sugar beets. Some studies suggest that aspartic acid supplements can help with endurance, but more research is needed. It's also present in the artificial sweetener, aspartame.		
Implications of low value	People who suffer from depression or brain atrophy may have decreased levels of aspartic acid (DOI: 10.1016/s0022-3476(77)81312-7).		
Implication of High Value	Aspartic acid is also a excitatory neurotransmitter, and high levels of it in some cases can be associated with seizures and other neurological symptoms (DOI: 10.1371/journal.pone.0173615).		
L-Cystathionine	**4260**	3162	8182
Description	Cystathionine is a chemical made of two amino acids, serine and homocysteine (DOI: 10.1373/clinchem.2006.085241).		
Implications of low value	Low levels of cystathionine may signal disregulation in the transsulfuration pathway and homocysteine metabolism (DOI: 10.1073/pnas.0400658101).		
Implication of High Value	It's a byproduct of the breakdown of another compound, methionine (DOI: 10.1093/ajcn/80.6.1611). In cases where the body is unable to produce an enzyme called cystathionase, cystathionine can build up and cause cystathioninuria, a symptom of vitamin B6 deficiency. Cystathionine is present in small amounts in normal human blood and spinal fluid, but in high amounts in those with a genetic disorder called cystathionase deficiency, which can be treated with vitamin B-6 supplements.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Cysteine	**9452**	3228	7658
Description	Cysteine is an amino acid that is found in all living organisms (DOI: 10.1681/ASN.2011121175). It is a non-essential amino acid, but it may be essential for certain individuals. It is a sulfur-containing amino acid, and it is unique among the natural amino acids because it contains a thiol group which can undergo oxidation and reduction reactions. Cysteine is an important source of sulfur in human metabolism. It can be found in the antioxidant glutathione, and it is a structural component of many tissues and hormones. It has clinical uses such as treating baldness, psoriasis, and preventing smoker's hack. It may play a role in the future treatment of cobalt toxicity, diabetes, psychosis, cancer, and seizures.		
Implications of low value	Low levels of cysteine may be associated with a number of different health conditions, including malnutrition, liver disease, and certain genetic disorders that impair the body's ability to produce cysteine or other sulfur-containing amino acids (DOI: 10.1681/ASN.2011121175). Additionally, low levels of cysteine may be a consequence of various lifestyle factors, such as a diet that is low in protein, or a history of alcohol or substance abuse. However, further research is needed to fully understand the implications of low levels of cysteine in humans.		
Implication of High Value	Elevated levels of cysteine in the blood can be a sign of certain medical conditions (DOI: 10.1016/0003-2697(92)90456-h).		
L-Cystine	**5625**	2632	5186
Description	Cystine is a form of the amino acid cysteine which is formed by two cysteine molecules joined together by a bond (DOI: 10.1021/acs.analchem.0c02008). It's found in high concentrations in enzymes and cells related to the immune system, skin and hair, and connective tissues. It's important in maintaining healthy levels of an important antioxidant called glutathione, especially in cells like macrophages and astrocytes, as well as in lymphocytes and neurons.		
Implications of low value	Low levels of cystine, also known as L-cystine, are generally not associated with any specific condition or disease (DOI: 10.1038/mp.2011.131). However, cystine is a non-essential amino acid that can be synthesized in the body from the essential amino acid methionine. Therefore, low levels of cystine may be a result of a deficiency in methionine or a problem with the enzymes responsible for its synthesis. It's important to note that measuring levels of amino acids alone is generally not used to diagnose any specific condition.		
Implication of High Value	There are specific medical conditions that would cause an abnormal accumulation of cystine in the body though, in general, high levels are not an indicator of any disease (DOI: 10.1007/s10545-010-9134-2).		
L-Dopa	**8748**	4160	8316
Description	L-DOPA is an amino acid found naturally in plants and animals (DOI: 10.1021/acs.analchem.0c02008). It is used to make neurotransmitters like dopamine, norepinephrine, and epinephrine, which help control movement and other functions. L-DOPA is commonly used as a treatment for Parkinson's disease and other movement disorders. It is typically taken as a pill, often with a vitamin B6 supplement and a medication that prevents conversion to dopamine outside the brain. Side effects can include high blood pressure, nausea, and confusion. L-DOPA is also a precursor to melanin, which gives color to skin, hair, and eyes.		
Implications of low value	Low levels of L-DOPA, or levodopa, are associated with Parkinson's disease, a disorder affecting movement control due to dopamine deficiency. Therefore, low L-DOPA levels can indicate Parkinson's disease (DOI: 10.1007/s00726-006-0409-8).		
Implication of High Value	High levels of L-DOPA, or levodopa, can be associated with Parkinson's disease therapy, as L-DOPA is used to treat the symptoms of Parkinson's by converting into dopamine in the brain (DOI: 10.1124/jpet.103.049270). Elevated levels may reflect therapeutic use for Parkinson's disease.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Glutamic acid	**2552**	3517	5461
Description	Glutamic acid is an amino acid used in protein synthesis (DOI: 10.1086/427564). It is present in all living organisms and helps remove excess nitrogen from the body. Glutamic acid is a neurotransmitter involved in cognitive functions like learning and memory. Discovered in 1866 in wheat gluten, it is used as a food additive and flavor enhancer known for its umami taste.		
Implications of low value	Low glutamic acid levels can be associated with neurological conditions such as depression, anxiety, schizophrenia, and some forms of epilepsy (DOI: 10.1038/nature07762). Low levels may also be related to dietary deficiencies or liver disease.		
Implication of High Value	High levels of glutamic acid can be harmful and may lead to cell death (DOI: 10.1177/154405910208100613).		
L-Glutamine	**1714**	2734	8340
Description	Glutamine is an amino acid found in all living organisms (DOI: 10.1038/nature07762). It is used in protein biosynthesis and is similar to glutamic acid. The body can produce glutamine, and it is also found in foods such as meat, dairy, eggs, and vegetables. Although non-essential, it is used in sports supplements and to reduce complications in sickle cell disease. It aids in replenishing amino acids after exercise and may benefit gut health and recovery from surgeries, but more research is needed.		
Implications of low value	Low glutamine levels are associated with conditions such as starvation, trauma, intestinal disorders, chronic stress, malnutrition, chronic illness, and intense exercise. Low levels can lead to muscle wasting, decreased immune function, and impaired nitrogen balance (DOI: 10.1177/154405910208100613).		
Implication of High Value	High levels of glutamine can be linked to severe infections or injury, cancer, kidney disease, and medical treatments like chemotherapy and radiation therapy (DOI: 10.1177/154405910208100613).		
L-Histidine	**9446**	2727	8703
Description	Histidine, or L-histidine, is an essential amino acid found in all organisms (DOI: 10.1172/JCI108033). It features an imidazole functional group, enabling it to act as a ligand in metalloproteins and as a proton shuttle in enzymes. Histidine must be obtained from the diet as the body cannot produce it. It plays a role in synthesizing compounds like histamine and carnosine. It has been used in therapies for rheumatoid arthritis, chronic renal failure, and asthma. Histidine supplementation may reduce inflammation, insulin resistance, and oxidative stress.		
Implications of low value	Low levels of histidine can lead to anemia, skin rashes, and stunted growth (DOI: 10.1111/cea.12089). Histidine deficiency is rare in individuals with a balanced diet.		
Implication of High Value	High histidine levels are not typically associated with specific conditions but may indicate liver disease or certain genetic disorders affecting amino acid metabolism (DOI: 10.1111/cea.12089).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Histidinol	**8109**	4216	6383
Description	L-Histidinol is a compound found in living organisms and some foods like white mulberries, radish, guaranas, yardlong beans, and dates (doi: 10.1038/nature07762). It is used as a marker for the consumption of these foods, and it is a primary metabolite, meaning it is important for an organism's growth and development.		
Implications of low value	Histidinol is an amino alcohol that is formed from the breakdown of the amino acid histidine (DOI: 10.1038/nature07762). The role and significance of histidinol in human health is not well understood, and more research is needed to determine the effects of low levels of histidinol.		
Implication of High Value	High levels of histidinol in the blood or urine can be a sign of an underlying health condition, but the exact conditions or diseases associated with elevated histidinol levels can vary and may depend on other factors such as age, gender, overall health, and other medical conditions (DOI: 10.1016/S0278-5846(03)00018-6). In some cases, high levels of histidinol may be a result of a genetic disorder, liver disease, or an overactive metabolism of histidine, an essential amino acid. However, it's important to note that elevated histidinol levels can also be due to dietary factors or other non-health-related causes, so it's important to consult with a healthcare provider to determine the underlying cause and appropriate course of treatment, if necessary.		
L-Homoserine	**7444**	3087	7353
Description	Homoserine is a variant of the amino acid serine that has an additional CH2 group in its chemical structure (DOI:10.1038/nature07762). This makes it more reactive than regular serine and unable to be used in protein formation. It is abyproduct of certain chemical reactions and is not found in living organisms. It's also a byproduct of certain microorganisms' metabolism.		
Implications of low value	There are no known health associations with low levels of homoserine (DOI: 10.1016/0378-4347(91)80571-s).		
Implication of High Value	Homoserine is a non-essential amino acid that can be synthesized by the body and is used in a variety of metabolic processes (DOI: 10.1054/mehy.2001.1527). It is not typically measured in routine blood tests, and there is limited information available on the clinical significance of high levels in the body		
L-Isoleucine	**7989**	3382	7928
Description	Isoleucine is an amino acid that is needed for building proteins and is an essential amino acid for humans, meaning that it cannot be made by the body and must be obtained from the diet (DOI: 10.1038/nature07762). It is commonly found in organisms from bacteria to plants to animals. It is a non-polar and uncharged amino acid and is also part of a group of amino acids called branched chain amino acids (BCAA) which also include leucine and valine. These amino acids have different metabolic routes and deficiency symptoms and are decreased in people with liver diseases.		
Implications of low value	In general, low levels of essential amino acids can be a sign of malnutrition or a deficiency in the specific amino acid (DOI:10.1177/154405910208100613).		
Implication of High Value	High levels of isoleucine are also associated with insulin resistance and studies showed that mice fed an isoleucine-deprived diet had improved insulin sensitivity and decreased blood glucose levels (DOI: 10.1042/bj2170365).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Leucine	**1887**	2767	7925
Description	Leucine is an essential amino acid that the body can't make and must be obtained from the diet (DOI: 10.1038/nature07762).It's found in foods that contain protein such as meats, dairy products, soy products, beans and legumes. Leucine is a branched chain amino acid (BCAA) that is important for stress, energy and muscle metabolism. BCAA supplementation holds promise for treatment of human health and disease. Leucine is a ketogenic amino acid, meaning it can be converted into acetyl-CoA and acetoacetate. It can also stimulate muscle protein synthesis and activate the protein biosynthesis and cell growth regulator mTOR.		
Implications of low value	Deficiencies in BCAAs can cause neurological defects, muscle tremors, poor growth, weight loss, skin rashes, hair loss, and desquamation (DOI: 10.1042/bj2170365). Some inherited metabolic disorders can also be caused by BCAA deficiencies.These can be treated by dietary restrictions of BCAAs and supplementation of other amino acids.		
Implication of High Value	High levels of leucine have been associated with insulin resistance (DOI: 10.1111/j.1471-4159.1984.tb02756.x).		
L-Lysine	**1804**	2337	7320
Description	Lysine (Lys) is an amino acid that is found in all living organisms and is used in the making of proteins (DOI:10.1038/nature07762). Lysine is an essential amino acid, meaning the body cannot produce it and it must be obtained from the diet. Lysine is mostly found in foods like wheat germ, cottage cheese, chicken, wild game and pork, but is not found in most fruits and vegetables, except avocados. Lysine is required by the body for protein formation, collagen production, absorption of essential minerals and in the production of carnitine, which is important for fatty acid metabolism.		
Implications of low value	Lysine deficiency can lead to mental and physical retardation, immunity issues and may be beneficial in the treatment of osteoporosis (DOI: 10.1177/154405910208100613).		
Implication of High Value	Lysine is considered safe with no known toxicity and is currently not used in therapeutic doses, but its metabolites have shown therapeutic potential (doi: 10.1042/bj2170365).		
L-Methionine	**3101**	3692	6878
Description	Methionine (Met) is an amino acid that is essential for human growth and development (DOI: 10.1093/jn/136.6.1682S). It is not produced by the body, so it must be obtained from food sources. Methionine is used in protein synthesis and is involved in various chemical reactions in the body. It is also the precursor of another amino acid, cysteine. It can also exacerbate symptoms in individuals with schizophrenia.		
Implications of low value	Low levels of methionine, an essential amino acid, can be associated with malnutrition or deficiencies in essential vitamins and minerals that are required for methionine metabolism (DOI: 10.1093/jn/136.6.1694S). Methionine deficiency has been linked to stunted growth, skin and hair problems, and liver damage. In addition, low levels of methionine may be associated with certain medical conditions, such as homocystinuria, an inherited disorder that affects methionine metabolism.		
Implication of High Value	Methionine is safe to consume in moderate amounts, but high levels can lead to increased risk of cardiovascular disease and other health problems (DOI: 10.1093/jn/136.6.1722S). There are several inborn errors of metabolism that are associated with chronically high levels of methionine.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Norleucine	**5570**	2043	5848
Description	L-Norleucine is an amino acid that is used in research to study the structure and function of proteins. It is a hydrophobic molecule, meaning it does not mix well with water, and is found in small amounts in cow's milk. It can bind to a protein in the blood called plasminogen and block it from activating and breaking down blood clots. It is not a natural amino acid and not found in most food sources.		
Implications of low value	Low levels of norleucine in the blood may be associated with certain metabolic disorders or nutritional deficiencies, but more research is needed to determine the exact causes and physiological effects of low norleucine levels.		
Implication of High Value	Information about possible associations between high levels of norleucine and any particular health condition or disease state is currently not available. It is important to keep in mind that the levels of individual amino acids can be affected by many factors, including diet, medical conditions, medications, and more.		
L-Phenylalanine	**7532**	3262	6793
Description	Phenylalanine (Phe) is an amino acid found in all organisms (DOI: 10.1007/s10545-008-0946-2). It's important for making protein and other important chemicals in the body. It's also an essential amino acid, which means the body can't make it, so it must be gotten through diet. Phenylalanine is found in many high protein foods such as meat, cheese, and wheat germ. Some artificial sweeteners, such as aspartame, also contain phenylalanine. High levels of phenylalanine can be harmful and can exacerbate a few genetic disorders such as phenylketonuria. People with phenylketonuria should avoid foods high in phenylalanine. Additionally, high levels of phenylalanine in the blood can be seen in people with heart failure, infection or inflammation and are associated with poor outcomes in critically ill patients.		
Implications of low value	Low levels of phenylalanine can be associated with phenylketonuria (PKU), an inborn error of metabolism that affects the breakdown of phenylalanine (DOI: 10.1038/nchembio.1002). PKU is caused by a deficiency in the enzyme phenylalanine hydroxylase, which is responsible for converting phenylalanine to tyrosine. Individuals with PKU must maintain a low-phenylalanine diet to prevent the buildup of phenylalanine and its toxic by-products in the body.		
Implication of High Value	High levels of phenylalanine can be associated with phenylketonuria (PKU), a genetic disorder that results in the inability to properly metabolize phenylalanine (DOI: 10.1016/j.ijid.2019.05.030). PKU can lead to a buildup of phenylalanine in the blood, which can cause intellectual disability and other neurological problems. High levels of phenylalanine can also be associated with other genetic disorders, such as tyrosinemia, as well as with high protein diet. Additionally, some studies suggested that high levels of phenylalanine in blood could increase the risk of developing hypertension.		
L-Proline	**7008**	2629	7691
Description	Proline (Pro) is an amino acid that is commonly found in proteins (DOI: 10.1016/0006-8993(88)90358-7). It is not considered essential because the body can produce it from another amino acid called glutamic acid. It is important for proper function of joints and tendons, and it is a component of collagen. Proline can be obtained from food sources such as meats, wheat germ and cottage cheese.		
Implications of low value	Low levels of proline in the blood have been associated with various health conditions and deficiencies, including malnutrition, anemia, liver disease, and certain genetic disorders (DOI: 10.1038/nature07762). In some cases, low levels of proline can indicate that the body is not absorbing or utilizing this amino acid properly, which can lead to a variety of symptoms. However, more research is needed to determine the specific health implications of low proline levels in humans.		
Implication of High Value	High levels of proline in the blood are associated with certain metabolic disorders, which can cause seizures, intellectual disability or other neurological or psychiatric problems (DOI: 10.1177/154405910208100613).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Serine	**5072**	5083	8874
Description	Serine (Ser) or L-serine is an amino acid that is used in building proteins (DOI: 10.1042/BJ20021785). It is found in all organisms, and it is polar and uncharged at physiological pH. It is nonessential amino acid, meaning it can be made by the body and does not need to be obtained through the diet. However, in certain conditions, it becomes essential and important for maintaining health. There are four sources of L-serine: dietary intake, biosynthesis, from glycine, and protein and phospholipid degradation. It is important for the synthesis of purine nucleotides and deoxythymidine monophosphate and it also plays a role in brain development and function. Some patients with psychiatric disorders and neurological abnormalities have been found to have altered levels of serine and glycine and defects of L-serine synthesis.		
Implications of low value	Low levels of serine might be seen in certain metabolic disorders, malabsorption, malnourishment, or other conditions that affect the body's ability to absorb, transport, or metabolize this amino acid (DOI: 10.1093/nar/14.20.7839).		
Implication of High Value	The meaning of high levels of serine in the body is not well established and may depend on the context and the method of measurement (DOI: 10.1038/nature07762). Serine is an amino acid that is involved in many biological processes, including the synthesis of proteins, phospholipids, and other metabolites. High levels of serine in the blood or other bodily fluids could be a sign of various underlying medical conditions, but more information is needed to make a definitive interpretation. It's also important to note that abnormal levels of serine may not always be significant, and can be influenced by factors such as diet, hydration status, and medications.		
L-Threonine	**4948**	3540	7656
Description	Threonine (Thr) is an essential amino acid that the body cannot make on its own and must be obtained from food (DOI: 10.1203/00006450-199812000-00013). It's found in many proteins, and is found in foods like cottage cheese, poultry, fish, meat, lentils, and sesame seeds. Adult humans need about 20 mg/kg of body weight/day. It's a crucial component of the proteins in the body and can be modified through different processes, like O-linked glycosylation and phosphorylation. Excessive intake of threonine during infant feeding should be avoided as it can affect neurotransmitter balance and brain development during early postnatal life. The human body metabolizes threonine in different ways, in many animals it's converted to pyruvate and in humans it's converted to alpha-ketobutyrate.		
Implications of low value	Low levels of threonine are typically not associated with any specific medical conditions or diseases (DOI: 10.1038/nature07762). However, threonine is an essential amino acid, and a deficiency can result in decreased growth and protein synthesis in the body. In some cases, low levels of threonine may be indicative of malabsorption or a diet that is deficient in protein. It is also possible that low levels of threonine may occur as a result of chronic liver disease, as the liver is one of the main sites of threonine metabolism.		
Implication of High Value	High levels of threonine may indicate a diet high in protein or an overproduction of threonine in the body (doi: 10.1177/154405910208100613). In some cases, high levels may also be indicative of certain genetic disorders or liver disease.		
L-Tryptophan	**9741**	4661	9310
Description	Tryptophan (Trp) is an essential amino acid, meaning the body cannot make it, and it must be obtained from the diet (DOI: 10.1177/106002809102501116). It can be found in foods such as chocolate, oats, meat, eggs, and dairy. Tryptophan is important for the production of serotonin and melatonin, which regulate sleep and wakefulness. Tryptophan deficiency can cause conditions such as depression, pellagra, and Hartnup's disease. Tryptophan supplements may be used to treat Hartnup's disease. Eating a meal high in carbohydrates can also increase the amount of tryptophan in the bloodstream, leading to drowsiness.		
Implications of low value	Low levels of tryptophan in the blood have been associated with malnutrition, as tryptophan is an essential amino acid that cannot be synthesized by the body and must be obtained from the diet (DOI: 10.4137/IJTR.S26862). Low levels of tryptophan can also result from a diet that is low in protein or from an increase in the demand for tryptophan, such as during an infection. Additionally, low levels of tryptophan can be a result of liver disease, since the liver plays a role in the synthesis and metabolism of tryptophan.		
Implication of High Value	High levels of tryptophan in the blood are not commonly associated with any specific health conditions (DOI: 10.4137/IJTR.S26862). Tryptophan is an essential amino acid that is a building block of proteins, and is involved in the production of serotonin, a neurotransmitter that regulates mood and sleep, among other things. However, high levels of tryptophan are not usually seen in the blood, as tryptophan is rapidly metabolized in the body. In some cases, high levels of tryptophan in the blood may be indicative of a tryptophan-rich diet, but this is not typically associated with any specific health risks.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
L-Tyrosine	**7977**	2979	8840
Description	Tyrosine is an amino acid found in protein-rich food such as chicken, fish, and soy products (DOI: 10.1097/00000658-197809000-00017). It plays a role in the production of neurotransmitters and hormones, including dopamine, norepinephrine, epinephrine, and thyroid hormones. It is also a precursor for the human pigment, melanin. The body can make tyrosine from another amino acid called phenylalanine. Tyrosine can help with stress, but high levels may not be good for treating psychosis. It may be used as an adjunctive treatment for Parkinson's disease.		
Implications of low value	Low levels of tyrosine in the blood can be associated with protein malnutrition or other conditions that lead to inadequate dietary intake of tyrosine and other amino acids (DOI: 10.21037/jtd.2016.05.24). Tyrosine is an amino acid that is required for the production of neurotransmitters, including dopamine and norepinephrine, and low levels of tyrosine may lead to deficiencies in these neurotransmitters and related neurotransmitter systems. Low levels of tyrosine may also be associated with certain genetic disorders that affect tyrosine metabolism. However, it is important to note that blood tyrosine levels can be affected by a variety of factors, including stress, hormonal changes, and medications, and that low tyrosine levels alone may not provide a definitive diagnosis of a specific condition.		
Implication of High Value	High levels of tyrosine have been associated with certain genetic disorders, such as tyrosinemia and phenylketonuria (PKU), in which the body is unable to properly metabolize the amino acid (DOI: 10.1097/00000658-197809000-00017). High levels of tyrosine can also be a result of taking tyrosine supplements. Additionally, some studies suggest that high levels of tyrosine in the blood may be associated with certain types of cancer, such as ovarian cancer.		
L-Valine	**5665**	3233	5736
Description	Valine (Val) is an essential amino acid that the body cannot produce; it must be obtained from food sources like meats, dairy products, soy products, beans, and legumes (DOI: 10.1038/nrendo.2014.171). Valine is a non-polar, uncharged, aliphatic amino acid that is critical to human life and is particularly involved in stress, energy, and muscle metabolism. Valine is a branched-chain amino acid (BCAA) along with leucine and isoleucine; BCAA supplementation as therapy holds great promise in human health and disease. Valine deficiency is marked by neurological defects in the brain. Valine is associated with insulin resistance, and higher levels of valine are observed in the blood of diabetic mice, rats, and humans. Valine is also used in sickle-cell disease as a replacement for glutamic acid in hemoglobin.		
Implications of low value	Low levels of valine in the body can be a sign of malnutrition or liver disease, but this condition is generally rare and typically occurs as a result of other underlying health problems (DOI: 10.1016/j.metabol.2014.03.006). In some cases, low levels of valine can also be a side effect of certain medications or medical treatments. Low valine levels can lead to muscle wasting and fatigue, as valine is an essential amino acid that is required for muscle metabolism. In severe cases, low valine levels can lead to a condition known as valine deficiency, which can be life-threatening if left untreated.		
Implication of High Value	Elevated levels of valine in the blood can be associated with a variety of medical conditions, including liver disease, genetic disorders of amino acid metabolism, and in some cases, alcoholism (DOI: 10.1113/JP275075). However, it is important to note that elevated valine levels are not specific to any one condition and may not necessarily indicate the presence of a particular disease. In some cases, high levels of valine may simply be a result of dietary intake and do not indicate an underlying medical issue.		
Linoleic acid	**3825**	2708	6503
Description	Linoleic acid is a type of fat that can't be made by the body and is found in plant oils (DOI: 10.1038/nature07762). It's important for human nutrition and is used to make things like cell membranes and a type of hormone called prostaglandins.		
Implications of low value	Low levels of linoleic acid in the blood have been associated with an increased risk of cardiovascular disease, as well as with a higher prevalence of skin conditions such as atopic dermatitis (DOI: 10.1007/BF00711898). Linoleic acid is an essential fatty acid that is important for the maintenance of healthy skin, as well as for cardiovascular health, and it is not produced by the body and must be obtained from the diet. Low levels of linoleic acid may indicate a deficiency in the diet, which can be corrected by consuming foods rich in this fatty acid, such as seeds, nuts, and vegetable oils.		
Implication of High Value	High levels of linoleic acid can be associated with a metabolic disorder called isovaleric acidemia (DOI: 10.1016/0005-2760(94)90138-4).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Malic acid	**8760**	2691	9165
Description	Malic acid is a type of acid that gives food a sour or tart taste (DOI: 10.1038/nature07762). It's found in foods like apples and can make wine taste tart. It plays an important role in the production of energy in the body by being involved in the Krebs cycle,a process that takes place in the mitochondria. It helps remove reducing equivalents, which can help prevent energy production from being blocked. Studies on rats have shown that a deficiency of malic acid could cause physical exhaustion and that administering malic acid can help increase energy production. It is also found in some fungal species like Aspergillus.		
Implications of low value	Low levels of malic acid have not been associated with any specific disease or health condition (DOI: 10.1016/0378-4347(91)80571-s). However, malic acid is involved in the metabolic pathways that produce energy, so low levels of malic acid could potentially indicate a problem with these pathways.		
Implication of High Value	High levels of malic acid in the body could be due to a diet that is rich in fruits and vegetables, or due to the consumption of malic acid-containing food products (DOI: 10.1007/BF00164476). Additionally, malic acid is also a intermediate in the citric acid cycle, high level could indicate some kind of metabolic disorder.		
Malonic acid	**7067**	4675	6732
Description	Malonic acid is a type of organic compound which has two carboxylic acid groups (DOI: 10.1016/s1570-0232(03)00277-0).It is found in all living organisms, including humans, and is involved in certain enzymatic reactions in the human body. It is also found in certain foods such as beetroots, corn, and cow milk.		
Implications of low value	Low levels of malonic acid in the body have not been linked to any specific health conditions (DOI:10.1007/s004310050619). The normal range of malonic acid in the blood is not well established, and more research is needed to determine the clinical significance of low levels of this compound.		
Implication of High Value	High levels of malonic acid have been linked to some diseases and metabolic disorder (DOI: 10.1021/bc050103c).		
Maltotriose	**2418**	2835	6236
Description	Maltotriose is a trisaccharide, which is a 3-part sugar made up of three glucose molecules linked together (DOI:10.1007/BF02469510. It's produced when the enzyme alpha-amylase breaks down starch in the body, and it's commonly found in human urine after consuming maltose. It's an oligosaccharide, a class of carbohydrates made up of 3 to 10 monosaccharide units linked together.		
Implications of low value	LThere is no reliable research on what low levels of maltotriose specifically are associated with and blood tests to measure maltotriose levels are not commonly performed in clinical settings (DOI: 10.1016/s0926-6593(65)80101-1).		
Implication of High Value	Maltotriose is also found in increased levels in a metabolic disorder called glycogen storage disease II (DOI:10.1038/nature07762).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Mannitol	**6146**	3368	8288
Description	Mannitol is a sugar alcohol that is produced by some plants and is used as a sweetener, diuretic, and renal diagnostic aid in medicine (DOI: 10.1007/s00253-009-2086-5). It is found in nature in many organisms such as bacteria, fungi, and plants. It is used to treat oliguria and has been used to determine glomerular filtration rate. It is also used in cell biology studies to control osmolarity. Mannitol is not permeable to biological membranes, and it can cause a solution to become acidic. It is associated with some inborn errors of metabolism, and it is a microbial metabolite found in certain microorganisms.		
Implications of low value	Low levels of mannitol in the blood have not been widely studied and there is limited information available about the health implications of reduced levels of mannitol in humans (DOI: 10.1128/AEM.70.7.4286-4292.2004). Mannitol is a sugar alcohol that is commonly used as a sweetener in food and drink products. It is not an essential nutrient, so low levels of mannitol in the blood do not typically cause any symptoms. However, mannitol can be used medically as a diuretic, so low levels in certain populations, such as individuals with kidney failure, could indicate impaired kidney function.		
Implication of High Value	High levels of mannitol in the blood can be associated with kidney disease, as the body is unable to properly filter and remove it (DOI: 10.1006/abio.1995.1041). In some cases, high levels of mannitol may also be associated with an overdose of mannitol as a medication. However, more research is needed to fully understand the health implications of elevated mannitol levels. It is important to note that high levels of mannitol in the blood can be dangerous and may cause a variety of symptoms.		
Methylmalonic acid	**5481**	3506	5215
Description	Methylmalonic acid is a substance found in the body that is important for the metabolism of fat and protein (DOI: 10.1172/JCI109580). It is converted into another substance called succinyl-CoA by an enzyme called methylmalonyl-CoA mutase. This process requires vitamin B12. If there is a problem with this conversion, it can lead to a condition called methylmalonic aciduria. This is a type of inborn error of metabolism which can cause acidosis (a buildup of acid in the body), and can lead to symptoms such as vomiting, weak muscle tone, and seizures.		
Implications of low value	In some cases, low levels of MMA may be indicative of a functional deficiency in certain enzymes involved in its metabolism, such as methylmalonyl-CoA mutase (DOI: 10.1177/000456329202900509). This can also be seen in vitamin B12 or folate deficiency and some inborn errors of metabolism.		
Implication of High Value	Elevated plasma methylmalonic acid is related to increased cardiovascular events (DOI: 10.1111/j.1600-0404.1998.tb05976.x). High levels of methylmalonic acid can also be associated with other inborn errors of metabolism and can lead to intellectual disability or delayed development in some individuals.		
myo-Inositol	**7729**	3010	7337
Description	Myo-Inositol is a naturally occurring compound found in many foods and is important for cellular signaling (DOI: 10.1016/j.chemphyslip.2007.07.002). It is involved in various biological processes, including the regulation of insulin and neurotransmitter activity. Myo-Inositol is also used in the treatment of polycystic ovary syndrome (PCOS) and has been shown to support ovarian function and improve insulin sensitivity. It is a precursor for inositol phosphates and is also a component of cell membranes.		
Implications of low value	Low levels of myo-Inositol can be associated with a range of health issues, including insulin resistance, metabolic syndrome, and reproductive issues such as polycystic ovary syndrome (PCOS) (DOI: 10.1016/j.chemphyslip.2007.07.002). Inadequate levels of myo-Inositol may also impact mood and cognitive functions, and some studies suggest a link with conditions like depression and anxiety.		
Implication of High Value	High levels of myo-Inositol are generally considered safe, but excessive levels might indicate over-supplementation. There is limited information on the adverse effects of high myo-Inositol levels, but potential concerns could include gastrointestinal discomfort and possible interactions with medications. More research is needed to fully understand the implications of elevated myo-Inositol levels (DOI: 10.1016/j.chemphyslip.2007.07.002).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
N-Acetylputrescine	**1082**	2710	7622

Description	N-Acetylputrescine is a chemical that is found in normal human urine and is also found in patients with leukemia (DOI:10.1093/oxfordjournals.jbchem.a124694). It is a form of a chemical called putrescine, which is related to cadaverine and is responsible for the foul odor of rotting flesh. Putrescine is also found in semen and is produced by living cells in small quantities. It can also be found in a type of bacteria called Corynebacterium.
Implications of low value	There are no specific health implications of low levels of N-acetylputrescine in humans (DOI: 10.1016/s0304-3835(97)00399-6).
Implication of High Value	There is limited information available on the health states that are associated with high levels of acetylputrescine in the blood in humans (DOI: 10.3390/metabo5020211). Further research is needed to determine the potential effects of high levels of acetylputrescine in the human body.

Niacinamide	**8742**	3808	6529

Description	Niacinamide, also known as nicotinamide, is a form of vitamin B3 found in food and used as a dietary supplement (DOI: 10.1038/nature07762). It helps to prevent and treat conditions such as black tongue and pellagra. It is found in high concentrations in some foods such as sage, cow's milk, and cocoa beans, and in lower concentrations in other foods like yardlong beans, apples, and oyster mushrooms. Niacinamide is commonly added to cereals and other foods and is also found in multivitamins. It is essential for animals to obtain this compound through their diet, as they cannot produce it in sufficient amounts to prevent deficiency.
Implications of low value	Low levels of niacinamide, also known as nicotinamide, can be associated with pellagra, a condition caused by niacin (vitamin B3) deficiency (DOI: 10.1016/j.ab.2004.06.036). Pellagra is characterized by symptoms such as dermatitis, diarrhea, and dementia. It is particularly prevalent in regions where corn is a staple food and there is limited access to niacin-rich foods such as meat, poultry, fish, or dairy products. Low levels of niacinamide can also result from malabsorption, liver disease, or certain medications that interfere with niacin absorption or metabolism.
Implication of High Value	There is limited information on the clinical significance of high levels of niacinamide in the body (DOI: 10.1111/j.1365-4632.2004.02375.x). Elevated niacinamide levels can occur due to niacin overdose, certain medical conditions, or the use of specific supplements or medications. While high levels of niacinamide might not necessarily be harmful, the clinical implications depend on the individual's overall health status and the underlying cause of the elevation.

Nicotinic acid	**2947**	3708	7519

Description	Niacin, also known as vitamin B3, is a vitamin that helps in energy metabolism in the cell and DNA repair (DOI: 10.1038/nm824). It comes in two forms, nicotinic acid and nicotinamide. A lack of niacin can lead to a disease called pellagra, and a mild lack of it can slow down metabolism. The recommended daily amount is 2-12 mg for children, 14 mg for women, 16 mg for men, and 18 mg for pregnant or breastfeeding women. It is found in various animal and plant tissues and can help with pellagra, widen blood vessels, and lower lipid levels. The liver can make niacin from tryptophan, but this process is slow and requires vitamin B6. Bacteria in the gut may also make niacin, but not as efficiently.
Implications of low value	Low levels of nicotinic acid, also known as niacin, are associated with a condition called pellagra (DOI: 10.1079/bjn19760068). Pellagra is a nutritional deficiency disease caused by a lack of niacin in the diet. It is characterized by symptoms such as skin rashes, diarrhea, and dementia. Low levels of niacin can also cause a condition known as pellagra encephalopathy, which is a neuropsychiatric disorder characterized by confusion, irritability, and disorientation. In severe cases, pellagra can lead to death. It is important to have adequate levels of niacin in the diet to prevent pellagra and maintain overall health.
Implication of High Value	There is limited research available on the association between high levels of nicotinic acid (also known as niacin) in the blood and specific medical conditions (DOI: 10.1016/0021-9673(95)00247-k). However, some studies have suggested that high levels of niacin in the blood can be a sign of liver disease, as the liver is a major site of niacin metabolism. Additionally, taking high doses of niacin supplements can lead to elevated levels of niacin in the blood, which may cause side effects such as flushing, itching, and gastrointestinal distress. It is important to note that the levels of niacin in the blood can be influenced by a variety of factors, including diet, medications, and other health conditions.

Metabolite	Relative Abundance (RA)	Low RA	High RA
O-Acetylserine	**9169**	4479	7681
Description	O-Acetylserine is a compound that is used in the process of making the amino acid cysteine in plants and bacteria (DOI: 10.1038/nature07762). It is made by adding an acetyl group to the amino acid serine. O-Acetylserine can be converted into cysteine by an enzyme called O-acetylserine (thiol)-lyase. It's found in small amounts in some fruits and vegetables. O-Acetylserine is an intermediate compound in the biosynthesis of cysteine, which is a common amino acid.		
Implications of low value	The health implications of low levels of O-acetylserine in humans are not well documented in scientific literature (DOI: 10.1016/0378-4347(94)80064-2).		
Implication of High Value	The health implications of high levels of O-acetylserine are not well understood, as this molecule is not commonly measured or studied in the context of human health. Further research is needed to determine if high levels of O-acetylserine are associated with any specific health conditions or disease states.		
Oleic acid	**8847**	3278	8597
Description	Oleic acid is a type of fatty acid that is found naturally in many animal and plant fats and oils (DOI: 10.1038/nature07762). It is the most common fatty acid found in human tissues and the main component of olive oil. It can also be found in other oils such as canola, pecan, and sunflower oil. It is odorless and colorless but may appear yellow in commercial samples. Oleic acid is also used in the production of soaps, surfactants and as an emulsifying agent in foods and pharmaceuticals.		
Implications of low value	Oleic acid is a monounsaturated fatty acid found in high amounts in certain foods like olive oil, avocado, and nuts, and it is an essential fatty acid that the body needs in small amounts (DOI: 10.1007/BF00711898). However, it is not clear that low levels of oleic acid would cause any negative effects on the body as it can be obtained from a variety of food sources. It may be associated with certain diet-related diseases if the person is on a very restricted diet. But this would be a symptom rather than a cause.		
Implication of High Value	High levels of oleic acid in the diet can lower the level of bad cholesterol and may raise the level of good cholesterol, but this is still debated (DOI: 10.1211/0022357011776135).		
Ornithine	**7496**	5081	7660
Description	Ornithine, also known as L-ornithine, is a non-essential amino acid that is involved in the urea cycle which allows for the disposal of excess nitrogen (DOI: 10.1016/j.ymgme.2005.08.013). It is created from the enzyme arginase acting on L-arginine and is a precursor of citrulline and arginine. Ornithine is found throughout most human tissues and is abundant in certain foods. It plays a role in certain metabolic disorders and is associated with other inborn errors of metabolism. It is claimed to have anabolic effects, improve athletic performance, have wound-healing effects, and boost the immune system.		
Implications of low value	Ornithine is an amino acid that is involved in the metabolism of other amino acids, such as arginine and proline, and it is not typically measured as a marker for any specific health condition (DOI: 10.1038/nature07762). However, low levels of ornithine may be found in individuals with malnutrition or malabsorption disorders.		
Implication of High Value	Ornithine is an amino acid that is produced naturally in the body, and levels of ornithine can fluctuate for a variety of reasons (DOI: 10.1177/154405910208100613). However, in certain medical conditions such as Ornithine transcarbamylase deficiency, high levels of ornithine may be observed. This is a rare genetic disorder that affects the metabolism of ornithine, leading to an accumulation of ornithine in the blood. This can lead to a variety of symptoms such as vomiting, lethargy, and seizures.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Oxalic acid	**6627**	5121	8808
Description	Oxalic acid is a type of acid that is found in many plants and vegetables (DOI: 10.1016/j.ejpn.2011.08.004). It is also produced in the body from the breakdown of other substances. It can be found in the urine of some patients with certain metabolic disorders. It can also be considered a toxin in patients with kidney disease.		
Implications of low value	Low levels of oxalic acid in the body can be seen in healthy individuals and are not typically associated with any specific physiological condition (DOI: 10.1681/ASN.2011121175). However, in some cases, low levels of oxalic acid may indicate a deficiency of vitamin C (ascorbic acid) or a decreased ability to absorb oxalates from the diet. It is important to note that oxalic acid is typically measured in urine, and low levels in the blood may not necessarily reflect low levels in the body as a whole.		
Implication of High Value	It can be harmful in high amounts, particularly for people with kidney problems (DOI: 10.1053/jren.2003.50002). It is also associated with certain types of molds and can also be elevated due to high consumption of vitamin C or exposure to a chemical called ethylene glycol.		
Oxoglutaric acid	**2414**	2464	5514
Description	Oxoglutaric acid, also known as alpha-ketoglutarate, is an important molecule in the body's metabolic process called the TCA cycle (DOI: 10.4062/biomolther.2015.078). It plays a key role in determining the overall rate of this cycle. It can be produced from other molecules in the body such as isocitrate, glutamate, and other amino acids. It also plays a role in protein synthesis, insulin and growth hormone production, and extending the lifespan of certain organisms. It is also produced by certain bacteria and yeast.		
Implications of low value	Low levels of oxoglutaric acid (also known as alpha-ketoglutaric acid) are not typically associated with any specific health condition or disease (DOI: 10.4062/biomolther.2015.078). In rare cases, low levels of oxoglutaric acid may be seen in certain genetic disorders that affect the metabolism of this compound.		
Implication of High Value	High levels of oxoglutaric acid are associated with certain inborn errors of metabolism (DOI: 10.4062/biomolther.2015.078).		
p-Hydroxyphenylacetic acid	**1253**	3637	8047
Description	p-Hydroxyphenylacetic acid (4-hydroxybenzeneacetate) is a compound that belongs to a class of substances called 1-hydroxy-2-unsubstituted benzenoids (DOI: 10.1086/341914). It is slightly water-soluble and acidic. It can be made by the body from a compound called acetic acid, and it is also a parent compound for other similar compounds. It can be found in some foods such as olives, cocoa, oats and mushrooms and it is found in most human tissue and fluids. Its concentration in some patients is associated with an overgrowth of certain bacteria such as Clostridia species and it is detected after the consumption of whole grain.		
Implications of low value	Low levels of p-HPA have been associated with genetic disorders such as phenylketonuria (DOI: 10.1038/nature07762).		
Implication of High Value	High levels of p-HPA have been associated with certain conditions such as cancer and chronic kidney disease (DOI: 10.1021/jf0404389).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Palmitic acid	**7770**	4873	7704
Description	Palmitic acid is a type of saturated fat that is commonly found in plants, animals, and microorganisms (DOI: 10.1042/bj0780541). It is a major component of palm oil and is formed when the body has excess carbohydrates. It is used to make soaps, cosmetics and other industrial products. It was used during World War II to make Napalm. It is also used to measure water hardness and as a component in some medical ultrasound contrast agents.		
Implications of low value	Low levels of palmitic acid in the blood have not been specifically linked to any particular health condition or disease (DOI: 10.1093/ajcn/31.6.990). However, palmitic acid is a saturated fat that is found in many foods, and high levels of saturated fat intake are associated with an increased risk of heart disease. Therefore, low levels of palmitic acid in the blood may be indicative of a diet that is low in saturated fat, which is generally considered to be a healthy dietary pattern.		
Implication of High Value	High levels of palmitic acid, a type of saturated fatty acid, have been associated with an increased risk of cardiovascular disease, obesity, and metabolic syndrome (DOI: 10.1038/nature07762). Elevated levels of palmitic acid in the blood have also been observed in individuals with diabetes and those with high cholesterol levels. Additionally, high levels of palmitic acid intake has also been linked to an increased risk of cancer.		
Phenylephrine	**9229**	4319	6197
Description	Phenylephrine is a medication used to constrict blood vessels and decrease blood flow (DOI: 10.1161/CIRCULATIONAHA.104.493338). It is often used to relieve nasal congestion caused by colds, allergies, or the flu. It is also used as an ingredient in some eye drops to dilate the pupils during eye exams. It is available as an over-the-counter medication and is also used as a combination medication with other drugs.		
Implications of low value	Low levels of phenylephrine in the body have not been specifically associated with any health conditions or disorders (DOI: 10.1002/jcp.20301). Phenylephrine is a type of sympathomimetic drug, which means it acts on the sympathetic nervous system to produce various effects, such as constriction of blood vessels, increased heart rate, and dilated pupils. In medical settings, phenylephrine is often used to treat low blood pressure, nasal congestion, and other conditions. However, levels of phenylephrine in the body are typically measured in response to a specific medical condition or treatment and are not routinely measured as part of a standard medical exam.		
Implication of High Value	High levels of phenylephrine in the blood are associated with exposure to or ingestion of this drug (DOI: 10.1016/j.exer.2004.10.012). Phenylephrine is a common active ingredient in over-the-counter nasal decongestants and other medications used to relieve nasal congestion, sinus pressure, and other symptoms associated with upper respiratory conditions such as the common cold. In some cases, high levels of phenylephrine may indicate an overdose or a potential for toxicity, and may cause side effects such as rapid or irregular heartbeat, headache, agitation, and elevated blood pressure. In such cases, it is important to seek medical attention immediately.		
Phenylpyruvic acid	**3599**	4128	7607
Description	Phenylpyruvic acid is a byproduct of the metabolism of phenylalanine, an amino acid (DOI: 10.1128/AEM.64.8.3009-3013.1998). It's also a byproduct of a bacteria Lactobacillus plantarum.		
Implications of low value	Low levels of phenylpyruvic acid are not typically associated with any specific medical condition or disease (DOI: 10.1016/0378-4347(91)80571-s).		
Implication of High Value	High levels of it can be found in the urine of people with phenylketonuria (PKU), a genetic disorder caused by the lack of an enzyme needed to process phenylalanine (DOI: 10.1016/s0378-4347(98)00388-0). PKU can cause mental retardation and other symptoms if not treated. PKU is treated by strict phenylalanine-restricted diet, supplementing with tyrosine and other nutritional requirements and by administering phenylalanine-free amino acid mixtures.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Phosphoserine	**4957**	3036	6334
Description	Phosphoserine is a form of serine that has a phosphoric acid group attached to it (DOI: 10.1002/bmc.1130070403). It can be found in many living organisms and is commonly found in proteins because of chemical changes. It is made by adding a phosphoric acid group to the serine amino acid and this process is catalyzed by certain enzymes called kinases. It is also found in biofluids and can come from the breakdown of proteins.		
Implications of low value	The medical significance of low levels of phosphoserine in the human body is not well established (DOI: 10.1038/nature07762). Phosphoserine is a naturally occurring amino acid that is involved in various biological processes, including protein synthesis, but information on the health effects of low levels of phosphoserine is limited. Further research is needed to determine the potential health implications of low levels of this molecule.		
Implication of High Value	Phosphoserine is a naturally occurring amino acid that is involved in various metabolic processes in the body and high levels of phosphoserine are not necessarily associated with any particular medical condition or disease (DOI: 10.1016/s0022-510x(97)00069-5).		
Protocatechuic acid	**9005**	6975	8968
Description	Protocatechuic acid is a chemical compound found in certain foods such as onions, cocoa, and star anise (DOI: 10.1111/j.1600-0773.1994.tb01095.x). It is also a metabolite of polyphenols found in green tea. It has been found to have antioxidant and anti-inflammatory properties and may have liver protective effects. It can be used as a biomarker for the consumption of certain foods.		
Implications of low value	Information on the association of low levels of protocatechuic acid with specific health states in humans is currently unknown (DOI: 10.1002/ptr.1760). Further research may be required to determine the potential health implications of low protocatechuic acid levels.		
Implication of High Value	There is limited research on the relationship between protocatechuic acid and health in humans (DOI: 10.1002/ptr.1628). Currently, there is no established association between high levels of protocatechuic acid and any specific health state. Further research is needed to better understand the potential effects of high levels of protocatechuic acid in the human body.		
Putrescine	**1639**	3749	7484
Description	Putrescine is a chemical that is produced by living and dead organisms and is related to another chemical called cadaverine (DOI: 10.1681/ASN.2011121175). They both can cause bad odors and are toxic in large doses. It is also found in urine and semen, and it is involved in the production of other chemicals called spermidine and spermine. Putrescine is necessary for cell division and has specific roles in skin, fertility, and growth. It can also be found in certain bacteria.		
Implications of low value	Putrescine is a naturally occurring small molecule that is involved in several biological processes, and diminished levels of putrescine may be associated with dysregulation of cell growth and differentiation, as well as the reduced modulation of the immune system (DOI: 10.1111/j.1432-1033.2004.04009.x).		
Implication of High Value	High levels of putrescine, a polyamine compound, are associated with various diseases and pathological conditions, such as cancer, ischemic heart disease, and neurodegenerative disorders (DOI: 10.1111/j.1582-4934.2005.tb00385.x). In some cases, high levels of putrescine may indicate an overproduction of polyamines by cells or tissues, which can contribute to the growth and progression of cancer cells. Additionally, high levels of putrescine have been observed in the brain in neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease. However, it's important to note that further research is needed to fully understand the relationship between putrescine levels and these diseases.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Pyridoxamine	**6814**	5087	7520
Description	Pyridoxamine is a form of vitamin B6, which is a chemical compound based on a pyridine ring structure, with different groups attached to it (DOI: 10.1038/nature07762). It is structurally different from another form of vitamin B6 called pyridoxine. It has properties that can help protect against damage caused by free radicals and byproducts of sugar and fat breakdown. It plays a role in various reactions within the human body and is found in small amounts in some foods. It can also help block the formation of harmful compounds linked to diabetes. Some studies suggest it can also help prevent the breakdown of glycated proteins.		
Implications of low value	Low levels of pyridoxamine, a form of vitamin B6, have been associated with a deficiency of vitamin B6 (DOI: 10.1016/j.cccn.2004.05.009). Vitamin B6 deficiencies can lead to a number of symptoms, including anemia, depression, confusion, and skin conditions. A deficiency of vitamin B6 can also affect the immune system and make it more difficult for the body to process proteins and amino acids. Additionally, low levels of pyridoxamine have been linked to conditions such as rheumatoid arthritis and cardiovascular disease.		
Implication of High Value	It is a form of vitamin B6, which is important for many functions in the body, including brain development, immune function, and the synthesis of neurotransmitters, hormones, and red blood cells (DOI: 10.1039/an9952000171). However, it is not clear what the effects of elevated pyridoxamine levels would be.		
Pyridoxine	**1408**	6186	8751
Description	Pyridoxine is a form of vitamin B6 that is found in food and can be taken as a supplement (DOI: 10.1111/j.1749-6632.1990.tb28037.x). It is important for making amino acids, carbohydrates, and lipids. It also helps with the production of red blood cells, balancing hormones, and the immune system. It is also used in treatment for morning sickness in pregnant women, and to prevent deficiency, certain types of anemia, metabolic disorders and mushroom poisonings.		
Implications of low value	Deficiency in pyridoxine can lead to anemia, nerve damage, seizures, skin problems, and sores in the mouth (DOI: 10.1681/ASN.V12102072).		
Implication of High Value	High levels of vitamin B6 can be toxic and cause neurological symptoms such as numbness and tingling in the extremities, as well as skin lesions and gastrointestinal symptoms (DOI: 10.1002/hep.1840060324).		
Pyroglutamic acid	**1780**	2762	6746
Description	Pyroglutamic acid is a type of amino acid that is derived from glutamic acid (DOI: 10.1038/nature07762). It is found in small amounts in the body and in some foods, such as cheese. It is sometimes sold as a supplement for improving blood flow in the brain. Some studies have found that it can have anti-anxiety effects in animals and can affect the metabolism of ethanol in humans.		
Implications of low value	Low levels of pyroglutamic acid are not commonly associated with any specific medical condition or disease (DOI: 10.1007/BF00711898). Pyroglutamic acid is a normal intermediate in the metabolism of some amino acids and is present in the body at low levels in healthy individuals. However, low levels can result from certain drugs or treatments.		
Implication of High Value	Pyroglutamic acid can also cause problems when found in excessive levels in the blood, urine, or brain, leading to a condition called acidosis (DOI: 10.1002/pd.1970140611). High levels of pyroglutamic acid can also be a symptom of certain metabolic conditions, such as liver disease or malnutrition.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Quinolinic acid	**8818**	5258	9195
Description	Quinolinic acid is a chemical found in all living organisms and plays a role in the metabolism of the amino acid tryptophan (DOI: 10.1038/nrn3257). It acts as a neurotoxin and has been linked to several neurodegenerative disorders, such as Alzheimer's and AIDS-dementia. It is also produced in the brain by activated microglia and macrophages. Studies have shown quinolinic acid may be involved in psychiatric disorders and neurodegenerative diseases and it has been detected in certain foods such as cinnamon, red bell peppers, and durian.		
Implications of low value	Low levels of quinolinic acid have not been specifically linked to any specific health condition or disease (DOI: 10.1038/nrn3257). Quinolinic acid is a naturally occurring chemical in the human body and its levels can be influenced by various factors such as diet, genetics, and other health conditions. Some studies have suggested that low levels of quinolinic acid may be associated with certain neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease, but more research is needed to confirm these findings.		
Implication of High Value	Elevated levels of quinolinic acid have been found in patients with AIDS, CNS infections, brain injuries, and certain metabolic disorders (DOI: 10.1111/j.1742-4658.2012.08485.x).		
Ribitol	**2869**	2910	7104
Description	Ribitol is a naturally occurring compound found in plants and some bacteria (DOI: 10.1002/bmc.1130030206). It is formed by the reduction of ribose and is a part of the chemical structure of two important compounds, riboflavin and flavin mononucleotide (FMN). It is also a metabolic byproduct of the breakdown of ribose in human cells. It is not present in breast milk.		
Implications of low value	The health implications of reduced blood levels of ribitol in humans are not well understood (DOI: 10.1086/320108). Further research and clinical studies are needed to determine the potential health consequences and potential underlying causes of low levels of ribitol.		
Implication of High Value	Elevated levels of ribitol in the urine or blood can be a sign of a metabolic disorder related to the pentose phosphate pathway, a process that produces energy and other important molecules in the cell (DOI: 10.1086/383204).		
Sarcosine	**3584**	5044	7312
Description	Sarcosine is a natural amino acid found in muscles and other body tissues, it can be made in the lab and is also found in some foods (DOI: 10.1038/nature07762). It is used in manufacturing biodegradable surfactants and toothpastes. Sarcosine is not known to be toxic.		
Implications of low value	The level of sarcosine in the body is not necessarily indicative of a specific medical condition (DOI: 10.1038/nature07762). However, in some studies, low levels of sarcosine have been observed in some individuals with depression and anxiety. However, more research is needed to fully understand the role of sarcosine in these conditions and its potential as a diagnostic marker.		
Implication of High Value	Recently it has been found as a biomarker for prostate and breast cancer, found in increased amounts in patients with prostate cancer progression to metastasis, and could be detected in urine samples (DOI: 10.1016/0378-4347(91)80571-s).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Sebacic acid	**2652**	6253	7807
Description	Sebacic acid is a chemical that is found naturally in the human body (DOI: 10.1016/s0009-8981(99)00145-x). It is a component of urine. Sebacic acid is also used in various industrial processes such as making plasticizers, lubricants, and cosmetics. It is also used as an intermediate for other chemicals used in paints and antiseptics. It has been named from the Latin sebaceus, meaning tallow candle, as it was used in making candles.		
Implications of low value	There is no information on the physiological significance of low levels of sebacic acid in humans (DOI: 10.1177/014860719201600132).		
Implication of High Value	When there is a deficiency of certain enzymes in the body, the levels of sebacic acid in urine may increase (DOI: 10.1016/0006-2952(93)90145-m). This is seen in a group of genetic disorders known as multiple acyl-CoA-dehydrogenase deficiency.		
Serotonin	**8967**	5084	7398
Description	Serotonin is a molecule that belongs to a class of compounds called indoleamines (DOI: 10.1007/s10571-005-3061-z). It is found in all living organisms and plays a role as a neurotransmitter, a chemical messenger and regulator in mammals. It is mostly found in the gut and platelets and plays a role in regulating intestinal movements and in the nervous system where it modulates sleep, arousal, and sexual behavior. It also found in some plants, such as walnuts and pineapples.		
Implications of low value	Its deficiency causes disorders like depression, anxiety and OCD (DOI: 10.1179/1476830513Y.0000000108).		
Implication of High Value	High levels of serotonin are associated with a variety of conditions, including: Depression and anxiety disorders, Headaches including migraines, Certain types of chronic pain, Liver disease, cancer, obesity, cardiovascular disease, and autoimmune disorders (DOI: 10.1111/j.1365-2893.2005.00706.x).		
Shikimic acid	**6212**	4796	7836
Description	Shikimic acid, also known as shikimate, is a chemical found in plants and microorganisms that is used as a building block for other important compounds in the body such as amino acids, indole derivatives, alkaloids and tannins (DOI: 10.1016/j.saa.2004.09.004). It is also a precursor for the production of Tamiflu, a flu medication. It is found in low concentrations in most living organisms. It was first isolated from the Japanese flower shikimi.		
Implications of low value	As an intermediate in the biosynthesis of essential aromatic amino acids, low levels of shikimic acid may indicate reduced synthesis of tryptophan, tyrosine, and phenylalanine (DOI: 10.1111/j.1464-410x.1976.tb02744.x).		
Implication of High Value	Shikimic acid is an intermediate in the biosynthesis of compounds such as pheophytin, pyrophosphate, and aromatic amino acids. However, high levels of shikimic acid in the blood or urine could potentially indicate an underlying metabolic or nutritional disturbance.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Spermidine	**6805**	1754	5631

Description	Spermidine is a chemical compound found in all living species, including humans (DOI: 10.1038/nature07762). It helps in the production of other compounds called spermine and 5'-methylthioadenosine. It can be found in high concentration in cow milk and oats. It may also be present in small amounts in some foods like chokecherries, watercress, and strawberry guava. It is considered a uremic toxin which can cause uremic syndrome. It is transported into the kidneys by specific transporters.
Implications of low value	Low levels of spermidine have been associated with various health conditions, such as: Age-related diseases: Spermidine has been shown to be important for healthy aging, and low levels of this polyamine have been linked to various age-related diseases, such as cardiovascular disease, neurodegeneration, and cancer (DOI: 10.1016/s0378-4347(01)00130-x). Impaired immune function: Spermidine has been shown to play a role in regulating the immune system, and low levels of this polyamine have been linked to decreased immune function and increased susceptibility to infections. Liver diseases: Spermidine is involved in the regulation of liver function, and low levels of this polyamine have been linked to liver diseases, such as liver steatosis (fatty liver) and liver fibrosis. Overall, low levels of spermidine may be a risk factor for various health conditions, but more research is needed to fully understand the mechanisms underlying these associations.
Implication of High Value	High levels of spermidine can be toxic, leading to conditions like renal damage, chronic kidney disease and cardiovascular disease (DOI: 10.1002/1097-0142(19800101)45:1<108::aid-cncr2820450120>3.0.co;2-w). However, some studies have suggested that high levels of spermidine may be associated with a reduced risk of certain age-related diseases, such as cardiovascular disease, stroke, and certain types of cancer. Additionally, high levels of spermidine have been linked to improved longevity in some animal studies. However, it's important to note that these findings are not conclusive and more research is needed to fully understand the effects of high levels of spermidine in the human body.

Metabolite	Relative Abundance (RA)	Low RA	High RA
Spermine	**1846**	1885	7258

Description	Spermine is a type of organic compound found in all living organisms, from bacteria to humans (DOI: 10.1038/nature07762). It's a byproduct of the amino acid ornithine, which is converted into spermidine and then into spermine. It is found in highest concentration in oats and in other foods like sapodilla, Mexican groundcherries, cloves, sourdocks, and sunflowers. Spermine can be toxic in high levels. It has a variety of uses in medicine and research, but not for food or supplement use.
Implications of low value	Spermine is a polyamine that is naturally present in cells and is involved in various biological processes (DOI: 10.1203/00006450-198011000-00009). However, we don't have information on specific associations of low spermine with particular health conditions.
Implication of High Value	The clinical significance of elevated levels of spermine in the human body is not well established (DOI: 10.1203/00006450-198011000-00009). Elevated levels of spermine have been associated with some diseases, including certain cancers, but more research is needed to determine the cause and effect relationship. The role of spermine in human health and disease is an active area of research.

Metabolite	Relative Abundance (RA)	Low RA	High RA
Stearic Acid	**3987**	3812	6411

Description	Stearic acid is a type of saturated fatty acid found in many animal and vegetable fats and oils (DOI: 10.1007/s11745-005-1484-z). It is commonly used as a food additive, in cleaning and personal care products and in lubricants. It exists as a waxy solid and is not very soluble in water. It is produced from carbohydrates in the body and is found in all living organisms. Its name comes from the Greek word stear, which means "tallow" or "hard fat".
Implications of low value	Low levels of stearic acid in the blood have not been consistently linked to any specific health conditions in humans (DOI: 10.1007/BF00711898). However, stearic acid is an essential fatty acid that the body needs in order to function properly, and a deficiency of stearic acid could potentially contribute to a range of health problems. It is important to note that levels of stearic acid can be influenced by a variety of factors, including diet and overall health status, and more research is needed to fully understand the implications of low levels of stearic acid in the blood.
Implication of High Value	The health implications of high levels of stearic acid in the blood are not well established (DOI: 10.1128/CDLI.6.4.587-593.1999). However, high levels of stearic acid, as well as other saturated fatty acids, have been associated with an increased risk of cardiovascular disease. Elevated levels of stearic acid in the blood may also be an indicator of a diet high in saturated fat. Further research is needed to determine the specific health effects of high levels of stearic acid in the blood.

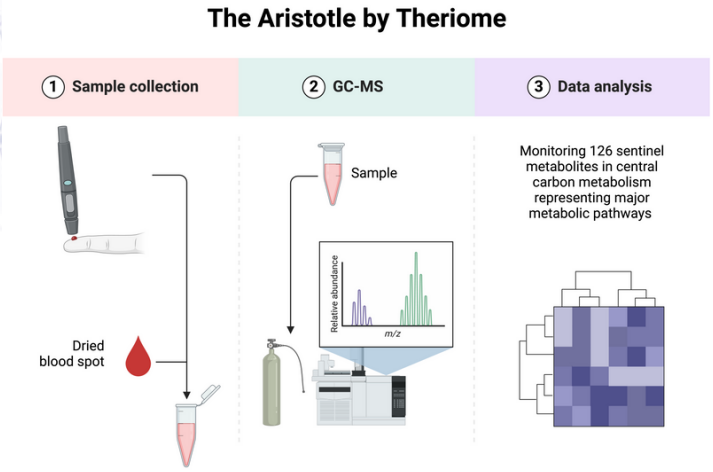
Metabolite	Relative Abundance (RA)	Low RA	High RA
Succinic Acid	**7073**	3690	5083
Description	Succinic acid, also known as succinate, is a type of organic acid found in all living organisms (DOI: 10.1007/s00018-005-5237-6). It is an important component of the citric acid cycle and is involved in the production of energy in cells through the process of ATP synthesis. It can also have a role in cell signaling and has been found to be elevated in certain types of cancer. Succinic acid is produced in the mitochondria and can be imported and exported from the mitochondria. It can be metabolized by the enzyme succinate dehydrogenase, and its metabolism can be dysregulated in certain genetic mitochondrial diseases. Additionally, some bacteria also produce succinic acid as well.		
Implications of low value	Low levels of succinic acid may be associated with a variety of conditions, including a lack of energy metabolism, nutritional deficiencies, and certain genetic disorders (DOI: 10.1016/j.bbabio.2016.03.012). In some cases, low levels of succinic acid may indicate a malfunction of the citric acid cycle, which is a series of chemical reactions in cells that produce energy. However, low levels of succinic acid can also be normal and may not always indicate a problem.		
Implication of High Value	High levels of succinic acid can be associated with various medical conditions and metabolic imbalances, such as: 1) Mitochondrial diseases: Succinic acid can accumulate in the blood and urine of people with mitochondrial diseases, which are a group of disorders caused by problems with the energy-producing mitochondria in cells. 2) Methylmalonic acidemia: This is a metabolic disorder in which the body is unable to process certain amino acids and fatty acids properly, leading to an accumulation of succinic acid and other toxic substances in the blood. 3) Overproduction of lactic acid: Succinic acid can be produced as a byproduct of anaerobic respiration, which occurs when the body lacks enough oxygen to produce energy aerobically. This can lead to elevated levels of succinic acid and lactic acid in the blood, especially during intense exercise (DOI: 10.1021/pr2010692).		
Sucrose	**5569**	3314	7727
Description	Sucrose is a type of sugar commonly found in plants such as sugarcane and sugar beet (DOI: 10.1186/s13321-018-0324-5). It is used as a sweetener and preservative in food and drinks and can also be used in the manufacture of other products such as syrups, confectionery, and pharmaceuticals. It is derived by processing sugarcane or sugar beet and is present in low levels in honey and maple syrup. The annual production of sucrose worldwide is over 90 million tons mostly from sugarcane and sugar beet. Some studies suggest that it can be produced by human gut micro bacteria and metabolized by liver enzymes.		
Implications of low value	Low levels of sucrose, also known as table sugar, are not necessarily associated with any specific medical condition or disease (DOI: 10.1038/nature07762). However, low levels of sugar in the diet can contribute to low blood sugar (hypoglycemia) and related symptoms such as fatigue, weakness, and confusion. In some cases, low sugar intake can also result in malnutrition and weight loss if not accompanied by adequate intake of other nutrients.		
Implication of High Value	High levels of sucrose can be associated with a diet high in sugar and carbohydrate-rich foods (DOI: 10.1016/0378-4347(91)80571-s). Consuming large amounts of sucrose can lead to elevated blood sugar levels and an increased risk of obesity, type 2 diabetes, and other health problems. Additionally, high levels of sucrose in the diet can also contribute to tooth decay, since it is a source of food for the bacteria that cause cavities.		
Taurine	**3575**	2515	7277
Description	Taurine is an amino acid like methionine, cystine, cysteine, and homocysteine (DOI: 10.1038/nature07762). It is not a building block for protein but is essential for infants and has diverse roles in the body like serving as a neurotransmitter in the brain, stabilizing cell membranes and facilitating the transport of ions. It is found in animal and fish protein and can be made by the body with the presence of vitamin B6. It also found to be associated with diseases like depression, epilepsy and retinitis pigmentosa. Taurine has many metabolic roles and is used in supplements.		
Implications of low value	Deficiency of taurine can occur in premature infants, neonates fed formula milk and various disease states (DOI: 10.1023/a:1024255208563).		
Implication of High Value	High levels are associated with diseases such as Perry syndrome and hypertaurinuric cardiomyopathy (DOI: 10.1111/j.1471-4159.1984.tb02756.x).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Thymine	**1209**	3009	6873
Description	Thymine is a chemical compound found in DNA and plays an important role in all living organisms (DOI: 10.1038/nature07762). It was first discovered by scientists in 1893 and is named after the organ it was found in, the thymus gland. Thymine combined with deoxyribose creates a nucleoside called deoxythymidine which when combined with phosphoric acid creates molecules that can be incorporated into DNA. In RNA, thymine is replaced by uracil in most cases. Thymine helps stabilize the structure of DNA by binding to adenine through hydrogen bonds. It also participates in several chemical reactions in the body to help with the creation of other molecules.		
Implications of low value	Low levels of thymine in the body have not been definitively linked to any specific health conditions (DOI: 10.1007/BF00965000). Thymine is one of the four nitrogenous bases that make up DNA, so it is essential for proper genetic function. However, there is limited research on the significance of low levels of thymine, and further studies are needed to fully understand its role in the body and any potential health implications of low levels.		
Implication of High Value	It is not common for the levels of thymine to be measured or discussed in a medical or scientific context (DOI: 10.1016/s1570-0232(03)00251-4). Thymine is a nitrogenous base found in DNA and its presence in the DNA molecule is necessary for normal cellular function. Abnormal levels of thymine are not typically associated with any medical condition.		
trans-Cinnamic Acid	**1314**	2285	8345
Description	trans-Cinnamic acid is a chemical compound found in some foods like Chinese cinnamon, olives, and lingonberries (DOI: 10.1128/am.16.2.320-325.1968). It has a sweet, balsam, and cinnamon taste. It is found in small amounts in other foods such as redcurrants, red raspberries, and coriander. It can also be produced by some bacteria. It is potentially toxic.		
Implications of low value	The health implications of low levels of trans-cinnamic acid in humans is currently unknown, as it is not commonly measured or studied (DOI: 10.1515/CCLM.2003.248).		
Implication of High Value	Blood levels of trans-cinnamic acid are not typically measured in routine medical tests, and there is limited information available on the normal range or reference values for this compound (DOI: 10.1128/AEM.69.5.2884-2892.2003). As such, it is difficult to determine what high levels of trans-cinnamic acid might be associated with.		
Trehalose	**2324**	2464	7549
Description	Trehalose is a sugar found in nature that helps plants and animals survive without water (DOI: 10.1073/pnas.142314099). It forms a gel that protects cell parts during dehydration and allows normal function when rehydrated. Trehalose is made up of two glucose units and is stable in high temperatures and acidic conditions. It is broken down by an enzyme called trehalase and is important in insects' breathing and is also a metabolite of some bacteria.		
Implications of low value	Trehalose is a type of sugar that is found in a variety of organisms and is used as a source of energy (DOI: 10.1016/j.biortech.2014.11.048). While levels of trehalose can vary in different tissues and organisms, there is no reliable information on a specific health condition that is associated with low levels of trehalose in the human body.		
Implication of High Value	High levels of trehalose in the blood or urine of humans are not commonly associated with any specific health conditions (DOI: 10.1073/pnas.142314099). However, elevated levels of trehalose can occur as a result of certain inherited metabolic disorders, such as trehalose-6-phosphate hydrolase deficiency. In some cases, high levels of trehalose may also be seen in individuals with certain types of cancer, or in individuals taking certain medications.		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Tryptamine	**7452**	3553	7854
Description	Tryptamine is a chemical compound that comes from the breakdown of tryptophan, an amino acid, by gut bacteria. It is found in the urine after being absorbed in the intestine and can be a precursor to other hormones and neurotransmitters. Tryptamine is found in some foods such as onions, acerola, Japanese walnuts, custard apples, and zucchinis, and could be used as a marker for the consumption of these foods.		
Implications of low value	Low levels of tryptamine are not necessarily associated with any specific medical condition or disease. However, tryptamine is a neurotransmitter that is involved in regulating mood and sleep, so imbalances in tryptamine levels could potentially contribute to certain mental health conditions. However, more research is needed to fully understand the relationship between tryptamine levels and various health conditions.		
Implication of High Value	High levels of tryptamine in the body have not been linked to any specific conditions or diseases (DOI: 10.1038/s41467-018-05470-4). However, elevated levels of tryptamine can result from certain metabolic imbalances or from taking certain drugs, such as monoamine oxidase inhibitors (MAOIs), which are used to treat depression, anxiety, and other psychiatric disorders. It's important to note that tryptamine is also a naturally occurring substance in the body and is involved in the regulation of various biological processes, including sleep, mood, and appetite. However, high levels of tryptamine in the body can cause potentially harmful effects, such as increased heart rate and blood pressure, and may interact with other medications in unexpected ways.		
Tyramine	**2720**	2524	3503
Description	Tyramine is a chemical found in some foods; it is produced by the breakdown of the amino acid tyrosine (DOI: 10.1038/s41467-018-05470-4). Foods that have high amount of tyramine are fermented or aged products like cheese, fish, soy sauce, and processed meat. Consuming large amounts of tyramine can cause a spike in blood pressure. Tyramine can also act as a neurotransmitter and is a biomarker for consumption of cheese.		
Implications of low value	Low levels of tyramine can be reflective of various physiological processes, including: Deficiencies in tyrosine, an amino acid that is the precursor of tyramine, Impaired metabolism of tyramine in the body, Reduced dietary intake of tyramine-rich foods, such as cheese, red wine, and fermented foods (DOI: 10.1016/0361-9230(83)90072-2).		
Implication of High Value	High levels of it can be found in people with a disease called maple syrup urine disease (MSUD), which can cause damage to the brain and other organs if not treated (DOI: 10.1176/ajp.138.3.371). Symptoms of MSUD can include abnormal behavior, hallucinations, difficulty eating, and seizures. It can also lead to intellectual disability or delayed development. It is a metabolic disorder caused by a deficiency of the enzyme BCKDC which causes a buildup of the branched-chain amino acids and their toxic by-products.		
Uracil	**5126**	3290	4705
Description	Uracil is a naturally occurring chemical compound found in RNA, it is one of the four nucleobases that make up RNA (DOI: 10.1016/0731-7085(93)80171-v). Uracil pairs with adenine and is replaced by thymine in DNA. It can be found in all living organisms, from bacteria to humans. It plays a role in the synthesis of enzymes and in the transport of sugars. It is also a potential drug delivery agent, 5-fluorouracil, a cancer drug is made from uracil.		
Implications of low value	Low levels of uracil in the blood are not commonly associated with a specific medical condition or disease (DOI: 10.1038/nature07762). Uracil is a naturally occurring substance in the body and the levels can vary based on factors such as diet, metabolism, and other physiological processes. However, low levels of uracil can sometimes be seen in certain conditions that affect the metabolism of purines, such as inborn errors of purine metabolism, malnutrition, or liver disease.		
Implication of High Value	Uracil is a nitrogenous base that is found in RNA, and its levels can be influenced by various factors, including diet, age, and disease state (DOI: 10.1016/s1570-0232(03)00251-4).		

Metabolite	Relative Abundance (RA)	Low RA	High RA
Uridine	**1471**	2379	7449
Description	Uridine is a type of compound found in all living cells that is important for the formation of RNA, a genetic material (DOI: 10.1007/BF00965000). It is a natural substance that can be found in small amounts in some foods like fruits and vegetables. Uridine is also used in the metabolic process of converting galactose into glucose. High levels of uridine are not commonly found in food, and it can be broken down in the liver and gut. It is involved in some metabolic disorders, but it is not toxic. There is some interest in the potential use of uridine supplements to boost certain bodily functions, such as muscle performance but more research is needed in these areas.		
Implications of low value	Low levels of uridine and other nucleotides have been observed in individuals with malnutrition or malabsorption disorders, and supplementation with these compounds has been used as a treatment for these conditions (DOI: 10.1002/rcm.1400). Additionally, low levels of uridine and other nucleotides have been seen in individuals with liver disease, and this has been suggested as a potential marker of liver damage.		
Implication of High Value	Elevated levels of uridine can occur due to certain medications, dietary supplements, or genetic factors (DOI: 10.3390/ijms21031043). In some cases, high levels of uridine may also indicate liver disease, renal disease, or other medical conditions.		
Uridine diphosphate-N-acetylglucosamine	**2216**	3104	7830
Description	Uridine diphosphate-N-acetylglucosamine (UDP-GlcNAc) is a chemical compound that is important for modifying proteins in the body (DOI: 10.1093/glycob/cwg007). It is produced in response to nutrient intake, and helps control cellular processes such as insulin signaling, gene regulation, and cell growth. It also helps in response to disease like diabetes and neurodegeneration. It is considered as a glucose sensor that depends on glucose and other metabolic factors for its synthesis.		
Implications of low value	Low levels of uridine diphosphate-N-acetylglucosamine (UDP-GlcNAc) have not been definitively linked to any specific medical conditions or diseases (DOI: 10.1210/jc.2002-020440). However, UDP-GlcNAc is a component of N-linked glycosylation, a type of post-translational modification that is important for the proper function of many proteins. Abnormalities in N-linked glycosylation can have effects on cellular processes such as cell signaling, protein folding and stability, and immune system function. As such, low levels of UDP-GlcNAc could potentially disrupt these processes and contribute to the development of various diseases. However, more research is needed to fully understand the implications of low levels of UDP-GlcNAc.		
Implication of High Value	Elevated levels of UDP-GlcNAc can impact how cells use insulin to take in glucose (DOI: 10.1007/BF02256538).		
Urocanic acid	**9112**	3990	8648
Description	Urocanic acid is a chemical that is produced in the body when histidine, an amino acid, is broken down (DOI: 10.1016/S1011-1344(98)00130-4). It is found in the skin and liver. In the skin, it can act as a UV protectant and can also affect the immune system. It can be found in mushrooms such as Coprinus atramentarius and Phallus impudicus.		
Implications of low value	Low levels of urocanic acid in the body can be associated with several conditions, including: 1. Vitamin B12 deficiency: Urocanic acid is involved in the metabolism of vitamin B12, so a deficiency of vitamin B12 can lead to low levels of urocanic acid. 2. Malabsorption disorders: Certain conditions that affect the absorption of nutrients in the gastrointestinal tract, such as celiac disease or Crohn's disease, can result in low levels of urocanic acid. 3. Immune disorders: Autoimmune disorders and certain infections can cause low levels of urocanic acid due to inflammation and oxidative stress. 4. Other factors: Certain medications, alcohol consumption, and exposure to ultraviolet light can also affect urocanic acid levels in the body (DOI: 10.1111/j.1751-1097.1997.tb01935.x).		
Implication of High Value	The exact consequences of high levels of urocanic acid are not well understood (DOI: 10.1016/0378-4347(84)80080-8). Elevated levels of urocanic acid have been observed in some studies in patients with certain medical conditions, such as autoimmune diseases and certain cancers. However, the relationship between elevated urocanic acid levels and these conditions is not fully understood, and more research is needed to determine the significance of high urocanic acid levels in these cases.		

Methodology

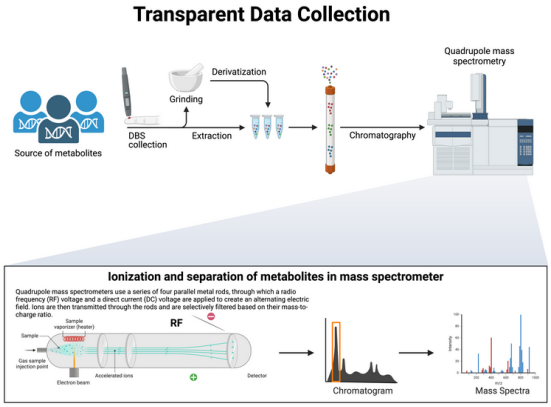


Sample collection and preparation:

The sample preparation process for the Aristotle test involved extracting dried blood spots using a standardized blood spot punch. Then, a mixture of 200 µL of a 10x diluted PBS solution and 80 µL of MeOH containing specific internal standards was added to sample. The sample was mixed with a 1/2 spoonful of stainless-steel micro beads and homogenized for 20 seconds. Next, 400 µL of a specific mixture of MTBE was added to sample, vortexed for 30 seconds, and sonicated in an ice bath for 20 minutes. The sample is then centrifuged at a high speed of 22,000 g to separate the different components. The aqueous bottom layer (180 µL) from this MTBE extraction was collected into a new tube for further derivatization and targeted metabolic profiling using GC-MS. This collected bottom layer was dried under vacuum at 37°C for 4 hours. The residues were then derivatized and incubated at 60oC before being vortexed and centrifuged again. Finally, 70 µL of the supernatant were collected from each sample into new glass vials for GC-MS analysis.

Analytical platform:

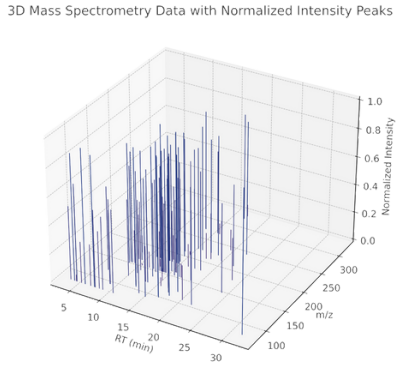
GC-MS experiments were performed on an Agilent 7820A GC-5977B MSD system by injecting 1 µL of prepared samples. Helium was used as the carrier gas with a constant flow rate of 1.2 mL/min. The separation of metabolites was achieved using an Agilent HP-5ms capillary column (30 m x 250 µm x 0.25 µm). The column temperature was maintained at 60°C for 1 min, increased at a rate of 10°C/min to 325°C, and then held at this temperature for 10 min. Mass spectral signals were recorded at an m/z range of 60-500.



Methodology

Data processing and analysis:

Data extraction was performed using Agilent MassHunter Profinder software. A batch recursive feature extraction algorithm for small molecules was used, and peaks were filtered so that only peaks with absolute height ≥ 1,000 counts were included. An RT tolerance of 0.10 min was established, and extraction was limited to the largest 1,000 compound groups. Results were filtered if the overall identification score was less than 75.



Metabolite identification and quantification:

Metabolite identities were confirmed using RT and base peak information from experimental GC-MS spectra and peaks were manually checked and integrated. Metabolites were quantified relative to three internal standards.

Quality control:

A quality control sample is injected at least three times during all analytical runs. Following peak integration, metabolites were filtered for reliability and only those with QC coefficient of variation (CV) < 20% and relative abundance of > 1,000 were retained for analysis.

Statistical analysis:

Bayesian statistics was used to allow for incorporating prior information into the analysis. In metabolomics, Bayesian statistics can be used to achieve single sample profiling, meaning that the analysis can be done on a single sample, rather than needing multiple samples to establish a reference range. This is done by using a Bayesian model to estimate the probability distributions of the concentration of each metabolite in the sample based on the measurement data, considering the variability of the measurement process and the prior knowledge about the metabolite concentrations. The Bayesian model uses the data from the sample, along with the prior information, to generate a probability distribution for each metabolite, which is then be used to estimate the most likely concentrations of metabolites in the sample, even if the sample is the only one available. This method allows for single-sample profiling, which is useful in cases where only one sample is available or when it is not possible to obtain multiple samples.

Limitations:

It is important to note that these results are only a snapshot of your current metabolite levels and should not be used to diagnose or treat any medical condition. It is recommended that you consult with your healthcare provider to further discuss these results and any potential implications they may have on your health.

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