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The role of the endothelial glycocalyx in the pathogenesis of atherosclerosis: a new frontier in cardiovascular health

By Derrick DeSilva Jr, MD, Jeffrey Gladden, MD, FACC, Chen Chen, PhD, Jon Ward, MA

Much recent work on the pathogenesis of atherosclerosis has focused on the "response to injury theory". In brief, the theory holds that atherosclerosis may be understood as an inflammatory response to insults occurring to the endothelium. [1]

When the endothelium is healthy atherosclerosis does not occur. When the endothelium is damaged, it produces surface-adhesion molecules causing monocytes and t-lymphocytes to stick to its surface, which then penetrate the endothelium into intima. As low density lipoprotein (LDL) particles follow the path, they enter the intima and begin to oxidize. This sets the stage for foam cell formation and plaque development. The resulting plaque then builds up and, when internally inflamed or externally eroded, can be a threat to rupture its contents into the arterial flow, potentially triggering a blood clot that if large enough or not lysed quickly enough can occlude the artery to various degrees causing anything from mild to devastating downstream ischemia. Indeed, it is the clotting in response to plaque disruption, not the plaque accumulation in the arteries per se that poses the real threat. 75% of heart attacks occur at arteries that are less than 50% blocked, while mild plaquing escapes traditional stress tests 80% of the time

Needless to say, this means that merely measuring the serum levels of LDL and HDL is inadequate to assess event risk. To interrupt the cycle, clinicians need to be primarily concerned with the health of the endothelium.

The injury-response theory is gaining widespread acceptance, but it begs an important question: What causes the injury to the endothelium in the first place? Multiple candidates have been cited such as:

- Direct trauma causing physical injury
- Turbulence in the blood flow, for example at artery bifurcations

- Excessive blood glucose levels
- Circulation of free radicals
- TMAO (trimethylamine-N-oxide)
- Higher than normal concentrations of LDL or VLDL
- High blood pressure
- Circulating toxins
- Deterioration of the NO system

All of these explanations have value, but they miss a critical factor in endothelial health which merits more attention than it has received in the current literature. That factor is the endothelial glycocalyx.

The Endothelial Glycocalyx

Popular accounts of the endothelium inaccurately describe it as "the inner lining" of the blood vessels. Here's Wikipedia:

"Endothelium is a type of epithelium that lines the interior surface of blood vessels and lymphatic vessels, forming an interface between circulating blood or lymph in the lumen and the rest of the vessel wall."

What's missing from these accounts is the glycocalyx, a slippery smooth gel coating of the endothelium that positions an additional layer between the endothelium and the circulating blood. This is the true interface. In other words, it's the endothelial glycocalyx—not the endothelial cells themselves—that has (or should have) direct contact with the circulating fluids and particles.

When we help doctors explain the endothelial glycocalyx to patients, we sometimes liken it to the non-stick surface of a frying pan. The analogy is useful because it highlights the protective function of this important structure. A healthy glycocalyx ensures that LDL particles "slip by" without contacting the endothelium. Conversely, when the endothelial glycocalyx is compromised (which happens very easily) the endothelium becomes susceptible to injury impairment and LDL penetration.

Important clinical implications follow. To prevent atherosclerosis, we must protect the endothelium from injury and preserve its vital functions. To protect endothelial function, we must support its existing natural protection, the endothelial glycocalyx. In layman's terms: if you want to stop food sticking to your saucepan, take care of the non-stick coating! If you want the infrastructure of the endothelium to work you need to protect its surface.

A Closer Look at the Glycocalyx

The endothelial glycocalyx is a thin gel-like layer that coats the entire luminal side of the vascular endothelium. It is a meshwork mainly of glycoproteins, proteoglycans and glycosaminoglycans at a thickness of approximately 1 μm magnitude.[2-4] Syndecans and glypicans are the core proteins of heparan sulfate (a glycosaminoglycan) proteoglycans bound to endothelial cells identified in the glycocalyx. Glycoproteins such as selectins and integrins are also anchored on endothelial cells while some other soluble proteins and proteoglycans simply dock in glycocalyx.[5]

Extensive research has revealed the importance of glycocalyx-mediated endothelial function in vascular and microvascular health.

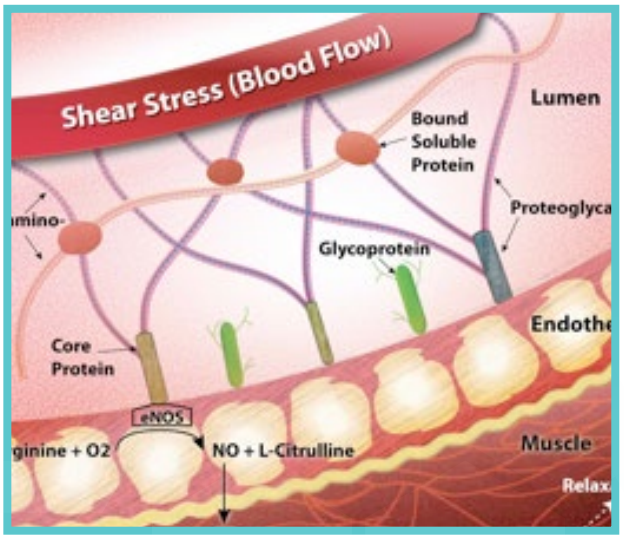
For example, the endothelial glycocalyx:

- Regulates vascular permeability and fluid balance due to the large size and negative charge of glycosaminoglycans.[6,7]
- Provides a physical barrier against inadvertent adhesion of platelets and leukocytes to the vascular wall.[8]
- Regulates coagulation as many of mediators of coagulation pathway are buried inside the glycocalyx under normal physiological condition.[5]

Most intriguingly, the glycocalyx is found to be a mechano-sensor and -transducer of the shear-force inside blood vessels.3 The signal is believed to be transduced to endothelial nitric oxide synthase (eNOS) via heparan sulfate in the glycocalyx to either up- or down-regulate the synthesis of nitric oxide (NO) in response to the blood flow.[9,10]

Figure 1 below illustrates the chemical structure of the endothelial glycocalyx and its signal transduction to eNOS and subsequently sGC (soluble guanynyl cyclase) to induce smooth muscle relaxation via shear stress.

Figure 1. Structure of the endothelial glycocalyx and its activation of vascular muscle relaxation via NO in response to increased shear force



Damage to the Endothelial Glycocalyx

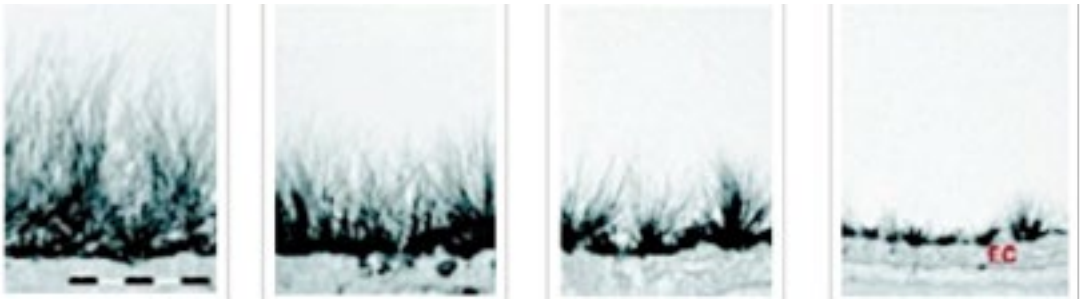
The endothelial glycocalyx is a delicate structure and can be damaged by several common mechanisms involved in the pathogenesis of atherosclerosis. These include high blood glucose, [11] oxidative stress, [12] and inflammation. [4] It is known that high-sugar diets, cigarette smoking, stress, and aging can all degrade the glycocalyx.

Hyperglycemia is a major cause for disruption of the endothelial glycocalyx.[11,13] In fact individuals with hyperglycemia and diabetes are known to have less endothelial glycocalyx.[14] Such a change may explain the endothelial dysfunction and increased microvascular permeability that lead to major complications in the diabetic population.[15,16]

There are several other disease conditions identified so far to be associated with a compromised endothelial glycocalyx:

- Coronary heart disease[17]
- Renal diseases[18]
- Lacunar stroke (a small vessel disease)[19]
- Severe trauma[20]

These electron-microscope images show the deterioration of the endothelial glycocalyx:



Clinical Interventions

Given the vital role the endothelial glycocalyx plays in the pathology of many vascular and micro-vascular related diseases, it has naturally become a target for pharmaceutical intervention.[21,22] However, glycocalyx drug development is still in its infancy and no substantial progress has been made to date. [23]

A dietary supplement has been tested and shown to have measurable benefits for a compromised glycocalyx in healthy subjects. Brand-named Arterosil, its primary ingredient is rhamnan sulfate derived from rare marine algae. Rhamnan sulfate has a similar chemical structure to heparan sulfate found abundantly in the human endothelial glycocalyx, and may exert its bioactivity by regenerating the glycocalyx.

In an early clinical trial, the positive impact on the glycocalyx was established by measuring recovery of RHI (reactive hyperemia index) in 20 healthy human subjects following a high-sugar, high-fat meal. Results were compared with and without consumption of ArterosilHP. The study confirmed a significant improvement in glycocalyx RHI recovery with the supplement.

Important safety data were obtained for complete metabolic panel (CMP), thyroid stimulating hormone (TSH), complete blood count (CBC), and partial thromboplastin time (PTT) from the trial. No significant changes were observed for any of these tests after 4 weeks of ArterosilHP supplementation. There was also no serious adverse event reported during the study and the product was well tolerated by all subjects.

The Glycocalyx and Arterial Elasticity: A New Frontier

The clinical significance of arterial elasticity is well established: Central arterial stiffness has been shown to be an independent predictor of cardiovascular morbidity and mortality. [24] While the prognostic value of this measure is widely accepted, the causes of arterial stiffness are still subject to debate. Some research suggests that the issue is not limited to the larger arteries themselves, but may extend to the microvascular system. [25] Other studies indicate the role of endothelial function in determining the degree of arterial elasticity. [26]

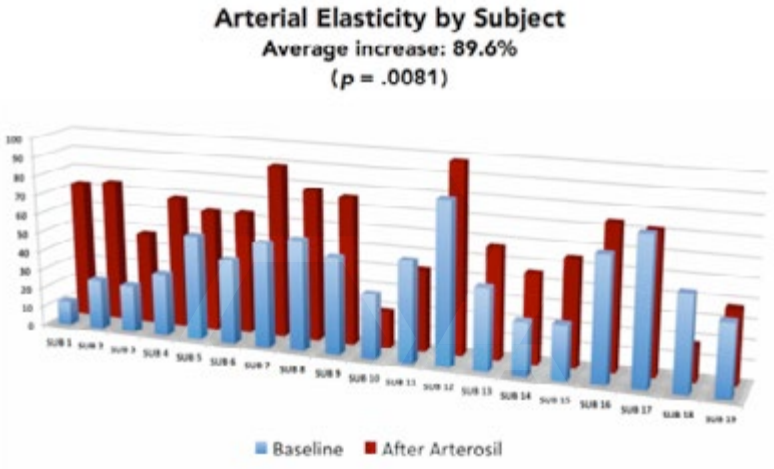
One useful contribution to this debate may prove to be a new focus on the endothelial glycocalyx. Because the glycocalyx serves to protect the integrity of the endothelium, and hence of the arterial wall, it stands to reason that a healthy glycocalyx might be associated with good arterial elasticity.

We conducted a pilot study to test patients for arterial elasticity — among other markers — before and after the consumption of ArterosilHP.

Nineteen healthy human subjects (11 males age 22 to 64 and 8 males age to 60) were randomly recruited for t single blinded clinical study, which w conducted at an independent cardiolo center on the Baylor Medical Campus Plano, Texas. Their vascular health con tion was evaluated utilizing MaxPulse, FDA approved Class II device (The Carc Group, 6440 N. Central Expressway, Su 100, Dallas, TX 75206). The MaxPulse utilizes accelerated plethysmography technology with data being gathered by way of a finger probe. This technology, also known as pulse wave analysis, includes multiple factors including wave type, arterial elasticity, eccentric constriction and remaining blood volume valuations.

In this study, the baseline reading was taken at approximately 2 hours (+/- 30 minutes) post consumption of a breakfast of the subjects' choice. Immediately after the baseline reading one capsule of Arterosil-HP was swallowed. A post-dose reading was taken every 30 minutes for 3 hours, for a total of 7 readings (baseline, 30 min, 60 min, 90 min, 120 min, 150 min & 180 min +/- 5 minutes). The patients were kept in a quiet ambient environment. No food or liquid (other than small amounts of water as needed) was consumed during the 3 hour testing period.

The results are summarized in the table below:



In sum, 78.9% of subjects experienced an increase in arterial elasticity. The average percentage increase in arterial elasticity was 89.6% ($p = .0081$) The mean time to maximum increase was 118 minutes. There was concurrent improvement in remaining blood volume and eccentric contraction.

In this preliminary study, we were able to demonstrate that ArterosilHP improves arterial elasticity in healthy human subjects. It is likely this acute beneficial effect is a result of improved glycocalyx and its mediated endothelial functions. These new data are in agreement with our previous findings that ArterosilHP helps regenerate the endothelial glycocalyx and restore compromised endothelial functions. Clearly there is a need for further studies to validate these early results.

We know that arterial stiffness indicates adverse changes of blood vessel structure and function, and poses a significant threat to patients' cardiovascular health. [27] If it transpires that rebuilding the glycocalyx has a rapid and positive impact on arterial elasticity, this could suggest a valuable clinical intervention, both for patients presenting disease conditions and for those seeking preventative care.

About the Primary Author

Dr. Derrick DeSilva is a practicing internist with a wide range of medical interests. He serves as Senior Attending Staff at the Department of Medicine, Raritan Bay Medical Center (RBMC) in Perth Amboy, New Jersey. He also serves on the teaching faculty of the JFK Medical Center in Edison, New Jersey. Dr. DeSilva serves as Chairman of the Planning Committee for the Age Management Medicine Group (AMMG) and is a Past President of the American Nutraceutical Association. He has been a recipient of the Alan Mintz Award for Excellence in Clinical Age Management Medicine, and he has received the Best Doctor Award by Castle Connolly for the past 15 consecutive years. Dr. DeSilva is host of "Ask the Doctor" on WCTC Radio, a medical correspondent for Cablevision (News 12 New Jersey) and host of "12 to Your Health".

References

1. Russell Ross, John Glomset & Laurence Harker. Response to Injury and Atherogenesis. Am J Pathol. (1977) 86(3): 675–684.
2. C. S. Alphonsus & R. N. Rodseth. The Endothelial Glycocalyx: A Review of the Vascular Barrier. Anaesthesia (2014) 69(7):777-84.
3. Bingmei M. Fu & John M. Tarbell. Mechano-sensing and Transduction by Endothelial Surface Glycocalyx: Composition, Structure, and Function. Wiley Interdiscip Rev Syst Biol Med. (2013) 5(3): 381–390.
4. Hana Kolálová, Barbora Ambruzová, Lenka Švihálková Šindlerová, Anna Klinke & Lukáš Kubala. Modulation of Endothelial Glycocalyx Structure under Inflammatory Conditions. Mediators of Inflammation (2014) Article ID 694312, 1-17.

5. Sietze Reitsma, Dick W. Slaaf, Hans Vink, Marc A. M. J. van Zandvoort & Mirjam G. A. oude Egbrink. The Endothelial Glycocalyx: Composition, Functions, and Visualization. Eur J Physiol (2007) 454:345–359.

6. Bernard F. Becker, Daniel Chappell & Matthias Jacob. Endothelial Glycocalyx and Coronary Vascular Permeability: the Fringe Bene t. Basic Research in Cardiology (2010) 105:687– 701.

7. F. E. Curry & R. H. Adamson. Endothelial Glycocalyx: Permeability Barrier and Mechanosensor. Annals of Biomedical Engineering (2012) 40:828–839.

8. A. W. Mulivor & H. H. Lipowsky. Role of Glycocalyx in Leukocyte-endothelial Cell Adhesion. American Journal of Physiology: Heart and Circulatory Physiology (2002) 283(4):H1282– H1291.

9. Eno E. Ebong, Sandra V. Lopez-Quintero, Victor Rizzo, David C. Spray & John M. Tarbell. Shear-induced Endothelial NOS Activation and Remodeling via Heparan Sulfate, Glypican-1, and Syndecan-1. Integr Biol (Camb). (2014) 6(3): 338–347.

10. Wanyi Yen, Bin Cai, Jinlin Yang, Lin Zhang, Min Zeng, John M. Tarbell & Bingmei M. Fu. Endothelial Surface Glycocalyx Can Regulate Flow-Induced Nitric Oxide Production in Microvessels In Vivo. PLoS One (2015) 10(1):e0117133.

11. Max Nieuwdorp, Timon W. van Haeften, Mirella C.L.G. Gouverneur, Hans L. Mooij, Miriam H.P. van Lieshout, Marcel Levi, Joost C.M. Meijers, Frits Holleman, Joost B.L. Hoekstra, Hans Vink, John J.P. Kastelein & Erik S.G. Stroes. Loss of Endothelial Glycocalyx During Acute Hyperglycemia Coincides With Endothelial Dysfunction and Coagulation Activation In Vivo. Diabetes (2006) 55(2):480-486.

12. Hans Vink, Alina A. Constantinescu, & Jos A.E. Spaan. Oxidized lipoproteins degrade the endothelial surface layer: implications for platelet-endothelial cell adhesion. Circulation (2000)101:1500–1502

13. Bart J. M. Eskens, Thomas M. Leurgans, Hans Vink & Jurgen W. G. E. VanTeeffelen. Early Impairment of Skeletal Muscle Endothelial Glycocalyx Barrier Properties in Diet Induced Obesity in Mice. Physiol Rep. (2014) 2(1):e00194.

14. Claudia Nussbaum, Ana Cavalcanti Fernandes Heringa, Zuzana Mormanova, Alexandra F. Puchwein-Schwepcke, Su- sanne Bechtold-Dalla Pozza & Orsolya Genzel-Boroviczény. Early Microvascular Changes with Loss of the Glycocalyx in Children with Type 1 Diabetes. J Pediatr. (2014) 164(3):584589.

15. Sandra V. Lopez-Quintero, Limary M. Cancel, Alexis Pierides, David Antonetti, David C. Spray & John M. Tarbell. High Glucose Attenuates Shear-Induced Changes in Endothelial Hydraulic Conductivity by Degrading the Glycocalyx. PLoS One. (2013) 8(11):e78954.

16. Andrew H. J. Salmon & Simon C. Satchell. Endothelial Glycocalyx Dysfunction in Disease: Albuminuria and Increased Microvascular Permeability. J Pathol (2012) 226: 562– 574.

17. Ties A. Mulders, Max Nieuwdorp, Erik S Stroes, Hans Vink & Sara-Joan Pinto-Sietsma. Non-invasive Assessment of Microvascular Dysfunction in Families with Premature Coronary Artery Disease. Int J Cardiol. (2013) 168(5):5026-5028.

18. Carmen A. Vlahu, Bregtje A. Lemkes,Dirk G. Struijk, Marion G. Koopman, Raymond T. Krediet & Hans Vink. Damage of the Endothelial Glycocalyx in Dialysis Patients. J Am Soc Nephro (2012) l23:1900–1908.

19. Remy J.H. Martens, Hans Vink, Robert J. van Oostenbrugge & Julie Staals. Sublingual Microvascular Glycocalyx Dimensions in Lacunar Stroke Patients. Cerebrovasc Dis (2013) 35:451–454.

20. Elaheh Rahbar, Jessica C Cardenas, Gyulnar Baimukanova, Benjamin Usadi, Roberta Bruhn, Shibani Pati, Sisse R Ostrowski, Pär I Johansson, John B Holcomb & Charles E Wade. Endothelial Glycocalyx Shedding and Vascular Per-meability in Severely Injured Trauma Patients. J Transl Med. (2015) 13:117.

21. Angela J. Drake-Holland & Mark I. Noble. The Important New Drug Target in Cardiovascular Medicine – the Vascular Glycocalyx. Cardiovascular & Haematological Disorders-Drug Targets (2009) 9:118-123.

22. Angela J. Drake-Holland & Mark I. Noble. Update on the Important New Drug Target in Cardiovascular Medicine the Vascular Glycocalyx. Cardiovascular & Haematological Disorders-Drug Targets (2012) 12:76-81.

23. John M. Tarbell & Limary M. Cancel. The Glycocalyx and Its Significance in Human Medicine. J Intern Med. (2016) 280(1):97-113. doi: 10.1111/joim.12465. Epub 2016 Jan 8.

24. M. Cecelja and P. Chowienczyk. Role of Arterial Stiffness in Cardiovascular Disease. JRSM Cardiovascular Disease (2012) 1(4): 11

25. E. Grey, C. Bratteli, S. P. Glasser, C. Alinder, S.M. Finkelstein, , B. R. Lindgren, & J. N. Cohn. Reduced Small Artery But Not Large Artery Elasticity Is an Independent Risk Marker for Cardiovascular Events American J of Hypertension (2003) 16(4): 265-269.

26. Jun Tao, Ya-Fei Jin, Zheng Yang, Li-Chun Wang, Xiu-ren Gao, Liu Lei & Hong Ma. Reduced Arterial Elasticity Is Associated with Endothelial Dysfunction in Persons of Advancing Age. American J of Hypertension (2004) 17(8): 654-659.

27. J.L. Cavalcante, J.A. Lima JA, A. Redheuil, M.H. Al-Mallah. Aortic Stiffness: Current Understanding and Future Directions. J Am Coll Cardiol. (2011) 57(14):1511-22. doi: 10.1016/j.jacc.2010.12.017.

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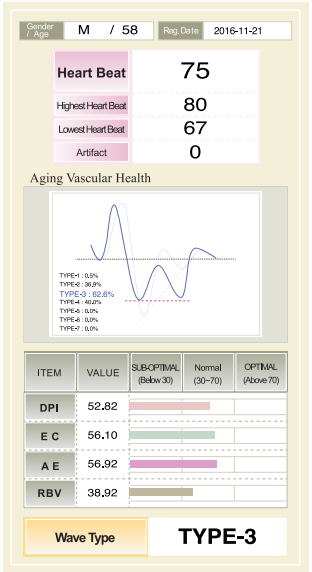

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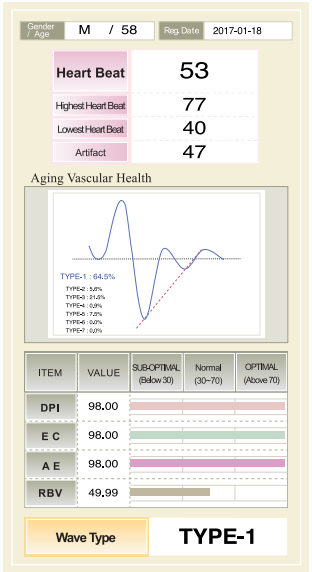

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Thierry Hertoghe, MD, a renowned specialist in the fields of anti-aging and hormone therapies, will provide the latest research related to aging therapies. Dr. Hertoghe will further discuss how to recognize and treat nutritional and hormonal deficiencies, and how hormone therapies can correct imbalances in both men and women.

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Nitric Oxide Workshop: Applications for Clinical Practice

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Considered an anti-aging molecule, nitric oxide will be reviewed by experts in this workshop, with a concentration on its biology, physiology, and the current clinical data regarding diagnostic tools for nitric oxide testing. Instructors will further provide lifestyle and therapeutic treatment options for rebalancing nitric oxide levels.

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This workshop will focus on the field of energy medicine, and its applications in building and maintaining health and wellness. Through a historic review of the uses of energy medicine in various cultures, Silvia Binder, ND, PhD will explore the roles of different energetic diagnostic approaches, and the significance of cellular detoxification through bioenergetics.

Menopause/Andropause: Improving the Health & Happiness of Your Patients with Bioidentical Hormones

December 17, 2017

8 CME CREDITS

Drs. Wright & Rosensweet will discuss the ways in which hormone therapies can serve as optimal treatments for menopause and andropause. The seminar is focused on practical, implementable information surrounding the practice of BHRT, with an investigation into various testing methods, and evaluation and treatment protocols.

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A nutritional formula produces a favorable glycemic response in healthy volunteers with prediabetes in a randomized, crossover evaluation

By Jyh-Lurn Chang, PhD (Scientific and Editorial Manager) and Kirti Salunkhe, MD (Senior Director of Medical Affairs)

Metagenics, Inc. | 9770 44th Ave. NW, Ste 100. Gig Harbor, WA 98332, USA.

INTRODUCTION

Individuals with obesity are likely to have insulin resistance and inflammation resulting from hyperglycemia and dyslipidemia.[1] This prediabetic phase—defined as impaired fasting glucose, impaired glucose tolerance, or elevated hemoglobin A1c (HbA1c)[2]—offers clinicians an opportunity to address insulin resistance earlier and prevent progression to type 2 diabetes (T2DM). Diet and lifestyle interventions can also foster weight loss[3] but compliance and adherence may be challenging for many patients.[4]

A new nutritional formula (UGC) was developed based on clinical care guidelines and current scientific evidence to promote a healthy glycemic response. The primary aim of the study was to compare glycemic responses in healthy, overweight, subjects with prediabetes following ingestion of UGC and a common American breakfast food (OAT). The secondary aim was to compare the glycemic response of UGC with 2 commercially available meal-replacement foods (LLC and GLU).

MATERIALS AND METHODS

Eligible participants were adult men and women aged 18-75 years with a BMI of ≥ 25 kg/m2 and baseline HbA1c value 5.5-6.5%. Subjects using medications for insulin resistance, T2DM, or dysglycemia were excluded from the study.

The study was an open-label randomized, crossover evaluation performed at the Functional Medicine Research Center (FMRC, Gig Harbor, WA), the research arm of Metagenics, Inc. Eligible subjects were then randomly assigned to receive one serving of UGC (Metagenics, Inc.), OAT, LCC and GLU at 4 different visits (**Table 1**). Blood samples were collected 30-180 minutes after sample ingestion to determine blood glucose. At each time point subjects

also fill out the hedonics and satiety questionnaires. The study was carried out in compliance with the Helsinki Declaration of 1975, and the study was approved by the Copernicus Group Independent Review Board (Durham, NC). Informed, written and witnessed consent was obtained from all participants prior to enrollment in the study.

parameters, paired t-tests were performed to compare UGC with other tested products. Data were reported as mean ± SEM. A two-sided value of $p<0.05$ was considered significant.

Table 1.
Nutritional content of UGC and the three commercially available foods.

	UGC (powder food drink)	OAT (instant oat meal)	LCC (powder meal replacement drink)	GLU (liquid meal replacement)
Serving size	55 g	43 g	65 g	237 ml
Total calories	220	160	266	190
Calories from fat	72	20	57	60
Fat (g)	8	2	6	7
Saturated fat (g)	1	0.5	1.5	1
Carbohydrate (g)	26	32	32	23
Dietary fiber (g)	4	3	4	3
Sugars (g)	3	11	10	6
Protein (g)	15	4	20	10
Sodium (mg)	180	210	340	210
Potassium (mg)	75	120		500

Glycemic response to the 4 study products was determined using incremental area-under-the-curve (iAUC) for blood glucose, peak blood glucose above baseline (Cmax), time to peak blood glucose (Tmax), and the terminal slope of a glucose response. Secondary outcomes included glycemic index, glycemic load, and hedonics and satiety questionnaires. Adverse events were documented throughout the study to determine whether there were any reactions to study products. For glycemic response

RESULTS

Primary endpoints: glycemic response UGC vs. OAT

Consumption of OAT resulted in a significantly higher glycemic response than consumption of UGC. The iAUC was significantly greater for OAT compared to UGC (**Table 2**). Comparison of post-prandial blood glucose levels for OAT and UGC demonstrated significant differences at 30,

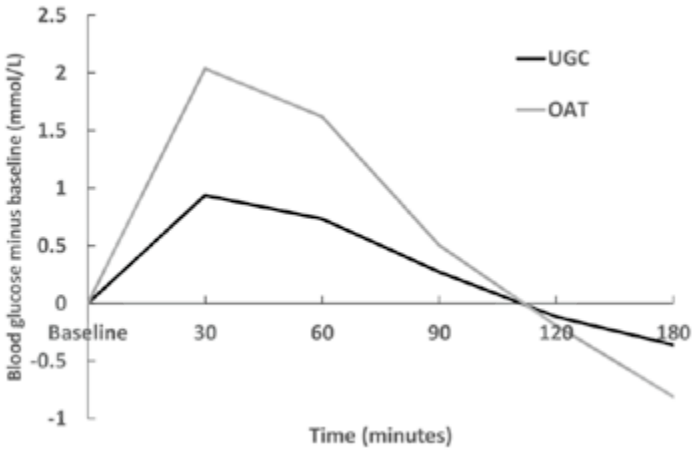
Table 2. Glycemic response parameters for UGC and OAT.

Parameter	Product	Mean (SEM)	P value*
iAUC, 0-1 hour (mg/dL x hour)	OAT UGC	25.79 (2.53) 12.42 (1.95)	<0.0001
iAUC, 0-2 hour (mg/dL x hour)	OAT UGC	39.58 (3.76) 22.36 (3.09)	0.0006
iAUC, 0-3 hour (mg/dL x hour)	OAT UGC	42.56 (3.79) 27.03 (4.28)	0.0051
Cmax (mg/dL)	OAT UGC	42.92 (3.19) 22.00 (3.07)	<0.0001
Tmax (hour)	OAT UGC	0.73 (0.06) 0.92 (0.134)	0.1289
Terminal Slope (mg/dL/min)	OAT UGC	-0.155 (0.263) -0.031 (0.136)	0.0001

60, and 90 minutes after ingestion (**Figure 1**; p<0.001, p<0.001, and p=0.0387, respectively). Cmax and terminal slope were significantly lower with UGC compared with OAT (**Figure 2**; p<0.0001).

Secondary endpoint: glycemic response

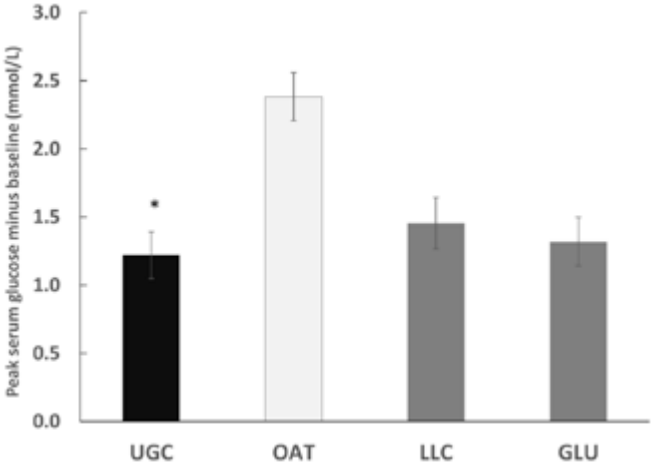
Figure 1. Mean serum glucose minus baseline vs. time after ingesting UGC and OAT.



UGC vs. LCC and GLU

Cmax of UGC was marginally reduced relative to LCC and GLU but the differences were not statistically different (**Table 3**).

Figure 2. Mean peak serum glucose minus baseline after ingesting 4 study products. *p<0.001 compared with OAT



Tmax of UGC was marginally later relative to LCC and GLU; the difference between UGC and GLU showed a trend toward significance (p=0.0646).

Secondary endpoint: glycemic index and glycemic load

UGC had a lower glycemic index (68 units vs. 91 units, p=0.0842) and glycemic load (15 units vs. 26 units, p=0.0006) compared to OAT. UGC, LCC, and GLU had similar glycemic index and glycemic load (data not shown).

Secondary endpoint: hedonics, satiety, and safety

Overall, participants rated all 4 products between a neutral "Neither like nor dislike" (score of 5) and "Like moderately" (score of 6). Considering both texture and flavor, UGC received a slightly higher score from participants than LCC (UGC= 5.750, LCC=4.708; p=0.0679) and a significantly higher score for texture compared to LCC (UGC= 5.458, LCC=4.083; p=0.0136). At hour 2 following ingestion, participants rated UGC higher than GLU in terms of

Table 3. Glycemic response parameters for UGC and OAT.

Parameter	Product	Mean (SEM)	P value in comparison with UGC
iAUC (mg/dL x hour	UGC LCC GLU	27.03 (4.28) 27.03 (3.76) 22.89 (3.94)	 1.00 0.4424
Cmax (mg/dL)	UGC LCC GLU	22.00 (3.07) 26.21 (3.41) 23.79 (3.22)	 0.3457 0.6873
Tmax (hour)	UGC LCC GLU	0.92 (0.134) 0.81 (0.094) 0.69 (0.089)	 0.3962 0.0646
Terminal Slope (mg/dL/min)	OUGC LCC GLU	-0.031 (0.136) -0.073 (0.020) -0.050 (0.016)	 0.1969 0.6262

sense of fullness (p=0.0198). No participant experienced any adverse effects during the study that required medical attention.

DISCUSSION

In this study, UGC intake was associated with reduced postprandial glycemic response (iAUC, Cmax and terminal slope) in healthy subjects with prediabetes who were overweight. Study subjects also rated UGC as similarly palatable as OAT, a standard American breakfast food. These data suggest that participants who consumed UGC might be less likely to experience hypoglycemia up to 180 minutes after ingestion.

The studied nutritional formula has a macronutrient ratio (as % energy) recommended by clinical care guidelines:[5] 40% carbohydrate, 30% fat, and 30% protein. It also contains plant-based fat that is high in monounsaturated fatty acids (MUFA) while minimizing saturated fat content. Studies have shown that increasing the proportion of dietary MUFA increases insulin sensitivity,[6] decreases LDL-cholesterol and triglyceride levels,[7] and increases the level of HDL cholesterol,[8] suggesting a benefit for both glucose and lipid metabolism. The amylopectin-enriched carbohydrate in UGC—originally designed to maintain steady blood glucose levels in patients with Glycogen Storage Disease (who frequently experience episodes of hypoglycemia during their sleep)[9]—helps maintain normoglycemia in athletes and insulin-sensitive adults as well as patients with type 1 diabetes.[10-12] Other added low-glycemic-index carbohydrates in the study product, such as the soluble fiber isomalto-oligosaccharides, have demonstrated beneficial effects in diabetic patients.[13] High-protein and reduced-carbohydrate diets also improved metabolic responses in patients with prediabetes and T2DM.[14]

The macronutrient composition in UGC differs from that in OAT, as carbohydrates contribute to nearly 80% total energy for OAT but only 40% for UGC. In comparison, the difference in macronutrient ratio between UGC and LCC and GLU is smaller, which may explain the less striking results when comparing their glycemic responses (secondary endpoints). One noticeable difference is that the main type of carbohydrates is heat-moisture treated amylopectin in UGC and maltodextrin in GLU. In a crossover clinical trial that compared these two types of carbohydrates, Rob-

erts et al. reported that ingestion of the heat-moisture treated amylopectin blunted the initial spike in serum glucose and insulin compared with maltodextrin.[10]

As the prevalence of prediabetes continues to increase (from 27.4% in 1999-2002 to 34.1% in 2007-2010, according to NHANES data),[15] a nutritional formula specifically designed for glucose control may help support patient compliance in long-term dietary modification regimen. This study, however, was limited to investigating the acute glycemic response after ingestion of one dose of the study product. Although a 16-week randomized controlled trial has reported beneficial effects of UGC on HbA1c and body weight in patients with T2DM,[16] similar studies in prediabetic populations have not been conducted.

In summary, in subjects with prediabetes, a single consumption of a novel nutritional formula UGC produced a balanced, sustained, and stable glucose response for up to 3 hours of use, as compared with a less favorable response to a commercial product (OAT)

REFERENCES

1. DeFronzo RA. Pathogenesis of type 2 diabetes mellitus. Med Clin North Am 2004;88:787-835, ix.
2. Buysschaert M, Bergman M. Definition of prediabetes. Med Clin North Am 2011;95:289-297, vii.
3. Li Z, Tseng CH, Li Q, et al. Clinical efficacy of a medically supervised outpatient high-protein, low-calorie diet program is equivalent in prediabetic, diabetic and normoglycemic obese patients. Nutr Diabetes 2014;4:e105.
4. Pi-Sunyer FX. Weight loss in type 2 diabetic patients. Diabetes Care 2005;28:1526-1527.
5. Clinical nutrition guideline for overweight and obese adults with type 2 diabetes, prediabetes or those at risk for developing type 2 diabetes. Joslin Diabetes Center & Joslin Clinic, 2011. (Accessed November 17, 2014, at https://www.joslin.org/bin_from_cms/Nutrition_Guidelines-8.22.11(1).pdf.)
6. Schwab U, Lauritzen L, Tholstrup T, et al. Effect of the amount and type of dietary fat on cardiometabolic risk factors and risk of developing type 2 diabetes, cardiovascular diseases, and cancer: a systematic review. Food Nutr Res 2014;58.
7. Allman-Farinelli MA, Gomes K, Favaloro EJ, Petocz P. A diet rich in high-oleic-acid sunflower oil favorably alters low-density lipoprotein cholesterol, triglycerides, and factor VII coagulant activity. J Am Diet Assoc 2005;105:1071-1079.
8. Labonte ME, Jenkins DJ, Lewis GF, et al. Adding MUFA to a dietary portfolio of cholesterol-lowering foods reduces apoAI fractional catabolic rate in subjects with dyslipidaemia. Br J Nutr 2013;110:426-436.
9. Correia CE, Bhattacharya K, Lee PJ, et al. Use of modified cornstarch therapy to extend fasting in glycogen storage disease types Ia and Ib. Am J Clin Nutr 2008;88:1272-1276.
10. Roberts MD, Lockwood C, Dalbo VJ, Volek J, Kerksick CM. Ingestion of a high-molecular-weight hydrothermally modified waxy maize starch alters metabolic responses to prolonged exercise in trained cyclists. Nutrition 2011;27:659-665.
11. Sands AL, Leidy HJ, Hamaker BR, Maguire P, Campbell WW. Consumption of the slow-digesting waxy maize starch leads to blunted plasma glucose and insulin response but does not influence energy expenditure or appetite in humans. Nutr Res 2009;29:383-390.
12. Qi X, Band M, Tester R, Piggott J, Hurel S. Use of slow release starch (SRS) to treat hypoglycaemia in type 1 diabetics. Nutrition & Food Science 2010;40:228-234.
13. Riccardi G, Rivellese AA, Giacco R. Role of glycemic index and glycemic load in the healthy state, in prediabetes, and in diabetes. Am J Clin Nutr 2008;87:269S-274S.
14. Hamdy O, Horton ES. Protein content in diabetes nutrition plan. Curr Diab Rep 2011;11:111-119.
15. Abraham TM, Fox CS. Implications of rising prediabetes prevalence. Diabetes Care 2013;36:2139-2141.
16. Mottalib A, Salsberg V, Mohd-Yusof B, et al. Effects of 3 different models of medical nutrition therapy on A1c and body weight in overweight and obese patients with type 2 diabetes: a randomized clinical study [Abstract]. American Diabetes Association 76th Scientific Sessions. New Orleans, LA2016:P-759..

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MODULE I

A Metabolic & Functional Approach to Endocrinology

This module provides an overview of the functions and interrelationships of specific hormones in the body including hormonal changes that manifest in men and women with aging. Metabolic, functional, and nutritional approaches to managing hormone deficiencies and endocrine disorders, including diabetes and obesity are covered in this module.

MODULE II

A Metabolic & Functional Approach to Cardiovascular Disease

The causes, mechanisms, diagnosis, and management of cardiovascular and cardiometabolic diseases including CHD, CHF, hypertension, metabolic syndrome, dyslipidemia, atherosclerosis, and renal disease are covered in this module. Topics include cardiovascular pathophysiology and biology, inflammation, oxidation, hormones, adipokines, stress, nutrition and nutrigenomics, glycemic control, environmental factors and toxicology, infections, and risk factor testing.

MODULE III

A Metabolic & Functional Approach to Neurology

This module reviews the most recent developments in the field of neurology utilizing a metabolic approach to the prevention, management, and treatment of neurologic diseases. The course will cover pathophysiology and the role of neurotransmitters, inflammatory and degenerative disorders, neurovascular diseases, psychological and psychiatric syndromes, the gut-immune-brain connection, and healthy brain function.

MODULE IV

A Metabolic & Functional Approach to Gastroenterology

Comprehensive metabolic, functional, and nutritional approaches to gastrointestinal dysfunction and disease are reviewed in this module. Physiology and pathophysiology, GI microbiome and dysbiosis, gut permeability, hormones, diet, inflammatory bowel diseases, celiac disease and gluten sensitivity, the gut-immune-brain connection, irritable bowel syndrome, and other digestive and glandular disorders are highlighted.

MODULE V

A Metabolic & Functional Approach to Nutrition & Exercise

This module focuses on the role of nutrition and exercise in metabolic medicine with an emphasis on guidelines, protocols, and clinical applications. Nutritional biochemistry, aging, metabolism, diet and nutritional supplements, weight gain, weight loss and maintenance, exercise/sports and activity, nutrigenomics, proteomics, and metabolomics, and cancer risk are discussed.

MODULE VI

A Metabolic & Functional Approach to Toxicology & Detoxification

This module covers symptoms, disorders and diseases associated with exposures of heavy metals, pesticides, chemicals, drugs, nutrients, the natural environment, and other toxic causes of oxidative stress. This course describes the pathophysiology of toxic exposure, methods to prevent and avoid exposure including nutritional and lifestyle approaches, early detection, lab testing, and treatment protocols. Metabolic, digestive and antioxidative detoxification phases and processes are detailed.

MODULE VII

A Metabolic & Functional Approach to Inflammation & Autoimmune Disease

This module focuses on inflammatory disorders, autoimmune diseases, allergies, cancer, and the gut-immune-brain connection. Cellular and molecular biology of immunity, the cellular stress response, oxidation, genetic damage, inflammation, etiology of disease including environmental and lifestyle factors, and the risk for cancer development are reviewed. Clinical approaches to patient evaluations, testing, and disease management are provided.

MODULE VIII (NON–CME)

Clinical Practice Protocols

This review course examines patient case histories with a range of metabolic symptoms, disorders, or diseases that are covered in Modules I-VII. This clinical intensive course provides the tools to prevent, detect, diagnose, treat, and manage a variety of patient conditions that are commonly and uncommonly observed in the clinical setting. The goal is to provide comprehensive metabolic, functional, and nutritional approaches towards disease management that enable the Fellow to practice Metabolic Medicine confidently and effectively.

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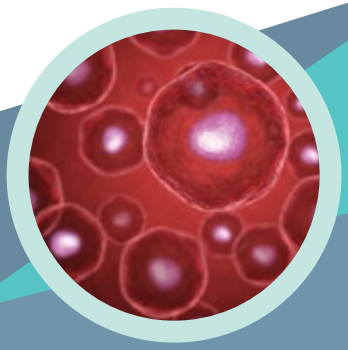

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OBJECTIVES

- Possess a thorough understanding of cell anatomy & biology, and basic stem cell properties and processes.
- Develop expert understanding of harvesting methods for various stem cell procedures.
- Demonstrate a working knowledge surrounding cardiovascular, vascular, and respiratory conditions with relation to stem cell therapies.
- Understand the treatment of musculoskeletal & neurodegenerative conditions through the use of various stem cell sources.
- Learn best practices for implementing and integrating regenerative medical treatments into practice.
- Assess the ethical considerations and controversies surrounding cellular therapy, while discussing the risks, benefits, applications, and current legalities surrounding cell cryopreservation and cell banking.
- Participate in interactive sessions with leading experts practicing live stem cell demonstrations.

MODULE I:
The Biological and Molecular Basis for Regenerative Medicine

MODULE II:
Best Practices in Regenerative Medicine

MODULE III:
In-Office Applications of Regenerative Therapies: Focus on Cardiovascular, Vascular, & Respiratory Conditions

MODULE IV:
In-Office Applications of Regenerative Therapies: Focus on Musculoskeletal, Neurological & Neuro-Degenerative Conditions

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First Randomized, Double-Blind, Placebo-Controlled Study to Show Telomeres Getting Longer in Humans

A new study, conducted on 97 relatively healthy cytomegalovirus-positive subjects aged 53-87, found participants taking TA-65MD® significantly increased telomere length over a 12 month period compared to a placebo group.[1]

TA-65® is a patented, all natural, plant-based compound that animal and in vitro studies have indicated activates telomerase.[1-4] Telomerase is an enzyme that counteracts the attrition of telomere length by adding telomere repeats to the end of chromosomes.[5]

Telomeres protect the chromosome, preventing the loss of DNA to ensure cells replicate properly. As people age, telomeres shorten and leave the genetic DNA on the chromosomes vulnerable to damage and mutations. Over time, telomere shortening causes cells to die or to become senescent. By activating telomerase, an enzyme that adds nucleotides to telomeres, cells are able to live longer and continue to function properly.

This new study, published in Rejuvenation Research, confirms previous scientific studies demonstrating that TA-65MD® activates telomerase and lengthens telomeres in a statistically significant manner. Notably, this is the first double blind, placebo-controlled study to show actual lengthening of telomeres in humans.

Study Summary:

- Study participants: 97 men and women (53-87 years old)
- Study length: 12 months
- First study to show statistically significant ($p<0.005$) lengthening of telomeres in humans

Placebo Group Decrease in median telomere lenght over 12 months	
Median telomere lenght	↓ 290=100bp
20th percentile telomere lenght	↓ 170=50bp

TA-65® Group Increase vs placebo group in median telomere lenght over 12 months	
Median telomere lenght	↑ 533=160bp
20th percentile telomere lenght	↑ 270=90bp

"By activating telomerase, we can help slow and perhaps even reverse cellular aging. These findings are an exciting step in our goal to safely prolong the life of human cells," said Noel Thomas Patton, the founder of T.A. Sciences, "We have been a leader in telomerase research since 2002 and will continue to invest in valuable research to help further the field of telomere biology."

References

1. Salvador, L., et al., A Natural Product Telomerase Activator Lengthens Telomeres in Humans: A Randomized, Double Blind, and Placebo Controlled Study. Rejuvenation Res, 2016. 19(6): p. 478-484.
2. Harley, C.B., et al., A natural product telomerase activator as part of a health maintenance program. Rejuvenation Res, 2011. 14(1): p. 45-56.
3. Harley, C.B., et al., A natural product telomerase activator as part of a health maintenance program: metabolic and cardiovascular response. Rejuvenation Res, 2013. 16(5): p. 386-95.
4. Dow, C.T. and C.B. Harley, Evaluation of an oral telomerase activator for early age-related macular degeneration - a pilot study. Clin Ophthalmol, 2016. 10: p. 243-9.
5. Wu, R.A., et al., Telomerase Mechanism of Telomere Synthesis. Annu Rev Biochem, 2017.

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- **Module B** Advanced Hormonal Prescribing and Herbal Therapies for Women
- **Module C** Advanced Insulin Therapies and Hormones/Botanicals and Pregnancy
- **Module D** Men's Health and Advanced Compounding for Hormonal Treatments

Weight & Lifestyle Management Certification

In this program you will learn the unique relationship between adrenal dysfunction stress with hormonal imbalance and weight gain plus weight loss plateaus. Participants will recognize and understand the prevalence of adult obesity and the risk factors involved and understand the bio-chemistry of how the body breaks down proteins, fats and carbohydrates.

- **Module A** Individualized Weight Management for the Patient
- **Module B** Comprehensive Weight Loss for the Integrative Physician
- **Module C** Weight Management
- **Module D** Brain Directed Weight Loss

Brain Fitness Certification

One of the major medical issues that will affect all of our patients is how to maintain memory throughout their life. The Brain Fitness Modules XV: A-D are a group of four modules that will give you new skills to help patients prevent memory loss along with treat patients who already have cognitive decline.

- **Module A** The Basics of Brain Fitness and Memory Maintenance
- **Module B** How the Brain Learns and Metabolism of the Brain
- **Module C** Dementia Disorders: A Practical Guide for Clinicians
- **Module D** Brain Fitness Therapies

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Metabolic Cardiovascular Certification

The modules will start with basic teaching of vascular biology concepts and how this relates to vascular disease. Vascular aging pathophysiology, diagnosis, prevention and treatment will be reviewed as well. Dyslipidemia will be defined based on new basic science and clinical research. Inflammation, oxidative stress, the role for expanded lipid profiles using LDL and HDL particle size and number are reviewed in the context of the pathophysiology of vascular damage. Proper analysis of CV risk factors, mediators and CV risk scoring will be taught using the COSEHC risk analysis methods. Review of CVD labs and noninvasive CV tests will be reviewed. The role of heavy metals in CVD will be extensively reviewed based on a functional medicine model.

Module A How to Apply Nutrition, Exercise and Weight Management Programs Related to Vascular Biology
Module B Components of Cardiovascular Disease
Module C Nutritional and Dietary Therapies for Prevention and Treatment of Cardiovascular Disease
Module D Various Conditions in Cardiovascular Disease

Sports Medicine Certification

This certification program focuses on the "science of eating," including diet programs, recipes and nutrients that help athletes reach peak performance and success. Factors that hinder such success are also reviewed. The program discusses the body's physiological response to exercise, treatments for sports-related conditions, biometrics, eating disorders, the aging athlete and psychology.

Module A The Body's Physiological Response to Exercise
Module B Treatments for Sports-Related Conditions
Module C Biometrics and Eating Disorders
Module D The Aging Athlete and Psychology

Lifestyle Coaching Certification

The Certification in Lifestyle Coaching teaches the healthcare practitioner how to properly administer information that will positively impact clinical outcomes and improve the overall standard of care. The client needs to live a healthy lifestyle and this course teaches you how to teach your client the proper steps. It's about setting up your clients to succeed.

Module A Wellness Revolution and How You Can Become a Part of the Solution
Module B Basic Nutrition
Module C Fundamentals of a Co-Active Coaching Model
Module D Counseling the Patient and Improving Energy

Addiction Medicine Certification

The goal of the Certification in Addiction Medicine is to train physicians and other healthcare providers in metabolic approaches to addiction recovery. This program covers all factors of addiction including triggers, pain management, different types of addiction, biochemical and neuroendocrine factors, electromagnetic changes, detoxification, recovery & treatment and much more.

Module A Addiction: The Types and Symptoms: Biochemical, Metabolic, Neurobiologic & Psycho-Emotional
Module B Addiction: The Behavior and Effects: Neuroendocrine Pathways
Module C Addiction: The Complexities of Comorbidity in Addiction
Module D Addiction: The Recovery: Treatment Steps and the Pillars of Healing

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▸ Completion of 4 Certification Modules ▸ Board Certification *(where applicable) ▸ Membership

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SERMORELIN & ASSOCIATED PEPTIDES:

Restoring Growth Hormone in Aging

By Anthony J. Campbell, PharmD

INTRODUCTION

There are few things in life as relentless as aging. It is an inescapable part of life; ever pursuing us from the moment we draw our first breath to the day we breathe our last. Patiently, aging slowly chips away at one's youthful vigor and vitality, gradually deteriorating things such as lean body mass, bone density, aerobic exercise capacity, and cognitive function to name a few. Because of the aggressive and unprovoked assault on human longevity, aging may be categorized by some as an adversary; a disease necessitating eradication. Truthfully, however, aging is as normal a life process as is breathing and while it does take its toll and demands its dues over time, aging should not be viewed as an ailment in need of a cure. Yet, due to increased frailty and because many of the traditional signs of aging appear to mirror the features associated with the distinct clinical entity of Adult Growth Hormone Deficiency (AGHD), providing growth hormone (GH) directly to individuals as they age would appear to be the most direct and obvious route to restoring declining levels of GH. However, due to the wide array of potential side effects in older adults (i.e. edema, arthralgia, elevated blood glucose, etc.) it is typically undesired and many times contraindicated. Moreover, while initiating therapy at lower doses may decrease the likelihood of developing these common side effects, its use for anti-aging purposes (outside of controlled clinical research studies) is currently prohibited by US Federal law, 21 U.S.C. §333(e). Nevertheless, with the discovery and implementation of GH secretagogues in aged individuals – (i.e. Growth Hormone Releasing Hormone [GHRH], Growth Hormone Releasing Peptides [GHRP], and similar mimetics – the signs and symptoms of aging have recently become vulnerable to an alternative method of having their deleterious effects on the body decreased and slowed in rate of appearance.

GROWTH HORMONE SECRETION AND REGULATION

A substantial number of studies and published literature indicate that while there is an exponential decline in GH secretion after puberty, there is a progressive and nearly linear rate of decline of GH secretion after the third decade of life in otherwise normal, healthy adults. In clinical literature, Melmed reports that GH secretion typically peaks at puberty at about 150μg/kg/day, then gradually and relentlessly decreases to approximately 25μg/kg/day by the age of 55.[1] Of particular interest is the fact that while the amplitude, or strength, of recurring GH pulses throughout the day are significantly reduced in older individuals, the frequency, or number of pulses, remain nearly unchanged; moreover, the nocturnal pulsatile release of GH secretion is most significantly reduced in an aged individual (Figure 1). It has been reported in the literature that there are as many as 10 pulses of GH secretion per day, each lasting approximately 90 minutes with a separation of about 2 hours with the highest secretory activity occurring within an hour after the onset of deep sleep.[2(p.122-123)] Due to this physiologic occurrence, many protocols utilizing GHRH and/or GHRP therapy call for a once-daily dose provided prior to bedtime. The release of GH subsequently stimulates the production of insulin-like growth factor-1 (IGF-1), which in addition to mediating many of GH's positive effects, happens to be a potent inhibitor in the negative feed-back loop of growth hormone releasing hormone (GHRH) and GH secretion. Therefore, because IGF-1 production is primarily regulated by GH, the consequence is a decrease in GH secretion via this negative feed-back loop (Figure 2). Perhaps for this reason, many clinicians find that treated patients will initially see IGF-1 levels surge, only to plateau or decrease with continued, uninterrupted use. This will be discussed a bit later as well as potential modalities to prevent this phenomenon from occurring or at least limit the severity of inhibition. In addition to IGF-1, there are three hypothalamic factors regulating GH secretion: (i) Somatostatin, a non-competitive inhibitor of GH secretion; (ii) GHRH, the principal stimulator for GH production/release; and (iii) Ghrelin, secreted by the stomach, an endogenous ligand to the GH secretagogue

receptor.2(p.122) Intertwined with one another and combined with other peripheral factors (e.g. exercise, sleep, food intake, stress, and body composition), all of these elements are involved in an intricate symphony regulating the physiologic patterns of pulsatile GH secretion.

GROWTH HORMONE BENEFITS AND THE ASSOCIATED RELATIVE RISK

It is true that a number of clinical trials have reported that by providing GH to adults with GHD, many of the features often associated with AGHD are significantly reversed or improved. Fat mass/volume is decreased, reductions in abdominal fat are obtained, and while there is little change in overall body weight, increases in lean body mass and skeletal muscle volume are observed signifying a shift away from fat to lean body mass. Additionally, there is no denying the thousands of published papers indicating better exercise capacity and cardiovascular function, improved bone mineral density, and enhanced quality of life in adults with GHD treated with GH. In spite of these advantageous findings, there remains an equal number of potential risks that have been described associated with the use of GH. In experimental trials, ≈40% of users reported clinical edema, ≈20% develop joint swelling and myalgia, and ≈10% develop carpal tunnel syndrome.[3] Additionally, many report hyperglycemia, hypertension, glucose intolerance and hyperinsulinemia.[4] Interestingly, a number of these adverse events can be attributed to incorrect dosing, in that they were much too high. In other words, they were the result of over-dosing and over-exposure to physiologic levels of GH. This is where the use of GHRH and other associated peptides have come to be advantageous as their mechanism of increasing GH preclude the potential for over-exposure or tachyphylaxis.

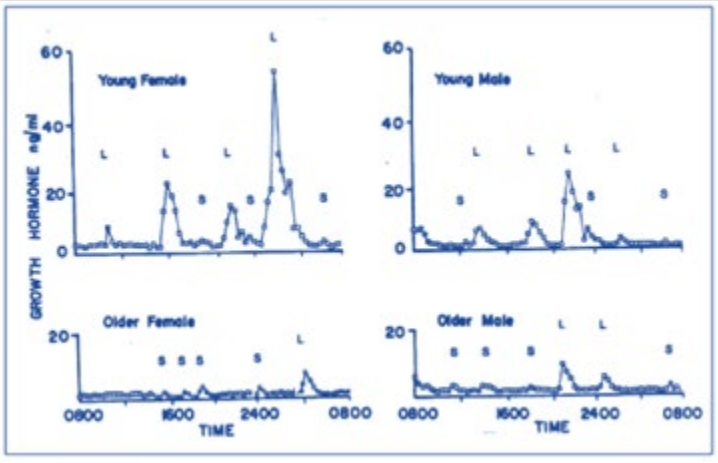

Figure 1 Patterns of GH secretion in younger & older women and men. There is a marked age-related decline in GH secretion in both sexes and a loss of nighttime enhancement of GH secretion see during deep sleep. This decrease is primarily due to a reduction in GH pulse amplitude, with little change in pulse frequency.
L=large pulse, S=small pulse. (From Ho et al 1987)[12]

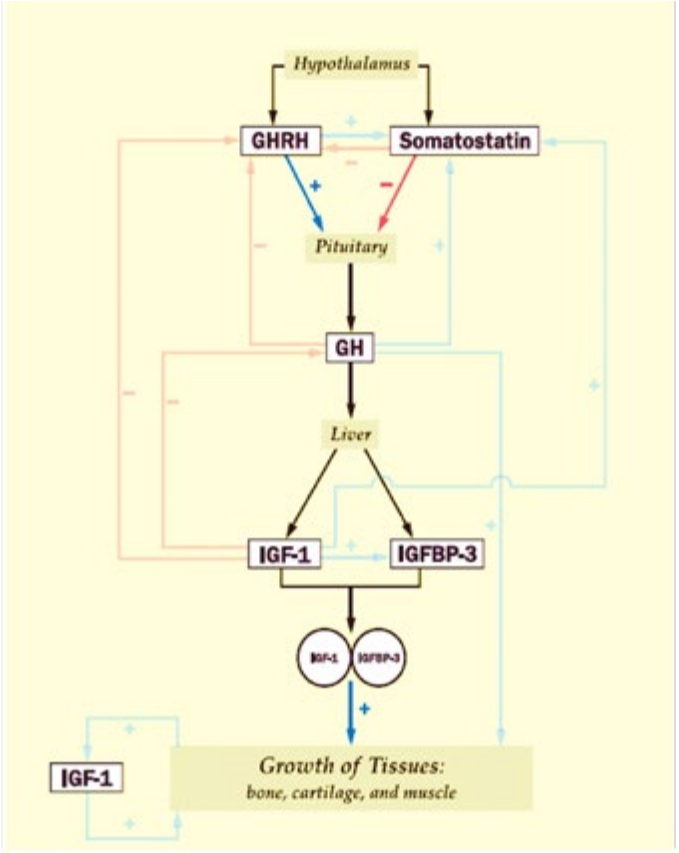

Figure 2 Regulation of the GH/IGF-1 axis. Pituitary inhibition of GH secretion results from an increase in Somatostatin as well as decreased GHRH stimulation, both of which result from increased levels of circulating IGF-1. (Mayo Communiqué March 2006)[13]

GHRH: A BETTER METHOD OF INCREASING GROWTH HORMONE

Physiologic and Clinical Advantages of GHRH

Rather than introducing exogenous and supraphysiologic doses of GH directly to the liver, GH secretagogues like GHRH (i.e. Sermorelin and others) stimulate the normal and physiologic secretion of GH in an intact and responsive pituitary (Figure 3). This normal and physiologic secretion results in a normal, time-separated, pulsatile release of GH, rather than prolonged elevation of exogenous exposure; thereby avoiding tachyphylaxis and preserving the capability for negative feed-back inhibition of GH by the rising levels of IGF-1.[2](p.127) It is because of this normal, negative feed-back regulation that treatment with GHRH results in much less frequent and milder side effects as compared to those experienced strictly with GH use. The most frequent side effects associated with GHRH (e.g. Sermorelin) use in clinical trials were reported to be localized injection site reactions such as pain, swelling, or redness; occurring in approximately 16% of users. Other events such as headache, flushing, dysphagia, dizziness, hyperactivity, somnolence, and urticaria were reported in less than 1%.[5]

SUGGESTED DOSING OF GHRH

In the complete sequence, hGHRH is a 44-amino acid chain. However, it is recognized that biological activity is induced solely utilizing only the first 29 amino acid sequence. It is this sequence, specifically GHRH(1-29)NH2 or Sermorelin, that received FDA approval (e.g., Geref®, Serono) in October 1997 for the treatment of GHD in children. Oddly enough, it was subsequently withdrawn from the market in November 2002 due to the limited demand for the product, most likely due to the limited efficacy Sermorelin has in elevating GH in children (i.e. GHD deficient children require much higher levels of GH than what can be achieved by stimulating their own, already deficient production). In the normal aging adult, however, pituitary stimulation of GH production by Sermorelin has been demonstrated to clinically elevate GH and subsequent IGF-1 levels to at least the lower portion of the young adult normal range and by as much as 35%.[2](p.127)

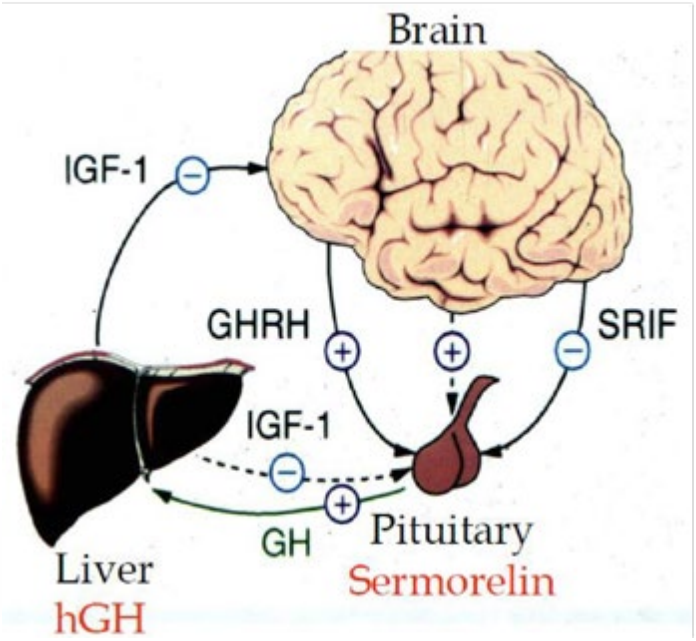

Figure 3 Sermorelin activity is upon the pituitary, stimulating the production of GH under negative feed-back control. Exogenously provided hGH acts directly upon the liver and GH is increased outside of the feed-back control mechanism resulting in prolonged, supraphysiologic GH exposure.

Dosing protocols in clinical literature widely vary and, as such, an established, standardized dose effective for everyone has not been determined. Nevertheless, early clinical studies performed by Corpas and colleagues used twice daily subcutaneous GHRH doses of both 500mcg and 1000mcg which resulted in significant increases in GH peak amplitude ($P < 0.05$), but also in mean 24-hour GH and IGF-1 ($P < 0.001$ and 0.005, respectively).[6] Likewise, later additional studies performed by Vittone, et al utilized nightly subcutaneous GHRH doses of 2000mcg resulting in significantly increased nocturnal GH peak amplitude.

Furthermore, 33% of participants showed improved measurements of muscle strength and endurance ($P < 0.04$).[7] Of particular interest, no significant adverse events were reported in either study. This is of importance because many of the currently employed dosing protocols utilize daily subcutaneous GHRH doses of ≤ 300mcg giving practitioners and patients alike at least some semblance of certainty that the risk of experiencing an adverse event is quite low. As promising as many of the published clinical findings report the use of GHRH to be, there still remains some uncertainty as to the frequency of dosing. Due to either small sample sizes, short trial duration and/or variances in doses, it is still clinically unknown whether GHRH can be equally effective when administered once daily as opposed to daily divided doses. To date, however, nearly all studies involving the use of once-daily, evening subcutaneous injections of GHRH(1-29)NH2 have proven to be well-tolerated, increasing 24-hour GH secretion, boosting circulating levels of IGF-1, and improve body composition in older patients.

Currently, typical dosing protocols for younger patients, in their 40's and early 50's, with good body composition have utilized single daily doses of 100 – 300mcg via subcutaneous injection administered one-hour prior to bedtime. This regimen very often results in sustaining youthful characteristics, health, and vitality without the use of additional hGH supplementation. In patients with excessive abdominal fat due to inactivity and increased weight gain (e.g. BMI > 30), a slightly different protocol may be considered. For example: 1-2u of hGH administered each morning for approximately 3 to 6 months until the patient's body composition has improved, followed by nightly injections of 200mcg to 300mcg of Sermorelin one hour prior to bedtime. This should provide the maintenance dose to sustain pituitary functional cells and increase hGH reserve and secretory volume. Although tachyphylaxis and IGF-1 mediated inhibition of GH is unlikely, one caveat to consider when evaluating a patient's declining response to daily GHRH therapy is the insertion of a short "drug-holiday" in the dosing protocol. Consider the provision of a 21/7 or 5/2 protocol (i.e. 21-consecutive days, followed by 7-days of rest or alternatively, a regimen of 5-consecutive days with 2-days off). This may be quite useful in order to maintain the continued benefits with chronic therapy, particularly in patients who have shown significant improvements initially only to find that later they begin to exhibit a plateau or declining effect of circulating IGF-1 levels.

THE ESTROGEN FACTOR AND ORAL DOSING

Doses for females on oral estrogen replacement therapy (ERT) will likely require dosage adjustments (i.e. increased) to see a clinical improvement in IGF-1 as it has been reported in the literature that estrogen has a blunting effect of hGH upon the liver to produce IGF-1.[8,9] Curiously, this blunting effect is only associated with oral estrogen therapy, and is not seen in women using transdermal ERT. Therefore, in order to elicit clinically effective outcomes, women should be transitioned and stabilized from oral to topical ERT prior to initiating daily GHRH therapy. Lastly, there is an alternative for patients averse to daily injections. Due to the smaller molecular nature of GH secretagogues, at least one of them has been clinically shown that it can be administered orally and elderly patients can still benefit from increases in pulsatile GH secretion and IGF-1.[10,11] These results provide speculative hope that other GH secretegogues may also be equally effective via alternative routes such as sublingual, transdermal, or nasal delivery.

GHRP: ELICITING ENHANCED OUTCOMES THROUGH DRUG-DRUG SYNERGISM

Growth Hormone Releasing Peptides

Concurrent administration of GHRH and GHRP has been well documented and established to provide synergistic release of GH from the pituitary. While there are a number of GHRPs that have been researched and/or studied, the two that have garnered much attention and clinical use are GHRP2 and GHRP6. Others that have been used are Ipamorelin and Hexarelin, but are typically un-favored favored due to the former being a weaker GH promoter and the latter having a stronger, adverse effect on cortisol and prolactin. GHRP2/6 are both very potent at promoting GH release, yet have little to no effect on cortisol or prolactin. While several studies have concluded increases in GH secretion and IGF-1 are achievable with solitary use, concurrent use with GHRH is more than additive. This is, in part, due to the fact that GHRH is much less capable of increasing GH when physiologic levels of somatostatin are high and GHRP inhibits somatostatin. Recommended doses for GHRP 2 or 6 are typically around 150mcg as there is a receptor saturation point, and delivering more yields little benefit and may promote desensitization with chronic dosing.

CONCLUSION

While the stimulation of GH with GHS – rather than direct GH replacement – clearly has the advantage of being more akin to mirroring a physiologic approach of increasing endogenous GH pulsatility and secretion, there still remain important and unanswered questions that need resolution before conclusive statements about efficacy and benefits can be made. Defining measurable, therapeutic endpoints, measuring a reduction in frailty, and the safety of chronic, long-term GHRH therapy are a few of the clinical outcomes that have yet to be determined. Certainly, GHRH has been shown to afford a place in therapy for the aging adult, but much larger and extended clinical trials will need to be completed before it takes its place among routine medicine for the aged. Until then, closely monitored individuals under a physician's direct care can benefit from its availability via compounding pharmacies. ■

REFERENCES

1. Melmed S. Physiology of growth hormone In: UpToDate 2006 [online]. Accessed 13 Jan 2017. URL: http://www.utdol.com Cited by: Hersch EC, Merriam GR. Growth hormone (GH)-releasing hormone and GH secretagogues in normal aging: Fountain of Youth or Pool of Tantalus? Clin Interv Aging 2008:3(1) 121-129.
2. Hersch EC, Merriam GR. Growth hormone (GH)-releasing hormone and GH secretagogues in normal aging: Fountain of Youth or Pool of Tantalus? Clin Interv Aging 2008:3(1) 122-123.
3. Cummings DE, Merriam GR. Age-Related Changes in Growth Hormone Secretion: Should the Somatopause Be Treated? Semin Reprod Med 1999;17(4): 319.
4. Walker RF, Bercu BB. Issues Regarding the Routine and Long-Term Use of Growth Hormone in Anti-Aging Medicine. Journal of Anti-Aging Medicine. Jul 2004: 290.
5. Gold Standard, Inc. Sermorelin, GHRH Geref. Clinical Pharmacology [database online]. Available at: http://www.clinicalpharmacology.com. Accessed: January 10, 2017.
6. Corpas E, Harman SM, Piñeyro MA, Roberson R, Blackman MR. Growth hormone (GH-releasing hormone-(1-29) twice daily reverses the decreased GH and insulin-like growth factor-I levels in old men. J Clin Endocrinol Metab. 1992 Aug;75(2):530-535.
7. Vittone J, Blackman MR, Busby-Whitehead J, et al. Effects of single nightly injections of growth hormone-releasing hormone (GHRH 1-29) in healthy elderly men. Metabolism 1997 Jan;46(1):89-96.
8. Merriam GR, Barsness S, Buchner D. et al. Growth Hormone Releasing Hormone Treatment in Normal Aging. Journ of Anti-Aging Med 2001;4(4):338.
9. Cook DM, Ludlam WH, Cook MB. Route of Estrogen Administration Helps to Determine Growth Hormone (GH) Replacement Dose in GH-Deficient Adults. J Clin Endocrinol Metab 1999 Nov;84(11): 3956-3960.
10. Chapman IM, Bach MA, Van Cauter E. et al. Stimulation of the growth hormone (GH)-insulin-like growth factor I axis by daily oral administration of a GH secretogogue (MK-677) in healthy elderly subjects. J Clin Endocrinol Metab 1996 Dec;81(12):4249-4257.
11. Svensson J, Lönn L, Jansson JO, et al. Two-month treatment of obese subjects with the oral growth hormone (GH) secretagogue MK-677 increases GH secretion, fat-free mass, and energy expenditure. J Clin Endocrinol Metab 1998 Feb;83(2):362-369.
12. Ho KY, Evans WS, Blizzard RM, et al. Effects of Sex and Age on the 24-Hour Profile of Growth Hormone Secretion in Man: Importance of Endogenous Estradiol Concentrations. J Clin Endocrinol Metab 1987 Jan;64(1):51-58.
13. MAYO CLINIC Mayo Medical Laboratories Communique March 2006;31(3) Available at: http://www.mayomedicallaboratories.com/media/articles/communique/mc2831-0306.pdf23. Bode, L, et al., Inhibition of monocyte, lymphocyte, and neutrophil adhesion to endothelial cells by human milk oligosaccharides. Thromb Haemost, 2004. 92(6): p. 1402-10.

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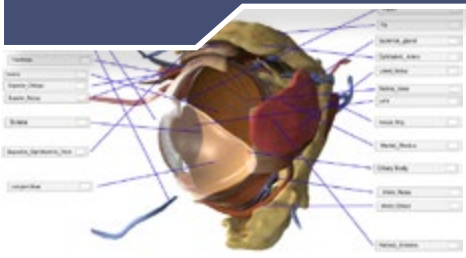

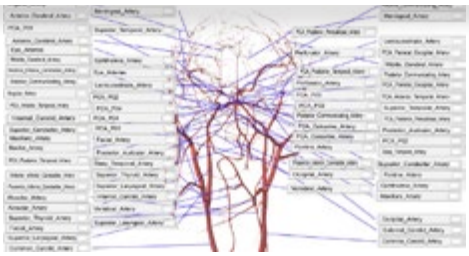

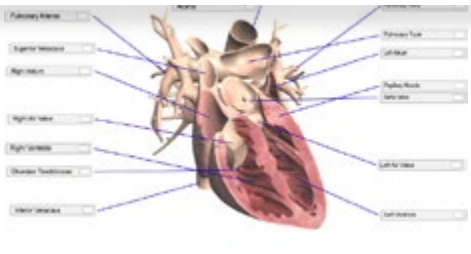

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Modulation of Metabolic Detoxification Pathways Using Foods and Food-Derived Components:
A Scientific Review with Clinical Application

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Research into human biotransformation and elimination systems continues to evolve. Various clinical and in vivo studies have been undertaken to evaluate the effects of foods and food-derived components on the activity of detoxification pathways, including phase I cytochrome P450 enzymes, phase II conjugation enzymes, Nrf2 signaling, and metallothionein. This review summarizes the research in this area to date, highlighting the potential for foods and nutrients to support and/or modulate detoxification functions. Clinical applications to alter detoxification pathway activity and improve patient outcomes are considered, drawing on the growing understanding of the relationship between detoxification functions and different disease states, genetic polymorphisms, and drug-nutrient interactions. Some caution is recommended, however, due to the limitations of current research as well as indications that many nutrients exert biphasic, dose-dependent effects and that genetic polymorphisms may alter outcomes. A whole-foods approach may, therefore, be prudent.

1. Introduction

Food-based nutrients have been and continue to be investigated for their role in the modulation of metabolic pathways involved in detoxification processes. Several publications to date have leveraged cell, animal, and clinical studies to demonstrate that food-derived components and nutrients can modulate processes of conversion and eventual excretion of toxins from the body [1]. In general, the nature of these findings indicates that specific foods may upregulate or favorably balance metabolic pathways to assist with toxin biotransformation and subsequent elimination [2, 3]. Various whole foods such as cruciferous vegetables [2, 4, 5], berries [6], soy [7], garlic [8, 9], and even spices like turmeric [10, 11] have been suggested to be beneficial and commonly prescribed as part of naturopathic-oriented and functional medicine-based therapies [12, 13].

While these foods are important to note, the science in this active area of inquiry continues to evolve to reveal new findings about food-based nutrients and their effect on health. Thus, the purpose of this review article is to summarize the science to date on the influence of whole foods, with a special focus directed towards phytonutrients and other food-based components, on influencing specific metabolic detoxification pathways, including phase I cytochrome enzymes, phase II conjugation enzymes, antioxidant support systems, and metallothionein upregulation for heavy metal metabolism. Based on this current science, the paper will conclude with clinical recommendations that may be applied in a personalized manner for patients via the discretion of a qualified health professional.

2. The Metabolic Pathways of Detoxification

Discussion of physiological pathways for detoxification has been mainly centered around phase I and phase II enzyme systems. This review will cover phase I cytochrome P450

enzymes as well as phase II enzymes, specifically UDP-glucuronosyl transferases, glutathione S-transferases, amino acid transferases, N-acetyl transferases, and methyltransferases. Note that there are other important classes of phase I enzymes, namely, hydroxylation and reduction, which are not covered in this review. While these important enzymes are pivotal to consider, this review of the effect of food on detoxification will also extend into other pathways, including ways to promote gene expression of antioxidant-related enzymes and of metallothionein, an endogenous protein carrier for heavy metals. Each of these four classes of detoxification-related pathways will be discussed within the context of nutrients.

2.1. Phase I Cytochrome P450 Enzymes. Initially, the "phases" of detoxification were described as functionalization (or phase I), or the addition of oxygen to form a reactive site on the toxic compound, and conjugation (phase II), or the process of adding a water-soluble group to this now reactive site [14, 15]. The "Phase I" cytochrome P450 superfamily of enzymes (CYP450) is generally the first defense employed by the body to biotransform xenobiotics, steroid hormones, and pharmaceuticals. These microsomal membrane-bound, heme-thiolate proteins, located mainly in the liver, but also in enterocytes, kidneys, lung, and even the brain, are responsible for the oxidation, peroxidation, and reduction of several endogenous and exogenous substrates [13, 15, 16]. Specifically, the function of CYP450 enzymes is to add a reactive group such as a hydroxyl, carboxyl, or an amino group through oxidation, reduction, and/or hydrolysis reactions [15]. These initial reactions have the potential to create oxidative damage within cell systems because of the resulting formation of reactive electrophilic species.

It is accepted that any variability in the number of CYP450 enzymes could have benefit(s) and/or consequence(s) for how an individual responds to the effect(s) of (a) toxin(s). Clinical application of the knowledge of these phase I CYP450 enzymes has been primarily addressed within pharmacology to understand the nature of drug interactions, side effects, and interindividual variability in drug metabolism [15]. The ability of an individual to metabolize 90% of currently used drugs will largely depend on the genetic expression of these enzymes [17]. It is established that many of these CYP450 genes are subject to genetic polymorphisms, resulting in an altered expression and function of individual enzymes. Currently, there exist some laboratory tests to identify the presence of these genetic variants. It is conceivable that having knowledge about foods and their individual (phyto)nutrients, especially in the case of dietary supplements and functional foods, could be worthwhile for clinicians to consider for patients who are taking a polypharmacy approach. Furthermore, as nutritional strategies become more personalized, it would seem that this information could be interfaced with a patient's known CYP450 polymorphisms to determine how to best optimize health outcomes.

2.1.1. CYP1 Enzymes. The CYP1A family is involved in metabolizing procarcinogens, hormones, and pharmaceuticals. It is well-known for its role in the carcinogenic bioactivation of polycyclic aromatic hydrocarbons (PAHs), heterocyclic aromatic amines/amides, polychlorinated biphenyls (PCBs), and other environmental toxins [18, 19]. Low CYP1A2 activity, for example, has been linked to higher risk of testicular cancer [20]. However, due to their rapid conversion to highly reactive intermediates, excessive activity of CYP1A enzymes without adequate phase II support may enhance the destructive effects of environmental procarcinogens [21]. Indeed, genetic polymorphisms in this cytochrome family have been suggested as useful markers for predisposition to certain cancers [15]. CYP1 enzymes are also involved in the formation of clinically relevant estrogen metabolites: CYP1A1/1A2 and CYP1B1 catalyze the 2-hydroxylation and 4-hydroxylation of estrogens, respectively [22]. The potential role of 4-hydroxyestradiol in estrogen-related carcinogenesis, via the production of free radicals and related cellular damage [22], has prompted investigation into factors that modulate CYP1 enzymes.

Various foods and phytonutrients alter CYP1 activity (Tables 1(a) and 1(b)). Cruciferous vegetables have been shown, in humans, to act as inducers of CYP1A1 and 1A2, and animal studies also suggest an upregulation of CYP1B1 [4, 23–27]. The inductory effect of crucifers on CYP1A2 seems especially well established. Clinical studies also indicate that resveratrol and resveratrol-containing foods are CYP1A1 enhancers [28]. Conversely, berries and their constituent polyphenol, ellagic acid, may reduce CYP1A1 overactivity [6], and apiaceous vegetables and quercetin may attenuate excessive CYP1A2 action [24, 29]. Cruciferous vegetables and berries have been suggested as possible modulators of estrogen metabolites: berries for their reducing effect on CYP1A1 [6] and cruciferous vegetables for their stronger induction of CYP1A versus 1B1 enzymes [25–27, 30]. Chrysoeriol, present in rooibos tea and celery, acts selectively to inhibit CYP1B1 *in vitro* [31] and may be especially relevant to patients with CYP1B1 overactivity. However, further research is needed to confirm this finding.

Many foods appear to act as both inducers and inhibitors of CYP1 enzymes, an effect which may be dose dependent or altered by the isolation of bioactive compounds derived from food. Curcumin at 0.1% of the diet has been shown, in animals, to induce CYP1A1, for example, [35], yet a diet of 1% turmeric was inhibitory [46]. Black tea at 54 mL/d induced both CYP1A1 and 1A2 [33], yet 20 mg/kg of theaflavins was inhibitory to CYP1A1 [45]. Soybean intake at 100 mg/kg upregulated CYP1A1 activity [7], yet at 1 g/kg black soybean extract [44] and 200 mg daidzein twice daily [49], its effect was inhibitory. Further research is needed to confirm different dose effects and impact in humans.

Varied effects may also occur from different members of the same food group. Seemingly contradictory to research showing that cruciferous vegetables activate CYP1 enzymes, kale (another member of the cruciferous family) appears to inhibit CYP1A2 (as well as 2C19, 2D6, and 3A4) in animals [51]. The dose used, at 2 g/kg per day, is 15-fold higher than the typical level of human consumption [51], and more research would be required to determine whether lower intake levels would also have a similar effect. The same authors also tested

Table 1: (a) Human and *in vivo* example nutrient inducers of CYP1 enzymes. (b) Human and *in vivo* example nutrient inhibitors of CYP1 enzymes.

(a)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP1A1	Cruciferous vegetables	Clinical	500 mg/d indole-3-carbinol [23]
	Resveratrol *Grapes, wine, peanuts, soy*, and *itadori tea* [32]	Clinical	1 g/d resveratrol [28]: *note high dose used*
	Green tea	*In vivo*	45 mL/d/rat (avg. 150 g animal weight) green tea [33]
	Black tea	*In vivo*	54 mL/d/rat (avg. 150 g animal weight) black tea [33]
	Curcumin *Turmeric, curry powder* [34]	*In vivo*	1,000 mg/kg/d/rat curcumin [35], or about 150 mg per rat per day
	Soybean	*In vivo*	100 mg/kg soybean extract [7]
	Garlic	*In vivo*	30 to 200 mg/kg garlic oil [36]
	Fish oil	*In vivo*	20.5 g/kg fish oil [36]: *note high dose used*
	Rosemary	*In vivo*	Diet of 0.5% rosemary extract [37]
	Astaxanthin *Algae, yeast, salmon, trout, krill, shrimp*, and *crayfish* [38]	*In vivo*	Diets of 0.001–0.03% astaxanthin for 15 days [39]
CYP1A2	Cruciferous vegetables	Clinical	7–14 g/kg cruciferous vegetables including frozen broccoli and cauliflower, fresh daikon radish sprouts and raw shredded cabbage, and red and green [24] 500 g/d broccoli [4] 250 g/d each of Brussel sprouts and broccoli [25] 500 g/d broccoli [26]
	Green tea	*In vivo*	45 mL/d/rat (avg. 150 g animal weight) green tea [33] Green tea (2.5% w/v) as sole beverage [40]
	Black tea	*In vivo*	54 mL/d/rat (avg. 150 g animal weight) black tea [33]
	Chicory root	*In vivo*	Diet of 10% dried chicory root [41]
	Astaxanthin *Algae, yeast, salmon, trout, krill, shrimp*, and *crayfish* [38]	*In vivo*	Diets of 0.001–0.03% astaxanthin for 15 days [39]
CYP1B1	Curcumin *Turmeric, curry powder* [34]	*In vivo*	Diet of 0.1% curcumin [35]
	Cruciferous vegtables	*In vivo*	25–250 mg/kg indole-3-carbinol [27]

(b)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP1A1	Black raspberry	*In vivo*	Diet of 2.5% black raspberry [6]
	Blueberry	*In vivo*	Diet of 2.5% blueberry [6]
	Ellagic acid *Berries, pomegranate, grapes, walnuts*, and *blackcurrants* [42]	*In vivo*	30 mg/kg/d ellagic acid [43] 400 ppm ellagic acid [6]
	Black soybean	*In vivo*	1 g/kg black soybean seed coat extract [44]: *note high dose used*
	Black tea	*In vivo*	20 mg/kg theaflavins [45]
	Turmeric	*In vivo*	Diet of 1% turmeric [46]

(b) Continued.

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP1A2	Apiaceous vegetables	Clinical	4 g/kg apiaceous vegetables, including frozen carrots and fresh celery, dill, parsley, and parsnips [24]
	Quercetin *Apple, apricot, blueberries, yellow onion, kale, alfalfa sprouts, green beans, broccoli, black tea*, and *chili powder* [47, 48]	Clinical	500 mg/d quercetin [29]
	Daidzein *Soybean* [49]	Clinical	200 mg twice daily dosing of daidzein [49]
	Grapefruit	Clinical	300 mL grapefruit juice [50]
	Kale	*In vivo*	2 g/kg/d kale, as freeze-dried kale drink [51]
	Garlic	*In vivo*	100 mg/kg garlic oil [52]
	Chamomile	*In vivo*	Free access to 2% chamomile tea solution [53]
	Peppermint	*In vivo*	Free access to 2% peppermint tea solution [53]
	Dandelion	*In vivo*	Free access to 2% dandelion tea solution [53]
	Turmeric	*In vivo*	Diet of 1% turmeric [46]

the effects of an equivalent volume of cabbage consumption and found no such inhibitory effect, pointing to the possibility that different cruciferous vegetables may have distinct effects on cytochrome activity.

2.1.2. CYP2A-E Enzymes. The large CYP2 family of enzymes is involved in the metabolism of drugs, xenobiotics, hormones, and other endogenous compounds such as ketones, glycerol, and fatty acids [15, 54]. Some notable polymorphisms occur in the CYP2C and CYP2D subgroups, leading to the classification of patients as "poor metabolizers" of various pharmaceuticals: warfarin and CYP2C9, antiarrhythmia agents, metoprolol and propafenone, and CYP2D6, phenytoin, cyclobarbital, omeprazole, and CYP2C19, for example, [15, 17]. CYP2D polymorphisms may be associated with Parkinson's disease and lung cancer [15]. Clinical evidence exists for the induction of CYP2A6 by quercetin and broccoli [4, 29] (Table 2(a)). In animals, chicory appears to induce CYP2A enzymes [41] and rosemary and garlic may upregulate CYP2B activity [9, 37]. Clinical studies using resveratrol and garden cress indicate CYP2D6 inhibition [28, 55] (Table 2(b)). Ellagic acid, green tea, black tea, and cruciferous vegetables also appear to inhibit various CYP2 enzymes.

CYP2E1 enzymes have also attracted particular interest for their role in various diseases. 2E1 metabolizes nervous system agents such as halothane, isoflurane, chlorzoxazone, and ethanol and bioactivates procarcinogenic nitrosamines and aflatoxin B1 [15, 65]. It produces free radicals regardless of substrate [15], and CYP2E1 polymorphisms have been associated with altered risk for coronary artery disease [66] and gastric cancer [67]. CYP2E1-induced oxidative stress has also been shown to lead to impaired insulin action via the suppression of GLUT4 expression [68]. Attenuation of 2E1 overactivity may therefore be an important consideration in high-risk patients.

Watercress and garlic are CYP2E1 inhibitors in humans [59, 60]. *In vivo* evidence also suggests that N-acetyl cysteine, ellagic acid, green tea, black tea, dandelion, chrysin, and medium chain triglycerides (MCTs) may downregulate CYP2E1 [33, 43, 54, 61, 63, 64]. MCT oil may specifically attenuate the ethanol-induced upregulation of CYP2E1 and production of mitochondrial 4-hydroxynonenal, a marker of oxidative stress [64].

2.1.3. CYP3A Enzymes. The occurrence of the different CYP3A isoforms is tissue-specific [15]. Rooibos tea, garlic, and fish oil appear to induce the activity of CYP3A, 3A1, and 3A2 [8, 36, 69, 70] (Table 3(a)). Possible inhibitory foods include green tea, black tea, and quercetin [33, 56, 71, 72] (Table 3(b)). The most clinically relevant of the enzymes is CYP3A4, which is expressed mainly in the liver and to a lesser extent in the kidney [13]. Caffeine, testosterone, progesterone, and androstenedione are substrates of the CYP3A4 enzyme system, as are various procarcinogens including PAHs and aflatoxin B1 [15]. To date, however, the principal driver for research on CYP3A4 has been due to its role in the metabolism of over 50 percent of all pharmaceuticals [73]. The potential for drug interaction with this single enzyme, coupled with the wide interindividual differences in enzymatic activity, generates some level of risk in administration of high doses and multiple drugs as well as food-drug

Table 2: (a) Human and *in vivo* example nutrient inducers of selected CYP2 enzymes. (b) Human and *in vivo* example nutrient inhibitors of selected CYP2 enzymes.

(a)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP2A	Chicory root	*In vivo*	Diet of 10% dried chicory root [41]
CYP2A6	Quercetin *Apple, apricot, blueberries, yellow onion, kale, alfalfa sprouts, green beans, broccoli, black tea*, and *chili powder* [47, 48]	Clinical	500 mg/d quercetin [29]
	Broccoli	Clinical	500 g/d broccoli [4]
CYP2B1	Rosemary	*In vivo*	Diet of 0.5% rosemary extract [37]
	Garlic	*In vivo*	0.5 and 2.0 mmol/kg diallyl sulfide, or about 75 and 300 mg, respectively [9]
CYP2B2	Rosemary	*In vivo*	Diet of 0.5% rosemary extract [37]
CYP2E1	Fish oil	*In vivo*	20.5 g/kg fish oil [36]: *note high dose used*
	Chicory root	*In vivo*	Diet of 10% dried chicory root [41]

(b)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP2B	Ellagic acid *Berries, pomegranate, grapes, walnuts,* and *blackcurrants* [42]	*In vivo*	10 and 30 mg/kg/d ellagic acid [43]
	Green tea	*In vivo*	100 mg/kg/d green tea extract [56]
	Cruciferous vegetables	*In vivo*	3 and 12 mg/kg/d sulforaphane [57]
CYP2B1	Turmeric	*In vivo*	Diet of 1% turmeric [46]
CYP2C	Green tea	*In vivo*	45 mL/d/rat (avg. 150 g animal weight) green tea [33]
	Black tea	*In vivo*	54 mL/d/rat (avg. 150 g animal weight) black tea [33]
	Ellagic acid *Berries, pomegranate, grapes, walnuts,* and *blackcurrants* [42]	*In vivo*	30 mg/kg/d ellagic acid [43]
CYP2C6	Ellagic acid *Berries, pomegranate, grapes, walnuts,* and *blackcurrants* [42]	*In vivo*	30 mg/kg/d ellagic acid [43]
CYP2C9	Resveratrol *Grapes, wine, peanuts, soy,* and *itadori tea* [32]	Clinical	1 g/d resveratrol [28]: *note high dose used*
	Myricetin *Onions, berries, grapes,* and *red wine* [58]	*In vivo*	2 and 8 mg/kg myricetin [58]
CYP2C19	Kale	*In vivo*	2 g/kg/d kale, as freeze-dried kale drink [51]
CYP2D6	Resveratrol *Grapes, wine, peanuts, soy,* and *itadori tea* [32]	*Clinical*	1 g/d resveratrol [28]: *note high dose used*
	Garden cress	Clinical	7.5 g twice daily intake of garden cress seed powder [55]
	Kale	*In vivo*	2 g/kg/d kale, as freeze-dried kale drink [51]

(b) Continued.

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP2E1	Watercress	Clinical	50 g watercress homogenate [59]
	Garlic	Clinical and *in vivo*	0.2 mg/kg diallyl sulfide, equivalent to high human garlic consumption [60] 100 mg/kg garlic oil [52] 200 mg/kg diallyl sulfide [8] 30 to 200 mg/kg garlic oil [36] Diet of 2% and 5% garlic powder [61]
	N-acetyl cysteine *Allium vegetables* [54]	*In vivo*	25 mg/kg and 50 mg/kg N-acetyl cysteine [54]
	Ellagic acid *Berries, pomegranate, grapes, walnuts,* and *blackcurrants* [42]	*In vivo*	10 and 30 mg/kg/d ellagic acid [43]
	Green tea	*In vivo*	45 mL/d/rat (avg. 150 g animal weight) green tea [33]
	Black tea	*In vivo*	54 mL/d/rat (avg. 150 g animal weight) black tea [33]
	Dandelion	*In vivo*	0.5 and 2 g/kg dandelion leaf water extract [62]
	Chrysin *Honey, honeycomb* [63]	*In vivo*	20 and 40 mg/kg/d chrysin [63]
	Medium-chain triglycerides (MCTs) *Coconut and coconut oil*	*In vivo*	32% calories as MCTs [64]

and herb-drug interactions. Grapefruit juice is perhaps the most well-known food inhibitor of this enzyme [74], though resveratrol and garden cress, a member of the cruciferous vegetable family, appear to have similar effects in humans, albeit at intakes above what would be expected without high-dose supplementation [28, 55]. Curcumin may upregulate 3A4 activity [11].

Once again, there are indications that a biphasic effect may be seen from dietary bioactive compounds; Davenport and Wargovich (2005) found that shorter-term or lower dosing with garlic organosulfur compounds produced potentially anticarcinogenic effects but that longer-term higher doses (200 mg/kg) of allyl sulfides led to minor hepatic toxicity [8]. One garlic clove contains only 2,500–4,500 μg of the allyl sulfide precursor, allicin [76], so the higher dose is much more than would be consumed in a typical human diet. In another example, two components of cruciferous vegetables, sulforaphanes and indole-3-carbinol, inhibited and increased activity, respectively [57, 75], highlighting the potential for human studies using whole foods to clarify the outcome of consumption.

2.1.4. CYP4 Enzymes. Less is known about this family of enzymes, since it is thought to play a smaller role in drug metabolism. It is, however, understood to be a primarily extrahepatic family of cytochromes, inducible by clofibrate and ciprofibrate (hypolipidemic drugs), NSAIDs, prostaglandins, and toxicants such as phthalate esters [15, 77]. The CYP4B1 isoform is involved in the metabolism of MCTs (medium chain triglycerides), as well as the bioactivation of pneumotoxic and carcinogenic compounds [78].

Polymorphisms and overexpression of this subgroup may be associated with bladder cancer [15] and colitis [79]. A report by Ye et al. (2009) which examined the link between colitis and CYP4B1 activity found that the promotion of CYP4B1 activity by caffeic acid (found in caffeine-containing foods) (Table 4) correlated with reduced inflammation and disease activity [79]. Green tea may act to induce CYP4A1, as suggested by animal studies [40]. More research is needed to clearly identify food influences on this enzyme family.

2.2. Phase II Conjugation Enzymes. After a xenobiotic has gone through the process of becoming hydrophilic through reactions overseen by CYP450 enzymes, its reactive site can be conjugated with an endogenous hydrophilic substance. This reaction is often referred to as "phase II detoxification." Conjugation involves the transfer of a number of hydrophilic compounds (via their corresponding enzymes), including glucuronic acid (glucuronyl transferases), sulfate (sulfotransferases), glutathione (glutathione transferases), amino acids (amino acid transferases), an acetyl group (N-acetyl transferases), and a methyl group (N- and O-methyltransferases) [81]. The result of the collective activity of these enzymes is an increase in the hydrophilicity of the metabolite, theoretically leading to enhanced excretion in the bile and/or urine [81]. Similar to the CYP450 enzymes, genetic polymorphisms can have profound influence on the function of these conjugating

Table 3: (a) Human and *in vivo* example nutrient inducers of selected CYP3 enzymes. (b) Human and *in vivo* example nutrient inhibitors of selected CYP3 enzymes.

(a)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP3A	Rooibos tea	*In vivo*	Rooibos tea, 4 g/L simmered for 5 minutes, as sole beverage [69]
CYP3A1	Garlic	*In vivo*	30 to 200 mg/kg garlic oil [36] 80 and 200 mg/kg garlic oil 3 times weekly [70]
	Fish oil	*In vivo*	20.5 g/kg fish oil [36]: *note high dose used*
CYP3A2	Garlic	*In vivo*	200 mg/kg diallyl sulfide [8]
	Cruciferous vegetables	*In vivo*	50 mg/kg/d indole-3-carbinol [75]
CYP3A4	Curcumin *Turmeric, curry powder* [34]	*In vivo*	50 and 100 mg/kg curcumin [11]

(b)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP3A	Green tea	*In vivo*	45 mL/d/rat (avg. 150 g animal weight) green tea [33] 400 mg/kg green tea extract [71] 100 mg/kg/d green tea extract [56]
	Black tea	*In vivo*	54 mL/d/rat (avg. 150 g animal weight) black tea [33]
	Quercetin *Apple, apricot, blueberries, yellow onion, kale, alfalfa sprouts, green beans, broccoli, black tea,* and *chili powder* [47, 48]	*In vivo*	10 and 20 mg/kg [72]
CYP3A2	Cruciferous vegetables	*In vivo*	12 mg/kg/d sulforaphane [57]
CYP3A4	Grapefruit	Clinical	200 mL grapefruit juice 3 times daily [74]
	Resveratrol *Grapes, wine, peanuts, soy,* and *itadori tea* [32]	Clinical	1 g/d resveratrol [28]: *note high dose used*
	Garden cress	Clinical	7.5 g twice daily dose of garden cress seed powder [55]
	Soybean	*In vivo*	100 mg/kg soybean extract [7]
	Kale	*In vivo*	2 g/kg/d kale, as freeze-dried kale drink [51]
	Myricetin *Onions, berries, grapes,* and *red wine* [58]	*In vivo*	0.4, 2, and 8 mg/kg myricetin [58]

Table 4: Human and *in vivo* example nutrient inducers of selected CYP4 enzymes.

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
CYP4A1	Green tea	*In vivo*	Green tea (2.5% w/v) as sole beverage [40]
CYP4B1	Caffeic acid *Coffee* [80]	*In vivo*	179 mg/kg caffeic acid [79]

enzymes [82], with potential implication in the development of several forms of cancer [83].

It is conceivable that modulation of phase II enzymes by food-based bioactive compounds may be advantageous in patients who have altered enzyme activity due to genetic polymorphisms or who have a high toxic burden due to chronic exposure to environmental pollutants, overactive phase I activity, or hormonal imbalance. For example, James et al. (2008) suggest that upregulation of glucuronidation and sulfonation by certain bioactive compounds may be

a useful consideration for the elimination of environmental PCBs [19].

2.2.1. UDP-Glucuronosyltransferases. This class of enzymes, comprising multiple proteins and even subfamilies, plays an essential role in enhancing the elimination of biotransformed toxins in urine and feces, as well as metabolizing steroid hormones and bilirubin [84, 85]. Their function is to catalyze the covalent linkage of glucuronic acid from UDP-glucuronic acid to an accepting functional group on the molecule, a process referred to as glucuronidation [86]. Glucuronidation occurs primarily in the liver but can occur in other tissues, such as the small intestine [86, 87]. Bilirubin, specifically, is principally conjugated by UGT1A1 in hepatocytes [88] and then excreted with bile into the intestinal tract. It has been estimated that 40–70% of all medications are subject to glucuronidation reactions in humans, thereby suggesting the significance of this conjugation enzyme family [88]. Since UDP-glucuronosyltransferases (UGTs) also metabolize phytochemicals, alterations in their effects may be seen with genetically downregulated enzyme activity; flavonoids are conjugated with glucuronide and sulfate; therefore, UGT or sulfotransferase (SULT) polymorphisms may produce variability in phytochemical clearance and efficacy [89].

Clinical and observational studies point to cruciferous vegetables, resveratrol, and citrus as foods and bioactive compounds that induce UGT enzymes [25, 28, 90–92] (Table 5(a)). Animal studies also suggest the potential for other foods and nutrients, including dandelion, rooibos tea, honeybush tea, rosemary, soy, ellagic acid, ferulic acid, curcumin, and astaxanthin, to enhance UGT activity [37, 39, 53, 93–95]. Interestingly, the effect of resveratrol was seen only in individuals with low baseline enzyme levels/activity, suggesting that some phytochemicals may modulate, rather than outright induce, enzymatic activity [28]. In addition, many studies note that effects are variable depending on gender and genotype [85, 90, 92]; for example, women with the UGT1A1 ∗28 polymorphism (7/7) were responsive to citrus intervention, whereas those with other genetic variants were not [92].

Meaningful interpretations of these studies may still be elusive, however: in one combined dietary trial, the consumption of 10 servings per day of a combination of cruciferous vegetables, soy foods, and citrus fruits did not have a significant effect on UGT enzyme activity compared with a diet devoid of fruits and vegetables [85]. The authors hypothesize that these results may be due to their choice of specific foods within those groups or due to Nrf2 activation (discussed in subsequent sections) when fruits and vegetables were avoided.

The effects of UGT activity may also be enhanced by D-glucaric acid by theoretical inhibition of beta-glucuronidase enzymes [100]. Beta-glucuronidase enzymes act to reverse UGT conjugation reactions. D-glucaric acid is found in many fruits, vegetables and legumes (Table 5(b)). When tested in humans, however, a diet supplemented with cruciferous vegetables (2/3 cup broccoli, 1/2 cup cabbage, and 1/2 cup radish sprouts), citrus fruits (1 cup grapefruit juice, 1/2 cup orange juice, 1 cup orange/grapefruit segments, and 1 orange peel), and soy foods was found to have no effect on beta-glucuronidase activity [101] (amounts standardized for 55 kg body weight), indicating that the clinical effects of D-glucaric acid consumption still need further clarification.

In vivo research suggests that polyphenol extracts of certain berries, specifically strawberries and blackcurrant, may inhibit beta-glucuronidase activity in the intestinal lumen; Kosmala et al. (2014) observed this effect using both strawberry pomace water extract and water-alcohol extract containing 5.1% and 17.1% ellagic acid, and 0.2% and 10.9% proanthocyanidins, respectively [100]. Jurgoński et al. (2014) found a similar inhibitory effect using a diet of 1.5% blackcurrant extract (total polyphenolic content 66.8 g/100 g extract) [102]. Interestingly, the highest levels of beta-glucuronidase activity were seen in rabbits fed a high fat diet (32% calories from fat, including 10% from lard), without blackcurrant extract supplementation, suggesting that dietary fat may also alter enzyme activity [102].

Inhibition of UGT enzymatic activity may be a consideration for modulation of hormone levels and the risk of certain cancers, such as prostate cancer [84]. *In vitro* studies suggest that various foods and food-based components may inhibit UGT activity, including green and black tea, quercetin, rutin, naringenin, allspice, peppermint oil, cacao, and silymarin [84], although further research is needed to evaluate their *in vivo* and clinical effects.

2.2.2. Sulfotransferases. As the name of this superfamily of enzymes might suggest, SULTs are responsible for the transfer of a sulfuryl group donated by 3′-phosphoadenosine-5′-phosphosulfate (PAPS) to hydroxyl or amine groups, particularly in the areas of liver, intestine, adrenal gland, brain, and skin tissues [103]. This process is often referred to as sulfation but is more accurately termed sulfonation or sulfurylation. Decreased function of these enzymes, through genetic variability or presence of environmental chemicals, can lead to eventual interference with thyroid hormone, estrogen, and androgen levels [104, 105], as well as variable polyphenol effects [106], since the active forms of these compounds can be degraded via sulfonation. Typically, once compounds have been conjugated with sulfate, there is less reactivity and toxicity incurred from the precursor molecule [105].

Few *in vivo* studies have examined the effects of dietary components on SULT activity, although caffeine and retinoic acid are possible SULT inducers according to animal studies [107, 108] (Table 6(a)). Although it is uncertain how their outcomes will translate *in vivo*, various *in vitro* studies have indicated the possibility of sulfotransferase inhibition (including competitive inhibition) by wine anthocyanins and flavonols, synthetic food colors (especially red colors), apple and grape juice, catechins including epigallocatechin gallate, quercetin, curcumin, resveratrol, flavonoids (apigenin, chrysin, fisetin, galangin, kaempferol, quercetin, myricetin, naringenin, and naringin), and certain phytoestrogens (daidzein, genistein) [3, 105]. Pyridoxal-6-phosphate, the active form of vitamin B6 (which is widely distributed in foods), may also be a competitive SULT inhibitor, according to one *in vitro* study [109], although human tissue concentrations and clinical effects

Table 5: (a) Human and *in vivo* example nutrient inducers of UGT enzymes. (b) Selected dietary sources of D-glucaric acid.

(a)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
UGTs	Cruciferous vegetables	Clinical	Approximately 5 and 10 servings/d of cruciferous vegetables including frozen broccoli, cauliflower, fresh cabbage (red and green), and fresh radish sprouts [90] 250 g/d each of Brussel sprouts and broccoli [25] 2 oz (56.8 g) watercress three times daily [91]
	Resveratrol *Grapes, wine, peanuts, soy,* and *itadori tea* [32]	Clinical	1 g/d resveratrol [28]: *note high dose used*
	Citrus	Observational	0.5+ servings/day of citrus fruits or foods [92]
	Dandelion	*In vivo*	Free access to 2% dandelion tea solution [53]
	Rooibos tea	*In vivo*	Rooibos tea as sole beverage; concentration 2 g tea leaves/100 mL water steeped for 30 minutes [93]
	Honeybush tea	*In vivo*	Honeybush tea as sole beverage; concentration 4 g tea leaves/100 mL water steeped for 30 minutes [93]
	Rosemary	*In vivo*	Diet of 0.5% rosemary extract [37]
	Soy	*In vivo*	150 and 500 mg/kg soy extract [94]
	Ellagic acid *Berries, pomegranate, grapes, walnuts,* and *blackcurrants* [42]	*In vivo*	Diet of 1% ellagic acid [95]
	Ferulic acid *Whole grains, roasted coffee, tomatoes, asparagus, olives, berries, peas, vegetables,* and *citrus* [96]	*In vivo*	Diet of 1% ferulic acid [95]
	Curcumin *Turmeric, curry powder* [34]	*In vivo*	Diet of 1% curcumin [95]
	Astaxanthin *Algae, yeast, salmon, trout, krill, shrimp,* and *crayfish* [38]	*In vivo*	Diets of 0.001–0.03% astaxanthin for 15 days [39]

(b)

Legumes	Mung bean seeds, adzuki bean sprouts [97]
Vegetables and fruits	Oranges, spinach, apples, carrots, alfalfa sprouts, cabbage, Brussel sprouts, cauliflower, broccoli, grapefruit, grapes, peaches, plums, lemons, apricots, sweet cherries, corn, cucumber, lettuce, celery, green pepper, tomato, and potatoes [97–99]

may be vastly different. Of note, caffeic acid demonstrates *in vitro* SULT-inhibitory properties [105]. This finding conflicts with its *in vivo* ability to induce SULT enzymes, as described by Zhou et al. (2012) [107], highlighting the difficulty of extrapolating meaningful conclusions from *in vitro* data.

SULT enzyme activity is dependent on a depletable reserve of inorganic sulfate [112]. Dietary sources of sulfur-containing compounds may therefore play an essential role in SULT function, by providing the substrate for enzyme action (Table 6(b)).

2.2.3. Glutathione S-Transferases. Similar to the aforementioned categories of conjugating enzymes, glutathione S-transferases (GSTs) include a complex of enzymes, whose main function is to attach a glutathione group to a biotransformed metabolite. The production of these enzymes can be induced through the production of reactive oxygen species and via gene transcription involving the antioxidant-responsive element (ARE) and the xenobiotic-responsive element (XRE), which will be subsequently discussed in this paper [113].

Cruciferous and allium vegetables and resveratrol demonstrate ability to induce GSTs in humans [28, 114–117] (Table 7(a)). Observational research also associates citrus consumption with increased GST activity [115]. *In vivo* data also suggest many foods and food constituents to be upregulators of these enzymes, including garlic, fish oil, black soybean, purple sweet potato, curcumin, green tea, rooibos tea, honeybush tea, ellagic acid, rosemary, ghee, and genistein [36, 43, 44, 70, 93, 118–123]. Conjugated linoleic acid has been shown to be at least partly responsible for the effect of ghee [122]. It is possible that the effects of at least some of these foods and bioactive compounds may be due to their upregulation of the Nrf2 signaling pathway.

Table 6: (a) *In vivo* example nutrient inducers of sulfotransferases (SULTs). (b) Selected dietary sources of sulfur-containing compounds (adapted from [110]).

(a)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
SULTs	Caffeine *Coffee, cocoa, black tea,* and *green tea* [111]	*In vivo*	2, 10, and 50 mg/kg caffeine [107]
	Retinoic acid (bioactive form of vitamin A) *Meat (especially liver), fish, egg,* and *dairy products* contain retinol; *apple, apricot, artichokes, arugula, asparagus,* and other plant foods contain provitamin A carotenes [111]	*In vivo*	2, 10, and 50 mg/kg/d retinoic acid suspension in corn oil [108]

(b)

Animal products	Fish, shellfish, lamb, beef, chicken, pork, duck, goose, turkey, egg, and cheese
Legumes	Lentils, peas, and butter beans
Grains	Barley, oatmeal
Vegetables and fruits	Cabbage, horseradish, Brussel sprouts, leeks, cress, haricot beans, apricots, peaches, spinach, and watercress
Nuts and seeds	Brazil nuts, almonds, peanuts, and walnuts
Herbs and spices	Mustard, ginger

Genetic variances, gender, and even possibly body weight appear to play a role in the effects of dietary factors on GST enzymes [114–116]. Clinical investigation of cruciferous and allium vegetables by Lampe et al. (2000) found that an upregulated effect was most marked in women, indicating gender variability, and that the effect was also genotype-dependent, occurring only in GSTM1-null individuals [116]. The same investigators also found that apiaceous vegetables inhibited GST activity, but only in GSTM1+ men [116] (Table 7(b)). High doses of quercetin and genistein have also shown inhibitory effects [123, 126].

There is evidence that at least some of these foods and phytonutrients may exert modulatory rather than absolute inductive/inhibitory effects; Chow et al. (2010) found that resveratrol increased GST only in those with low baseline enzyme levels or activity [28]. It is also noteworthy that bioactive components of crucifers, including isothiocyanates, are substrates for GST enzymes and that GST genotype may therefore alter the response to cruciferous vegetables consumption on other mechanisms such as glutathione peroxidase and superoxide dismutase [134, 135]. GSTM1-null genotype is associated with a more rapid excretion of isothiocyanates, leading some researchers to conclude that the benefits of cruciferous vegetable consumption may be lessened in individuals with this genetic variation [89].

Support for glutathione conjugation also involves enhancing reduced glutathione (GSH) status. Glutathione is a low-molecular weight tripeptide containing residues of cysteine, glutamate, and glycine [136]. Most glutathione from foods and supplements is poorly absorbed, so liposomal delivery has been used [137]. The sulfur-containing amino acids methionine and cystine are important precursors to glutathione formation; their depletion leads to depressed GSH levels [138]. N-acetyl cysteine has also been used to restore depleted GSH levels in a clinical setting [139].

Various nutrients may also enhance endogenous glutathione synthesis, including vitamin B6, magnesium, and selenium [140, 141]. Curcuminoids (from turmeric), silymarin (from milk thistle), folic acid, and alpha-lipoic acid have been shown, in humans, to restore depleted GSH [129, 130, 142, 143]. In animal studies, cruciferous vegetables and artichoke have also demonstrated a GSH-protective effect [131–133]. There is therefore the potential to improve glutathione status via diet or supplementation (Table 7(c)).

2.2.4. Amino Acid Transferases. Amino acids of various types (e.g., taurine, glycine), whether endogenous or exogenous (from dietary sources) in origin, can be utilized for attaching to molecules for their excretion. For the benefit of providing a substrate to these enzymes, it is generally thought that dietary protein is required for an effective detoxification protocol. Table 8 lists amino acids used in phase II conjugation reactions and selected food sources.

2.2.5. N-Acetyl Transferases (NAT). This class of enzymes is responsible for the transfer of an acetyl group to convert aromatic amines or hydrazines to aromatic amides and hydrazides, which is significant for those taking pharmaceuticals such as isoniazid, hydralazine, and sulphonamides [83]. Polymorphisms in genes for this category of enzymes, leading to slow metabolism, have been shown to be associated with hepatoxicity during drug treatment [146]. One small human study found that 500 mg quercetin daily enhanced NAT activity [29]. However, more research is needed to understand the relationship between dietary nutrients and NAT function.

Table 7: (a) *In vivo* example nutrient inducers of glutathione S-transferases (GSTs). (b) *In vivo* example nutrient inhibitors of glutathione S-transferases (GSTs). (c) Selected dietary sources of nutrients for glutathione support ([111] unless otherwise noted).

(a)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
GSTs	Cruciferous vegetables	Clinical, observational	Approximately 5 and 10 servings/d of cruciferous vegetables including frozen broccoli, cauliflower, fresh cabbage (red and green), and fresh radish sprouts [114] >31.2 g/d cruciferous vegetables [115] 4.5 cups of cruciferous vegetables/d, including 0.5 cups of radish sprouts, 1 cup of frozen cauliflower, 2 cups of frozen broccoli, and 1 cup of fresh cabbage [116] 300 g/d cooked Brussels sprouts [117]
	Allium vegetables	Clinical	3 tbsp fresh chives, 1.33 cups of fresh leeks, 1 tsp garlic, and 0.5 cups of fresh onion [116]
	Resveratrol *Grapes, wine, peanuts, soy,* and *itadori tea* [32]	Clinical	1 g/d resveratrol [28]: *note high dose used*
	Citrus	Observational, *in vivo*	>76 g/d citrus [115] 20 mg limonoid mixture every 2 days [124]
	Garlic	*In vivo*	30 to 200 mg/kg garlic oil [36] 80 and 200 mg/kg garlic oil 3 times weekly [70]
	Fish oil	*In vivo*	20.5 g/kg fish oil [36]: *note high dose used*
	Black soybean	*In vivo*	1 g/kg black soybean seed coat extract [44]
	Purple sweet potato	*In vivo*	100 and 200 mg/kg anthocyanin extract from purple sweet potato [118]
	Curcumin	*In vivo*	Diet of 2% curcumin [119]
	Green tea	*In vivo*	Equivalent of 4 cups/d (200 mL each) of green tea [120]
	Rooibos tea	*In vivo*	Rooibos tea as sole beverage; concentration 2 g tea leaves/100 mL water steeped for 30 minutes [93]
	Honeybush tea	*In vivo*	Honeybush tea as sole beverage; concentration 4 g tea leaves/100 mL water steeped for 30 minutes [93]
	Ellagic acid *Berries, pomegranate, grapes, walnuts,* and *blackcurrants* [42]	*In vivo*	30 mg/kg/d ellagic acid [43]
	Rosemary	*In vivo*	20 mg/kg carnosic acid 3 times weekly [121]
	Ghee (clarified butter)	*In vivo*	19.5 mg CLA (conjugated linoleic acid)/g fat [122]
	Genistein (kidney GSTs) *Fermented soy* (e.g., *miso, tempeh*) contains up to 40% bioavailable genistein versus 1% or less in other soy products [125]	*In vivo*	1.5 g/kg genistein [123]: *note high dose used*

(b)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
GSTs	Apiaceous vegetables	Clinical	1 tsp fresh dill weed, 0.5 cups of fresh celery, 3 tbsp. fresh parsley, 1.25 cups of grated parsnips, and 0.75 cups of frozen carrots [116]

(b) Continued.

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
GSTs	Quercetin *Apple, apricot, blueberries, yellow onion, kale*, and *alfalfa sprouts, green beans, broccoli, black tea*, and *chili powder* [47, 48]	*In vivo*	2 g/kg quercetin [126]: *note high dose used*
	Genistein (liver GSTs) *Fermented soy* (e.g., *miso, tempeh*) containsup to 40% bioavailable genistein, versus 1% or less in other soy products [125]	*In vivo*	1.5 g/kg genistein [123]: *note high dose used*

(c)

Vitamin B6	Turkey, pork, chicken, beef, amaranth, lentils, pistachio nuts, sunflower seeds, garlic, and prunes
Magnesium	Nuts, seeds, beans, and whole grains
Selenium	Brazil nuts, pork, turkey, lamb, chicken, and egg
Methionine	Turkey, pork, chicken, beef, egg, Brazil nuts, soybean, sesame seeds, and spirulina
Cystine	Pork, turkey, chicken, egg, soybean, spirulina, sesame seeds, and oats
Glycine	Turkey, pork, chicken, amaranth, soybean, peanuts, pumpkin seed, and beef
Folate (dietary form of folic acid)	Mung bean, adzuki bean, and other legumes, liver, sunflower seeds, quinoa, spinach, asparagus, avocados, mustard greens, and artichokes
Alpha-lipoic acid	Spinach, broccoli, tomato, peas, Brussels sprouts, and visceral meats [127, 128]
Functional foods	Turmeric, milk thistle, cruciferous vegetables, and artichoke [129–133]

Table 8: Amino acids used in phase II conjugation and selected food sources.

Glycine	Turkey, pork, chicken, soybean, seaweed, eggs, amaranth, beef, mollusks, peanuts, pumpkin seeds, almonds, duck, goose, mung beans, sunflower seeds, lentils, lamb, bison, lobster, and fish [111]
Taurine	Many cooked meats and fish supply taurine. Taurine is also synthesized in the body from cystine (requiring niacin and vitamin B6) and homocysteine (requiring additionally betaine and serine) [144]
Glutamine	Plant and animal proteins such as beef, pork, chicken, dairy products, spinach, parsley, and cabbage [145]
Ornithine	Ornithine is synthesized endogenously via the urea cycle, requiring arginine and magnesium [144]
Arginine	Turkey and pork are especially rich sources; also chicken, pumpkin seeds, soybean, butternuts, egg, peanuts, walnuts, split peas, mollusks, almonds, sesame seeds, lentils, fava beans, mung beans, pine nuts, beef, sunflower seeds, and white beans [111]

2.2.6. Methyltransferases. Relatively significant attention has been given in various medical communities to this class of phase II enzymes due to the increasing importance of methylation for reducing disease risk. The conjugating donor compound in methyltransferase reactions is a methionine group from S-adenosyl-L-methionine (SAMe) [147]. Catechol O-methyltransferase (COMT) is one of the prominent methyltransferases that has received wide attention due to its role in estrogen detoxification [148].

Support for methylation consists of nutrient cofactors and methyl donors, such as methionine, vitamin B12, vitamin B6, betaine, folate, and magnesium [144]. Various foods can provide these nutrients (Table 9). Conversely, a high sucrose diet may inhibit methylation enzymes such as COMT [149].

3. Gene Induction of Phase II Detoxification and Antioxidant Enzymes through Nrf2

The transcription factor, Nrf2 [nuclear factor erythroid 2 (NF-E2) p45-related factor 2], is key to regulating the body's detoxification and antioxidant system. When activated, Nrf2 dissociates from the cytosolic protein, Keap1 (Kelch-like ECH associated protein 1), and translocates to the nucleus to bind to AREs in the promoter/enhancer portion of genes associated with phase II detoxification and antioxidant enzyme genes [150] (Figure 1). Nrf2-deficient animals experience increased toxicity from drugs [151], carcinogens, allergens, and environmental pollutants [152] and do not respond as well to the anti-inflammatory effects of phytochemicals [153], indicating the essentiality of these enzymes. Conversely, Nrf2

Table 9: Selected dietary sources of nutrients for methylation support (adapted from [111]).

Methionine	Meats, poultry, fish, shellfish, egg, nuts (especially Brazil nuts), seeds (especially sesame seeds and pumpkin seeds), spirulina, teff, soybeans Lower amounts found in other legumes and whole grains (especially teff and oats)
Vitamin B12	Meats and meat products (especially liver and kidney), poultry, fish, shellfish, and eggs
Vitamin B6	Meats, nuts (especially pistachio), garlic, whole grains, seeds (especially sesame and sunflower seeds), legumes (especially chickpeas and lentils), and prunes
Betaine	Quinoa, beets, spinach, whole grains (especially rye, kamut, bulgur, amaranth, barley, and oats) sweet potato, meats, and poultry
Folate	Beans and legumes (especially mung beans, adzuki beans, chickpeas, and lentils), liver, nuts (especially peanuts), seeds (especially sunflower seeds), spinach, asparagus, mustard greens, and avocado
Magnesium	Seeds (especially pumpkin seeds and sesame seeds), beans (especially soybeans), nuts (especially Brazil nuts and almonds), and whole grains (especially amaranth)

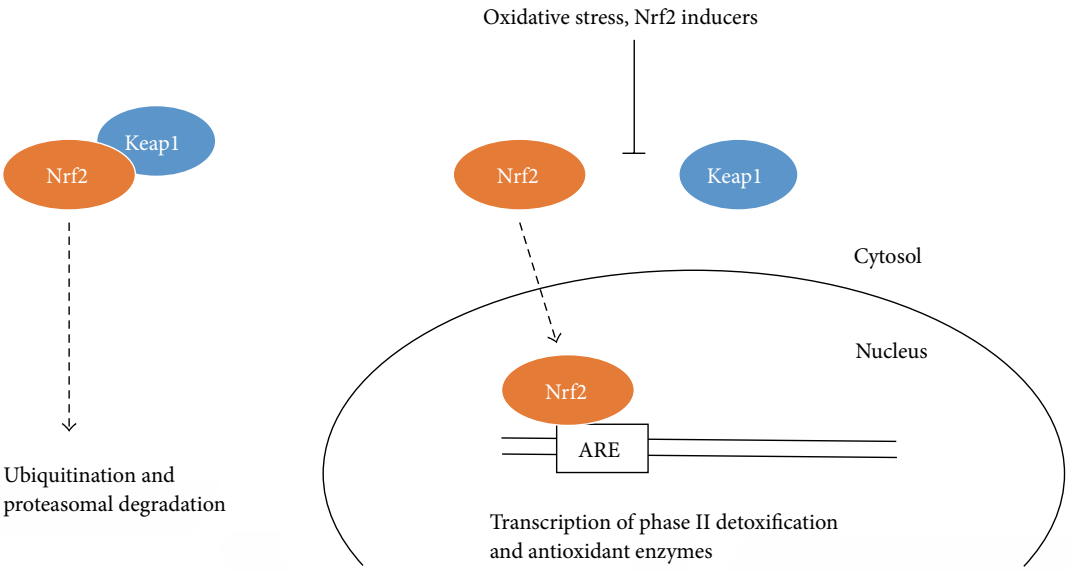

Figure 1: Nrf2/Keap1 signaling (created from text in [154]).

induction is considered protective against various oxidative stress-related conditions such as cancer, kidney dysfunction, pulmonary disorders, arthritis, neurological disease, and cardiovascular disease [154].

Research demonstrates that dietary components, especially phytochemicals, not only scavenge reactive oxygen species, thereby acting as direct antioxidants, but also regulate Nrf2 activity [150]. *In vivo* evidence exists for Nrf2-modulation by curcumin [155–158], broccoli constituents [159, 160], garlic [161–163], epicatechins [164–167], resveratrol [168, 169], ginger [170, 171], purple sweet potato [118], isoflavones [172, 173], coffee [174], rosemary [175, 176], blueberry [166, 177], pomegranate [178], naringenin [179], ellagic acid [166], astaxanthin [166], and γ-tocopherol [180] (Table 10(a)). A clinical trial by Magbanua et al. (2011), investigating the Nrf2 modulation effects of fish oil and lycopene in the context of prostate cancer risk, also demonstrated that these dietary compounds can upregulate Nrf2 signaling and response to oxidative stress in humans [181]. Direct comparison of the magnitude of effect between these compounds can be difficult to gauge. Some information on their relative effects is provided by Kavitha et al. (2013), who ranked the order of potency of the compounds they tested (from highest to lowest) as chlorophyllin (a semisynthetic compound derived from chlorophyll), blueberry, ellagic acid, astaxanthin, and EGCG [166].

Various studies point to the advantageous effects of whole foods, and food combinations, versus specific bioactive compounds. Zhou et al. (2014), for example, illustrate how organosulfur compounds are not the only Nrf2-enhancing bioactive compounds in garlic; garlic carbohydrate derivatives also show Nrf2-modulatory activity [186]. Balstad et al. (2011), in testing the effects of a combination of food extracts on Nrf2 activity in mice, found that the combination produced a larger-than-expected effect, indicating an additive or synergistic effect [176]. By their calculations, the food extract they used equated to a human (70 kg) dose of 14–23 g each of turmeric, rosemary, and thyme, which is clearly not practical for clinical application, as well as 140–233 g each of coffee, red onion, and broccoli. Calabrese et al. (2010) and Houghton et al. (2013) have also argued that Nrf2 inducers exhibit biphasic effects, with lower doses demonstrating stimulatory effects

Table 10: (a) *In vivo* example nutrient inducers of the Nrf2 pathway. (b) *In vivo* example nutrient inhibitors of the Nrf2 pathway.

(a)

Enzyme	Food, beverage, or bioactive compounds *Food sources in italics*	Type of study	Dosages used and references
Nrf2	Fish oil	Clinical	3 × 1 g/d fish oil containing 1098 mg EPA and 549 mg DHA [181]
	Lycopene *Tomatoes, rose hips, guava, watermelon,* and *papaya* [111]	Clinical	2 × 15 mg/d lycopene [181]
	Curcumin *Turmeric, curry powder* [34]	*In vivo*	200 mg/kg/d curcumin [155] 75 mg/kg/d curcumin [156] 50 mg/kg/d curcumin [157] 200 mg/kg/d curcumin [158]
	Cruciferous vegetables	*In vivo*	0.5 mg/kg/d sulforaphane [159] Diet of 15% crushed broccoli seed [160]
	Garlic	*In vivo*	50 and 100 mg/kg/d diallyl disulfide [161] 250 mg/kg/d raw garlic [162] 25 mg/kg S-allyl cysteine [163]
	Catechins *Tea* (especially *green tea*), *cocoa, legumes,* and *grapes* [182]	*In vivo*	5, 15, and 45 mg/kg epicatechin [164] 15 mg/kg epicatechin [165] 20 mg/kg Theaphenon E (95% EGCG) [166] 5, 15, and 30 mg/kg epicatechin [167]
	Resveratrol *Grapes, wine, peanuts, soy,* and *itadori tea* [32]	*In vivo*	10 mg/kg/d [168] 20 mg/kg/d [169]
	Ginger	*In vivo*	100 mg/kg/d [6]-shogaol [170] 10 and 100 mg/kg dried ginger extract [171]
	Purple sweet potato	*In vivo*	100 and 200 mg/kg anthocyanin extract from purple sweet potato [118]
	Isoflavones *Soy, kudzu root,* and *red clover* [183]	*In vivo*	80 mg/kg/d soy isoflavones [172] 60 and 120 mg/kg puerarin from kudzu root [173]
	Coffee	*In vivo*	2.0 mL/d coffee to an average animal weight of 200 g ± 10 g [174]
	Rosemary	*In vivo*	50 and 100 mg/kg carnosic acid [175] 5 mg/animal carnosol extract [176]
	Blueberry	*In vivo*	200 mg/kg blueberry [166] 0.6 and 10 g/day [177]
	Pomegranate	*In vivo*	1 and 10 g/kg pomegranate extract [178]: *note high doses used*
	Naringenin *Citrus* [179]	*In vivo*	50 mg/kg/d naringenin [179]
	Ellagic acid *Berries, pomegranate, grapes, walnuts,* and *blackcurrants* [42]	*In vivo*	Diet of 0.4% ellagic acid [166]
	Asthaxanthin *Algae, yeast, salmon, trout, krill, shrimp,* and *crayfish* [38]	*In vivo*	15 mg/kg astaxanthin [166]
	γ-tocopherol *Nuts, seeds, whole grains, vegetable oils,* and *legumes* [111]	*In vivo*	20.8 mg/kg γ-tocopherol [180]

(b)

Enzyme	Food, beverage, or bioactive compounds	Type of study	Dosages used and references
Nrf2	Luteolin	*In vivo*	40 mg/kg luteolin three times per week [184]
	Quercetin	*In vivo*	50 mg/kg/d quercetin [185]

and higher doses exhibiting Nrf2-interference [187, 188]. These data suggest that the doses found in whole foods may be more beneficial than supplements at supraphysiological doses. In fact, it may well be their weak prooxidant effects that stimulate Nrf2 inducers' favorable antioxidant responses [188].

Nonuniform activities of different foods within the same food group should, once again, be considered; in their recent review of the effects of plant-derived compounds on Nrf2 activation, Stefanson and Bakovic (2014) noted that pak choi, via presumed Nrf2 activation, was more effective at reducing inflammation in the colon than broccoli and that broccoli upregulated some additional Nrf2-related antioxidant enzymes compared with pak choi [189]. Interestingly, this effect was only apparent when steamed, rather than cooked, broccoli was used [189], indicating that food preparation may be an important consideration.

Conversely to its role in cancer prevention, overexpression of Nrf2 is found in many cancer cells and has been shown to promote tumor growth and resistance to anticancer therapy [154]. Consequently, the inhibition of Nrf2 signaling may be clinically relevant for patients receiving cancer chemotherapy [184, 185]. Overexpression of Nrf2 and CYP2E1 has also been associated with impaired GLUT4 activity and insulin resistance [68]. As noted above, supplementation (above levels normally consumed through diet) with certain phytochemicals may have inhibitory effects on Nrf2 activation, including luteolin [184] and quercetin [185] (Table 10(b)). Vitamins A, C, and E and N-acetyl cysteine have also been implicated as Nrf2 inhibitors at high doses [188]. These findings point to the need for further research to clarify outcomes as they relate to specific disease states as well as potential biphasic dose effects.

4. Metallothionein

Metallothionein, a cysteine-rich protein with the ability to bind divalent cations, including toxic metals such as mercury, cadmium, lead, and arsenic, is gaining recognition as an important component in heavy metal detoxification [190–192]. Similar to the upregulation of phase II and antioxidant enzymes, metallothionein can be induced at specific promoter regions of genes by stimuli such as heavy metals, oxidative stress, glucocorticoids, and even zinc [192]. In addition to sequestering heavy metals, it is capable of scavenging free radicals and reducing injury from oxidative stress [192], as well as inhibiting NF-κB signaling [193].

Dietary patterns and nutrients may result in changes in metallothionein production. Lamb et al. (2011) reported a 54% increase in metallothionein mRNA production in a small clinical trial in women with fibromyalgia following an elimination diet in conjunction with a phytonutrient-rich medical food consisting of hops, pomegranate, prune skin, and watercress [194]. Zinc supplementation (15 mg/day) to healthy men over 10 days led to significantly increased metallothionein mRNA, up to 2-fold in leukocytes and up to 4-fold from dried blood spots [195]. Metallothionein has been shown to be decreased in the intestinal mucosa of patients with inflammatory bowel disease (IBD); however, zinc supplementation (300 mg zinc aspartate, equal to 60 mg elemental zinc per day for 4 weeks) in 14 zinc-deficient patients with IBD resulted in slightly higher metallothionein concentration in the intestinal mucosa [196]. Cruciferous phytonutrients may also modulate metallothionein expression, as suggested by a 10-fold increase following a single oral dose of 50 μmol sulforaphane to rats [197]. Chromium may *inhibit* zinc-induced metallothionein expression, according to animal studies by Kimura et al. (2011) [198]. Early-stage, *in vitro* studies also suggest that quercetin and *Cordyceps sinensis*, a mushroom native to the Himalayan region, may upregulate metallothionein expression [199, 200].

5. Clinical Applications

With the continued emergence of data supporting the role of toxins in chronic disease processes, it is becoming increasingly necessary for clinicians to understand how to provide therapeutic modalities to reduce toxin load in patients. In this paper, several studies regarding the influence of foods and food-based nutrients on the systems of detoxification were presented. From the current information presented, listed below are some key concepts for translation into the clinical setting.

5.1. Nonclinical versus Clinical Studies. One of the limitations that comes to the forefront in this collection of studies is how the information, in many cases, is constrained primarily to studies in cells or animals. It remains questionable as to whether similar effects would be seen in humans at moderate, reasonable doses. In the cell studies, it is difficult to anticipate findings due to the lack of pleiotropic activity that occurs in a complex, living system with multiple detoxification systems working simultaneously. Along similar lines, animal studies are often difficult to extrapolate to individuals due to the degree of variability in genotype and environmental phenotype seen in the diverse human population. Therefore, at this time, it is best to take precaution in firmly advocating foods or food-based nutrients that only have cell or animal data as support. It is best to rely on the clinical studies that have been published to date in making more firm recommendations.

5.2. Single Agent versus Lifestyle. While this paper focuses on isolated nutrients and foods that contain those nutrients, it might be optimal from a clinical perspective to consider how an entire lifestyle might induce or inhibit the array of detoxification enzymes. For example, this paper has not addressed behaviors like smoking, physical activity, or stress. The modern clinician needs to weigh all these variables against each other. Yet, science has not fully demonstrated the individual impacts of these factors, along with all of them together. Therefore, at this time, a dietary pattern favoring whole, unprocessed, plant-based foods and the removal or reduction of toxic substances in one's environment is a two-prong approach that would seem to have the best overarching scientific underpinning.

5.3. Modulating versus Inhibiting/Inducing Effects. In several instances, certain foods exhibited a particular activity on an enzyme, while, at higher doses, they had another, opposite effect. Essentially, many foods serve as what is commonly referred to as being "bifunctional modulators," possessing the ability to effectively induce or inhibit detoxification enzyme activity based on the dose response. Therefore, the resulting clinical takeaway might be to encourage patients to follow a mixed, varied diet, full of different plant-based, whole foods. Smaller amounts of many compounds might be more therapeutic and supportive for biochemical pathways rather than overriding signals derived from high concentrations of nutrients through high-dose supplementation or the repeat, daily ingestion of large quantities of the same food.

5.4. Polypharmacy. For patients who are taking multiple pharmaceuticals, it is important to know which detoxification systems will be influenced by nutrients and foods so that side effects are minimized or avoided.

5.5. Dietary Supplements versus Foods. Since there can be potent effects of food-based nutrients on detoxification pathways, it would be best for the average patient to follow, as indicated above, a mixed, complex, and whole-foods diet. Additionally, dietary supplements may be a helpful adjunct in patients in which the practitioner has information about the patient's genetic variability, so that nutrients can be tailored accordingly. Without a full understanding of a patient's SNPs (single nucleotide polymorphisms), it becomes difficult to make accurate assessments about nutrients and dosing.

5.6. Duration of Dosing. Another factor to consider in therapeutic intervention is the timing and duration of the dose of nutrient or the food. In some of the research presented here, effects on detoxification enzymes were seen after several days of food intake or supplementation, while, in other cases, induction of an enzyme might be fairly rapid, followed by efficient adaptability. This variable needs to be considered in further clinical research and requires close monitoring in clinical practice.

5.7. Foods Known to Impact Detoxification. Based on the four systems examined in this paper, there are several foods which seem to have demonstrated an influence on detoxification systems. Many of them have been acknowledged as part of naturopathic medicine. Hence, it would be useful to have a knowledge base of this cumulative set of foods as patients embark upon detoxification protocols. This recent scientific update notes clinical evidence of effects from cruciferous vegetables (in combination, and specifically watercress, garden cress, and broccoli), allium vegetables, apiaceous vegetables, grapefruit, resveratrol, fish oil, quercetin, daidzein, and lycopene. Many other foods, beverages, and nutrient bioactive compounds, based on this review of scientific literature, are also suggested as modulators of detoxification enzymes *in vivo* (Table 11).

Table 11: Food, beverages, and bioactive compounds with demonstrated, or potential, clinical impact on detoxification systems.

Food or beverage	Nutrient bioactive compounds
Allium vegetables	Astaxanthin
Apiaceous vegetables	Caffeic acid
Black raspberry	Catechins (*including EGCG*)
Black tea	Chrysin
Blueberry	Curcumin
Chamomile tea	Daidzein
Chicory root	Ellagic acid
Citrus	Ferulic acid
Coffee	Fish oil
Cruciferous vegetables (*with potential for distinct effects of different crucifers*)	Genistein
	Luteolin
	Lycopene
Dandelion tea	MCTs
Garlic	Myricetin
Ghee	N-acetyl cysteine
Ginger	Naringenin
Grapefruit	Quercetin
Green tea	Resveratrol
Honeybush tea	Retinoic acid (*vitamin A*)
Peppermint tea	
Pomegranate	
Purple sweet potato	
Rooibos tea	
Rosemary	
Soybean/black soybean	
Turmeric	

6. Conclusions

Over the past decade, there has been investigation into nutrigenomic and epigenetic influences of food constituents on chronic diseases [201, 202]. Similarly, studies have revealed that exposure to and accumulation of toxins play a significant role in cardiovascular disease, type 2 diabetes, and obesity [203–207]. Thus, one's dietary intake and environmental influences may have large bearing on the incidence of chronic disease. In fact, these influences may be significant not just for the individual, but for several generations due to the transgenerational inheritance of epigenetic changes [208, 209]. Therefore, it would seem that designing clinical recommendations to maximize the effects of food and reduce the impact of toxins is essential. However, it is not without caution and critical thinking that a detoxification protocol should be assembled for patients by trained clinicians. There remain many unresolved issues regarding knowing how and what foods modulate detoxification pathways.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Authors' Contribution

All authors read and approved the final version of the paper.

References

[1] W. Baer-Dubowska and H. Szaefer, "Modulation of carcinogen-metabolizing cytochromes P450 by phytochemicals in humans," *Expert Opinion on Drug Metabolism and Toxicology*, vol. 9, no. 8, pp. 927–941, 2013.

[2] H. Steinkellner, S. Rabot, C. Freywald et al., "Effects of cruciferous vegetables and their constituents on drug metabolizing enzymes involved in the bioactivation of DNA-reactive dietary carcinogens," *Mutation Research*, vol. 480-481, pp. 285–297, 2001.

[3] Y. J. Moon, X. Wang, and M. E. Morris, "Dietary flavonoids: effects on xenobiotic and carcinogen metabolism," *Toxicology in Vitro*, vol. 20, no. 2, pp. 187–210, 2006.

[4] N. Hakooz and I. Hamdan, "Effects of dietary broccoli on human in vivo caffeine metabolism: a pilot study on a group of Jordanian volunteers," *Current Drug Metabolism*, vol. 8, no. 1, pp. 9–15, 2007.

[5] D. James, S. Devaraj, P. Bellur, S. Lakkanna, J. Vicini, and S. Boddupalli, "Novel concepts of broccoli sulforaphanes and disease: induction of phase II antioxidant and detoxification enzymes by enhanced-glucoraphanin broccoli," *Nutrition Reviews*, vol. 70, no. 11, pp. 654–665, 2012.

[6] H. S. Aiyer and R. C. Gupta, "Berries and ellagic acid prevent estrogen-induced mammary tumorigenesis by modulating enzymes of estrogen metabolism," *Cancer Prevention Research*, vol. 3, no. 6, pp. 727–737, 2010.

[7] Bogacz A, P. Ł. Mikołajczak, P. Ł. Mikołajczak et al., "The influence of soybean extract on the expression level of selected drug transporters, transcription factors and cytochrome P450 genes encoding phase I drug-metabolizing enzymes," *Ginekologia Polska*, vol. 85, no. 5, pp. 348–353, 2014.

[8] D. M. Davenport and M. J. Wargovich, "Modulation of cytochrome P450 enzymes by organosulfur compounds from garlic," *Food and Chemical Toxicology*, vol. 43, no. 12, pp. 1753–1762, 2005.

[9] C. K. Lii, C. W. Tsai, and C. C. Wu, "Garlic allyl sulfides display differential modulation of rat cytochrome P450 2B1 and the placental form glutathione S-transferase in various organs," *Journal of Agricultural and Food Chemistry*, vol. 54, no. 14, pp. 5191–5196, 2006.

[10] C. M. Kaefer and J. A. Milner, "The role of herbs and spices in cancer prevention," *Journal of Nutritional Biochemistry*, vol. 19, no. 6, pp. 347–361, 2008.

[11] Y. W. Hsieh, C. Y. Huang, S. Y. Yang et al., "Oral intake of curcumin markedly activated CYP 3A4: in vivo and ex-vivo studies," *Scientific Reports*, vol. 4, article 6587, 2014.

[12] M. Murray and J. Pizzorno, *Encyclopedia of Natural Medicine*, Prima Publishing, Rocklin, Calif, USA, 2nd edition, 1998.

[13] Institute for Functional Medicine, *Textbook of Functional Medicine*, Johnston Printing, Boulder, Colo, USA, 2006.

[14] V. Ullrich, "Cytochrome P450 and biological hydroxylation reactions," *Topics in Current Chemistry*, vol. 83, pp. 67–104, 1979.

[15] P. B. Danielson, "The cytochrome P450 superfamily: biochemistry, evolution and drug metabolism in humans," *Current Drug Metabolism*, vol. 3, no. 6, pp. 561–597, 2002.

[16] A. J. Paine, "Hepatic cytochrome P-450," *Essays in Biochemistry*, vol. 17, pp. 85–126, 1981.

[17] Q. Chen, T. Zhang, J. F. Wang, and D. Q. Wei, "Advances in human cytochrome P450 and personalized medicine," *Current Drug Metabolism*, vol. 12, no. 5, pp. 436–444, 2011.

[18] Q. Ma and A. Y. H. Lu, "CYP1A induction and human risk assessment: an evolving tale of in vitro and in vivo studies," *Drug Metabolism and Disposition*, vol. 35, no. 7, pp. 1009–1016, 2007.

[19] M. O. James, J. C. Sacco, and L. R. Faux, "Effects of food natural products on the biotransformation of PCBs," *Environmental Toxicology and Pharmacology*, vol. 25, no. 2, pp. 211–217, 2008.

[20] K. Vistisen, S. Loft, J. H. Olsen et al., "Low CYP1A2 activity associated with testicular cancer," *Carcinogenesis*, vol. 25, no. 6, pp. 923–929, 2004.

[21] N. Božina, V. Bradamante, and M. Lovrić, "Genetic polymorphism of metabolic enzymes P450 (CYP) as a susceptibility factor for drug response, toxicity, and cancer risk," *Arhiv za Higijenu Rada i Toksikologiju*, vol. 60, no. 2, pp. 217–242, 2009.

[22] Y. Tsuchiya, M. Nakajima, and T. Yokoi, "Cytochrome P450-mediated metabolism of estrogens and its regulation in human," *Cancer Letters*, vol. 227, no. 2, pp. 115–124, 2005.

[23] J. J. Michnovicz and H. L. Bradlow, "Induction of estradiol metabolism by dietary indole-3-carbinol in humans," *Journal of the National Cancer Institute*, vol. 82, no. 11, pp. 947–949, 1990.

[24] S. Peterson, Y. Schwarz, S. S. Li et al., "*CYP1A2*, *GSTM1*, and *GSTT1* polymorphisms and diet effects on CYP1A2 activity in a crossover feeding trial," *Cancer Epidemiology Biomarkers and Prevention*, vol. 18, no. 11, pp. 3118–3125, 2009.

[25] D. G. Walters, P. J. Young, C. Agus et al., "Cruciferous vegetable consumption alters the metabolism of the dietary carcinogen 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine (PhIP) in humans," *Carcinogenesis*, vol. 25, no. 9, pp. 1659–1669, 2004.

[26] M. A. Kall, O. Vang, and J. Clausen, "Effects of dietary broccoli on human in vivo drug metabolizing enzymes: evaluation of caffeine, oestrone and chlorzoxazone metabolism," *Carcinogenesis*, vol. 17, no. 4, pp. 793–799, 1996.

[27] T. L. Horn, M. A. Reichert, R. L. Bliss, and D. Malejka-Giganti, "Modulations of P450 mRNA in liver and mammary gland and P450 activities and metabolism of estrogen in liver by treatment of rats with indole-3-carbinol," *Biochemical Pharmacology*, vol. 64, no. 3, pp. 393–404, 2002.

[28] H. H. S. Chow, L. L. Garland, C. H. Hsu et al., "Resveratrol modulates drug- and carcinogen-metabolizing enzymes in a healthy volunteer study," *Cancer Prevention Research*, vol. 3, no. 9, pp. 1168–1175, 2010.

[29] Y. Chen, P. Xiao, D. S. Ou-Yang et al., "Simultaneous action of the flavonoid quercetin on cytochrome p450 (cyp) 1a2, cyp2a6, n-acetyltransferase and xanthine oxidase activity in healthy volunteers," *Clinical and Experimental Pharmacology and Physiology*, vol. 36, no. 8, pp. 828–833, 2009.

[30] R. S. Lord, B. Bongiovanni, and J. A. Bralley, "Estrogen metabolism and the diet-cancer connection: rationale for assessing the ratio of urinary hydroxylated estrogen metabolites," *Alternative Medicine Review*, vol. 7, no. 2, pp. 112–129, 2002.

[31] H. Takemura, H. Sakakibara, S. Yamazaki, and K. Shimoi, "Breast cancer and flavonoids—a role in prevention," *Current Pharmaceutical Design*, vol. 19, no. 34, pp. 6125–6132, 2013.

[32] J. Burns, T. Yokota, H. Ashihara, M. E. J. Lean, and A. Crozier, "Plant foods and herbal sources of resveratrol," *Journal of Agricultural and Food Chemistry*, vol. 50, no. 11, pp. 3337–3340, 2002.

[33] H. T. Yao, Y. R. Hsu, C. K. Lii, A. H. Lin, K. H. Chang, and H. T. Yang, "Effect of commercially available green and black tea beverages on drug-metabolizing enzymes and oxidative stress in Wistar rats," *Food and Chemical Toxicology*, vol. 70, pp. 120–127, 2014.

[34] R. F. Tayyem, D. D. Heath, W. K. Al-Delaimy, and C. L. Rock, "Curcumin content of turmeric and curry powders," *Nutrition and Cancer*, vol. 55, no. 2, pp. 126–131, 2006.

[35] S. S. Bansal, H. Kausar, M. V. Vadhanam et al., "Curcumin implants, not curcumin diet, inhibit estrogen-induced mammary carcinogenesis in ACI rats," *Cancer Prevention Research*, vol. 7, no. 4, pp. 456–465, 2014.

[36] H. W. Chen, C. W. Tsai, J. J. Yang, C. T. Liu, W. W. Kuo, and C. K. Lii, "The combined effects of garlic oil and fish oil on the hepatic antioxidant and drug-metabolizing enzymes of rats," *British Journal of Nutrition*, vol. 89, no. 2, pp. 189–200, 2003.

[37] P. Debersac, J. M. Heydel, M. J. Amiot et al., "Induction of cytochrome P450 and/or detoxication enzymes by various extracts of rosemary: Description of specific patterns," *Food and Chemical Toxicology*, vol. 39, no. 9, pp. 907–918, 2001.

[38] R. R. Ambati, P. S. Moi, S. Ravi, and R. G. Aswathanarayana, "Astaxanthin: sources, extraction, stability, biological activities and its commercial applications—a review," *Marine Drugs*, vol. 12, no. 1, pp. 128–152, 2014.

[39] S. Gradelet, P. Astorg, J. Leclerc, J. Chevalier, M.-F. Vernevaut, and M.-H. Siess, "Effects of canthaxanthin, astaxanthin, lycopene and lutein on liver xenobiotic-metabolizing enzymes in the rat," *Xenobiotica*, vol. 26, no. 1, pp. 49–63, 1996.

[40] A. Bu-Abbas, M. N. Clifford, R. Walker, and C. Ioannides, "Selective induction of rat hepatic CYP1 and CYP4 proteins and of peroxisomal proliferation by green tea," *Carcinogenesis*, vol. 15, no. 11, pp. 2575–2579, 1994.

[41] M. K. Rasmussen, C. Brunius, G. Zamaratskaia, and B. Ekstrand, "Feeding dried chicory root to pigs decrease androstenone accumulation in fat by increasing hepatic 3β hydroxysteroid dehydrogenase expression," *Journal of Steroid Biochemistry and Molecular Biology*, vol. 130, no. 1-2, pp. 90–95, 2012.

[42] C. Usta, S. Ozdemir, M. Schiariti, and P. E. Puddu, "The pharmacological use of ellagic acid-rich pomegranate fruit," *International Journal of Food Sciences and Nutrition*, vol. 64, no. 7, pp. 907–913, 2013.

[43] G. Celik, A. Semiz, S. Karakurt, S. Arslan, O. Adali, and A. Sen, "A comparative study for the evaluation of two doses of ellagic acid on hepatic drug metabolizing and antioxidant enzymes in the rat," *BioMed Research International*, vol. 2013, Article ID 358945, 9 pages, 2013.

[44] T. Zhang, S. Jiang, C. He, Y. Kimura, Y. Yamashita, and H. Ashida, "Black soybean seed coat polyphenols prevent B(a)P-induced DNA damage through modulating drug-metabolizing enzymes in HepG2 cells and ICR mice," *Mutation Research*, vol. 752, no. 1-2, pp. 34–41, 2013.

[45] F. Catterall, N. J. McArdle, L. Mitchell, A. Papayanni, M. N. Clifford, and C. Ioannides, "Hepatic and intestinal cytochrome P450 and conjugase activities in rats treated with black tea theafulvins and theaflavins," *Food and Chemical Toxicology*, vol. 41, no. 8, pp. 1141–1147, 2003.

[46] R. Thapliyal and G. B. Maru, "Inhibition of cytochrome P450 isozymes by curcumins in vitro and in vivo," *Food and Chemical Toxicology*, vol. 39, no. 6, pp. 541–547, 2001.

[47] L. Sampson, E. Rimm, P. C. H. Hollman, J. H. M. de Vries, and M. B. Katan, "Flavonol and flavone intakes in US health professionals," *Journal of the American Dietetic Association*, vol. 102, no. 10, pp. 1414–1420, 2002.

[48] M. G. L. Hertog, E. J. M. Feskens, P. C. H. Hollman et al., "Content of potentially anticarcinogenic flavonoids of 28 vegetables and 9 fruits commonly consumed in the Netherlands," *Journal of Agricultural and Food Chemistry*, vol. 40, no. 12, pp. 2379–2383, 1992.

[49] W. X. Peng, H. D. Li, and H. H. Zhou, "Effect of daidzein on CYP1A2 activity and pharmacokinetics of theophylline in healthy volunteers," *European Journal of Clinical Pharmacology*, vol. 59, no. 3, pp. 237–241, 2003.

[50] U. Fuhr, K. Klittich, and A. H. Staib, "Inhibitory effect of grapefruit juice and its bitter principal, naringenin, on CYP1A2 dependent metabolism of caffeine in man," *British Journal of Clinical Pharmacology*, vol. 35, no. 4, pp. 431–436, 1993.

[51] I. Yamasaki, M. Yamada, N. Uotsu, S. Teramoto, R. Takayanagi, and Y. Yamada, "Inhibitory effects of kale ingestion on metabolism by cytochrome P450 enzymes in rats," *Biomedical Research*, vol. 33, no. 4, pp. 235–242, 2012.

[52] T. Zeng, C. L. Zhang, F. Y. Song, X. Y. Han, and K. Q. Xie, "The modulatory effects of garlic oil on hepatic cytochrome P450s in mice," *Human and Experimental Toxicology*, vol. 28, no. 12, pp. 777–783, 2009.

[53] P. P. Maliakal and S. Wanwimolruk, "Effect of herbal teas on hepatic drug metabolizing enzymes in rats," *Journal of Pharmacy and Pharmacology*, vol. 53, no. 10, pp. 1323–1329, 2001.

[54] A. U. Nissar, M. R. Farrukh, P. J. Kaiser et al., "Effect of N-acetyl cysteine (NAC), an organosulfur compound from Allium plants, on experimentally induced hepatic prefibrogenic events in wistar rat," *Phytomedicine*, vol. 20, no. 10, pp. 828–833, 2013.

[55] F. I. Al-Jenoobi, A. A. Al-Thukair, M. A. Alam et al., "Effect of garden cress seeds powder and its alcoholic extract on the metabolic activity of CYP2D6 and CYP3A4," *Evidence-Based Complementary and Alternative Medicine*, vol. 2014, Article ID 634592, 6 pages, 2014.

[56] D. Park, J. H. Jeon, S. Shin et al., "Green tea extract increases cyclophosphamide-induced teratogenesis by modulating the expression of cytochrome P-450 mRNA," *Reproductive Toxicology*, vol. 27, no. 1, pp. 79–84, 2009.

[57] V. Yoxall, P. Kentish, N. Coldham, N. Kuhnert, M. J. Sauer, and C. Ioannides, "Modulation of hepatic cytochromes P450 and phase II enzymes by dietary doses of sulforaphane in rats: implications for its chemopreventive activity," *International Journal of Cancer*, vol. 117, no. 3, pp. 356–362, 2005.

[58] C. Li, S. C. Lim, J. Kim, and J. S. Choi, "Effects of myricetin, an anticancer compound, on the bioavailability and pharmacokinetics of tamoxifen and its main metabolite, 4-hydroxytamoxifen, in rats," *European Journal of Drug Metabolism and Pharmacokinetics*, vol. 36, no. 3, pp. 175–182, 2011.

[59] I. Leclercq, J. P. Desager, and Y. Horsmans, "Inhibition of chlorzoxazone metabolism, a clinical probe for CYP2E1, by a single ingestion of watercress," *Clinical Pharmacology and Therapeutics*, vol. 64, no. 2, pp. 144–149, 1998.

[60] G. D. Loizou and J. Cocker, "The effects of alcohol and diallyl sulphide on CYP2E1 activity in humans: a phenotyping study

using chlorzoxazone," *Human and Experimental Toxicology*, vol. 20, no. 7, pp. 321–327, 2001.

[61] K. A. Park, S. Kweon, and H. Choi, "Anticarcinogenic effect and modification of cytochrome P450 2E1 by dietary garlic powder in diethylnitrosamine-initiated rat hepatocarcinogenesis," *Journal of Biochemistry and Molecular Biology*, vol. 35, no. 6, pp. 615–622, 2002.

[62] C. M. Park, Y. S. Cha, H. J. Youn, C. W. Cho, and Y. S. Song, "Amelioration of oxidative stress by dandelion extract through CYP2E1 suppression against acute liver injury induced by carbon tetrachloride in sprague-dawley rats," *Phytotherapy Research*, vol. 24, no. 9, pp. 1347–1353, 2010.

[63] M. Tahir and S. Sultana, "Chrysin modulates ethanol metabolism in Wistar rats: a promising role against organ toxicities," *Alcohol and Alcoholism*, vol. 46, no. 4, Article ID agr038, pp. 383–392, 2011.

[64] C. S. Lieber, Q. Cao, L. M. Decarli et al., "Role of medium-chain triglycerides in the alcohol-mediated cytochrome P450 2E1 induction of mitochondria," *Alcoholism: Clinical and Experimental Research*, vol. 31, no. 10, pp. 1660–1668, 2007.

[65] S. A. Sheweita, "Drug-metabolizing enzymes: mechanisms and functions," *Current Drug Metabolism*, vol. 1, no. 2, pp. 107–132, 2000.

[66] N. K. Zgheib, Z. Mitri, E. Geryess, and P. Noutsi, "Cytochrome P4502E1 (CYP2E1) genetic polymorphisms in a Lebanese population: frequency distribution and association with morbid diseases," *Genetic Testing and Molecular Biomarkers*, vol. 14, no. 3, pp. 393–397, 2010.

[67] C. A. González, N. Sala, and G. Capellá, "Genetic susceptibility and gastric cancer risk," *International Journal of Cancer*, vol. 100, no. 3, pp. 249–260, 2002.

[68] M. Armoni, C. Harel, M. Ramdas, and E. Karnieli, "CYP2E1 impairs GLUT4 gene expression and function: NRF2 as a possible mediator," *Hormone and Metabolic Research*, vol. 46, no. 7, pp. 477–483, 2014.

[69] K. Matsuda, Y. Nishimura, N. Kurata, M. Iwase, and H. Yasuhara, "Effects of continuous ingestion of herbal teas on intestinal CYP3A in the rat," *Journal of Pharmacological Sciences*, vol. 103, no. 2, pp. 214–221, 2007.

[70] C. C. Wu, L. Y. Sheen, H. W. Chen, W. W. Kuo, S. J. Tsai, and C. K. Lii, "Differential effects of garlic oil and its three major organosulfur components on the hepatic detoxification system in rats," *Journal of Agricultural and Food Chemistry*, vol. 50, no. 2, pp. 378–383, 2002.

[71] S. Misaka, K. Kawabe, S. Onoue et al., "Green tea extract affects the cytochrome P450 3A activity and pharmacokinetics of simvastatin in rats," *Drug Metabolism and Pharmacokinetics*, vol. 28, no. 6, pp. 514–518, 2013.

[72] S. N. Umathe, P. V. Dixit, V. Kumar, K. U. Bansod, and M. M. Wanjari, "Quercetin pretreatment increases the bioavailability of pioglitazone in rats: involvement of CYP3A inhibition," *Biochemical Pharmacology*, vol. 75, no. 8, pp. 1670–1676, 2008.

[73] J. Liu, G. J. Tawa, and A. Wallqvist, "Identifying cytochrome P450 functional networks and their allosteric regulatory elements," *PLoS ONE*, vol. 8, no. 12, Article ID e81980, 2013.

[74] S. Tanaka, S. Uchida, S. Miyakawa et al., "Comparison of inhibitory duration of grapefruit juice on organic anion-transporting polypeptide and cytochrome P450 3A4," *Biological and Pharmaceutical Bulletin*, vol. 36, no. 12, pp. 1936–1941, 2013.

[75] D. A. Leibelt, O. R. Hedstrom, K. A. Fisher, C. B. Pereira, and D. E. Williams, "Evaluation of chronic dietary exposure to indole-3-carbinol and absorption-enhanced 3,3′-diidolylmethane in Sprague-Dawley rats," *Toxicological Sciences*, vol. 74, no. 1, pp. 10–21, 2003.

[76] Linus Pauling Institute, *Garlic and Organosulfur Compounds*, Micronutrient Information Center, Corvallis, Ore, USA, 2008, http://lpi.oregonstate.edu/infocenter/phytochemicals/garlic/.

[77] C. Ioannides, "Effect of diet and nutrition on the expression of cytochromes P450," *Xenobiotica*, vol. 29, no. 2, pp. 109–154, 1999.

[78] B. Baer and A. Rettie, "CYP4B1: an enigmatic P450 at the interface between xenobiotic and endobiotic metabolism," *Drug Metabolism Reviews*, vol. 38, no. 3, pp. 451–476, 2006.

[79] Z. Ye, Z. Liu, A. Henderson et al., "Increased CYP4B1 mRNA is associated with the inhibition of dextran sulfate sodium-induced colitis by caffeic acid in mice," *Experimental Biology and Medicine (Maywood)*, vol. 234, no. 6, pp. 606–616, 2009.

[80] S. Lafay, C. Morand, C. Manach, C. Besson, and A. Scalbert, "Absorption and metabolism of caffeic acid and chlorogenic acid in the small intestine of rats," *British Journal of Nutrition*, vol. 96, no. 1, pp. 39–46, 2006.

[81] C. Xu, C. Y. Li, and A. T. Kong, "Induction of phase I, II and III drug metabolism/transport by xenobiotics," *Archives of Pharmacal Research*, vol. 28, no. 3, pp. 249–268, 2005.

[82] G. Ginsberg, K. Guyton, D. Johns, J. Schimek, K. Angle, and B. Sonawane, "Genetic polymorphism in metabolism and host defense enzymes: implications for human health risk assessment," *Critical Reviews in Toxicology*, vol. 40, no. 7, pp. 575–619, 2010.

[83] P. Jancova, P. Anzenbacher, and E. Anzenbacherova, "Phase II drug metabolizing enzymes," *Biomedical Papers*, vol. 154, no. 2, pp. 103–116, 2010.

[84] C. Jenkinson, A. Petroczi, and D. P. Naughton, "Effects of dietary components on testosterone metabolism via UDP-glucuronosyltransferase," *Frontiers in Endocrinology*, vol. 4, article 80, 2013.

[85] J. L. Chang, J. Bigler, Y. Schwarz et al., "UGT1A1 polymorphism is associated with serum bilirubin concentrations in a randomized, controlled, fruit and vegetable feeding trial," *Journal of Nutrition*, vol. 137, no. 4, pp. 890–897, 2007.

[86] A. Rowland, J. O. Miners, and P. I. Mackenzie, "The UDP-glucuronosyltransferases: their role in drug metabolism and detoxification," *International Journal of Biochemistry and Cell Biology*, vol. 45, no. 6, pp. 1121–1132, 2013.

[87] C. P. Strassburg, S. Kneip, J. Topp et al., "Polymorphic gene regulation and interindividual variation of UDP-glucuronosyltransferase activity in human small intestine," *The Journal of Biological Chemistry*, vol. 275, no. 46, pp. 36164–36171, 2000.

[88] P. G. Wells, P. I. Mackenzie, J. R. Chowdhury et al., "Glucuronidation and the UDP-glucuronosyltransferases in health and disease," *Drug Metabolism and Disposition*, vol. 32, no. 3, pp. 281–290, 2004.

[89] J. W. Lampe, "Interindividual differences in response to plant-based diets: Implications for cancer risk," *The American Journal of Clinical Nutrition*, vol. 89, no. 5, pp. 1553S–1557S, 2009.

[90] S. L. Navarro, S. Peterson, C. Chen et al., "Cruciferous vegetable feeding alters UGT1A1 activity: diet- and genotype-dependent changes in serum bilirubin in a controlled feeding trial," *Cancer Prevention Research (Phila)*, vol. 2, no. 4, pp. 345–352, 2009.

[91] S. S. Hecht, S. G. Carmella, and S. E. Murphy, "Effects of watercress consumption on urinary metabolites of nicotine in smokers," *Cancer Epidemiology Biomarkers and Prevention*, vol. 8, no. 10, pp. 907–913, 1999.

[92] M. R. Saracino, J. Bigler, Y. Schwarz et al., "Citrus fruit intake is associated with lower serum bilirubin concentration among women with the UGT1A1*28 polymorphism," *Journal of Nutrition*, vol. 139, no. 3, pp. 555–560, 2009.

[93] J. L. Marnewick, E. Joubert, P. Swart, F. van der Westhuizen, and W. C. Gelderblom, "Modulation of hepatic drug metabolizing enzymes and oxidative status by rooibos (*Aspalathus linearis*) and Honeybush (*Cyclopia intermedia*), green and black (*Camellia sinensis*) teas in rats," *Journal of Agricultural and Food Chemistry*, vol. 51, no. 27, pp. 8113–8119, 2003.

[94] A. Marahatta, B. Bhandary, S.-K. Jeong, H.-R. Kim, and H.-J. Chae, "Soybean greatly reduces valproic acid plasma concentrations: a food-drug interaction study," *Scientific Reports*, vol. 4, article 4362, 2014.

[95] E. M. J. van der Logt, H. M. J. Roelofs, F. M. Nagengast, and W. H. M. Peters, "Induction of rat hepatic and intestinal UDP-glucuronosyltransferases by naturally occurring dietary anticarcinogens," *Carcinogenesis*, vol. 24, no. 10, pp. 1651–1656, 2003.

[96] E. Graf, "Antioxidant potential of ferulic acid," *Free Radical Biology and Medicine*, vol. 13, no. 4, pp. 435–448, 1992.

[97] C. B. Simone II, N. L. Simone, M. Pallante, and C. B. Simone, "Cancer, lifestyle modification and glucarate," *Journal of Orthomolecular Medicine*, vol. 16, no. 2, pp. 83–90, 2001.

[98] R. Zółtaszek, M. Hanausek, Z. M. Kiliańska, and Z. Walaszek, "The biological role of D-glucaric acid and its derivatives: potential use in medicine," *Postpy Higieny i Medycyny Doświadczalnej*, vol. 62, pp. 451–462, 2008.

[99] C. Dwivedi, W. J. Heck, A. A. Downie, S. Larroya, and T. E. Webb, "Effect of calcium glucarate on beta-glucoronidase activity and glucarate content of certain vegetable and fruits," *Biochemical Medicine and Metabolic Biology*, vol. 43, no. 2, pp. 83–92, 1990.

[100] M. Kosmala, Z. Zduńczyk, K. Kołodziejczyk, E. Klimczak, J. Jukiewicz, and P. Zduńczyk, "Chemical composition of polyphenols extracted from strawberry pomace and their effect on physiological properties of diets supplemented with different types of dietary fibre in rats," *European Journal of Nutrition*, vol. 53, no. 2, pp. 521–532, 2014.

[101] S. S. Maruti, J. L. Chang, J. A. Prunty et al., "Serum β-glucuronidase activity in response to fruit and vegetable supplementation: a controlled feeding study," *Cancer Epidemiology Biomarkers and Prevention*, vol. 17, no. 7, pp. 1808–1812, 2008.

[102] A. Jurgoński, J. Juśkiewicz, Z. Zduńczyk, P. Matusevicius, and K. Kołodziejczyk, "Polyphenol-rich extract from blackcurrant pomace attenuates the intestinal tract and serum lipid changes induced by a high-fat diet in rabbits," *European Journal of Nutrition*, vol. 53, no. 8, pp. 1603–1613, 2014.

[103] M. O. James and S. Ambadapadi, "Interactions of cytosolic sulfotransferases with xenobiotics," *Drug Metabolism Reviews*, vol. 45, no. 4, pp. 401–414, 2013.

[104] S. Kodama and M. Negishi, "Sulfotransferase genes: regulation by nuclear receptors in response to xeno/endo-biotics," *Drug Metabolism Reviews*, vol. 45, no. 4, pp. 441–449, 2013.

[105] L.-Q. Wang and M. O. James, "Inhibition of sulfotransferases by xenobiotics," *Current Drug Metabolism*, vol. 7, no. 1, pp. 83–104, 2006.

[106] D. Ung and S. Nagar, "Variable sulfation of dietary polyphenols by recombinant human sulfotransferase (SULT) 1A1 genetic variants and SULT1E1," *Drug Metabolism and Disposition*, vol. 35, no. 5, pp. 740–746, 2007.

[107] T. Zhou, Y. Chen, C. Huang, and G. Chen, "Caffeine induction of sulfotransferases in rat liver and intestine," *Journal of Applied Toxicology*, vol. 32, no. 10, pp. 804–809, 2012.

[108] S. Maiti, X. Chen, and G. Chen, "All-trans retinoic acid induction of sulfotransferases," *Basic and Clinical Pharmacology and Toxicology*, vol. 96, no. 1, pp. 44–53, 2005.

[109] K. Kamio, K. Honke, and A. Makita, "Pyridoxal 5'-phosphate binds to a lysine residue in the adenosine 3′-phosphate 5′-phosphosulfate recognition site of glycolipid sulfotransferase from human renal cancer cells," *Glycoconjugate Journal*, vol. 12, no. 6, pp. 762–766, 1995.

[110] M. Masters and R. A. McCance, "The sulfur content of foods," *Biochemical Journal*, vol. 33, no. 8, pp. 1304–1312, 1939.

[111] USDA National Nutrient Database for Standard Reference, *Nutrient Data Laboratory. Release 27*, Agriculture Research Service, Washington, DC, USA, 2011, http://ndb.nal.usda.gov/ndb/.

[112] S. A. McFadden, "Phenotypic variation in xenobiotic metabolism and adverse environmental response: focus on sulfur-dependent detoxification pathways," *Toxicology*, vol. 111, no. 1–3, pp. 43–65, 1996.

[113] J. D. Hayes and D. J. Pulford, "The glutathione S-transferase supergene family: regulation of GST and the contribution of the isoenzymes to cancer chemoprotection and drug resistance," *Critical Reviews in Biochemistry and Molecular Biology*, vol. 30, no. 6, pp. 445–600, 1995.

[114] S. L. Navarro, J. L. Chang, S. Peterson et al., "Modulation of human serum glutathione *S*-transferase A1/2 concentration by cruciferous vegetables in a controlled feeding study is influenced by *GSTM1* and *GSTT1* genotypes," *Cancer Epidemiology Biomarkers and Prevention*, vol. 18, no. 11, pp. 2974–2978, 2009.

[115] P. A. Wark, M. J. A. L. Grubben, W. H. M. Peters et al., "Habitual consumption of fruits and vegetables: associations with human rectal glutathione S-transferase," *Carcinogenesis*, vol. 25, no. 11, pp. 2135–2142, 2004.

[116] J. W. Lampe, C. Chen, S. Li et al., "Modulation of human glutathione S-transferases by botanically defined vegetable diets," *Cancer Epidemiology Biomarkers and Prevention*, vol. 9, no. 8, pp. 787–793, 2000.

[117] W. A. Nijhoff, T. P. J. Mulder, H. Verhagen, G. van Poppel, and W. H. M. Peters, "Effects of consumption of brussels sprouts on plasma and urinary glutathione S-transferase class-alpha and -pi in humans," *Carcinogenesis*, vol. 16, no. 4, pp. 955–957, 1995.

[118] Y. P. Hwang, J. H. Choi, H. J. Yun et al., "Anthocyanins from purple sweet potato attenuate dimethylnitrosamine-induced liver injury in rats by inducing Nrf2-mediated antioxidant enzymes and reducing COX-2 and iNOS expression," *Food and Chemical Toxicology*, vol. 49, no. 1, pp. 93–99, 2011.

[119] M. Iqbal, S. D. Sharma, Y. Okazaki, M. Fujisawa, and S. Okada, "Dietary supplementation of curcumin enhances antioxidant and phase II metabolizing enzymes in ddY male mice: possible role in protection against chemical carcinogenesis and toxicity," *Pharmacology and Toxicology*, vol. 92, no. 1, pp. 33–38, 2003.

[120] B. J. Newsome, M. C. Petriello, S. G. Han et al., "Green tea diet decreases PCB 126-induced oxidative stress in mice by up-regulating antioxidant enzymes," *Journal of Nutritional Biochemistry*, vol. 25, no. 2, pp. 126–135, 2014.

[121] C. Y. Lin, J. H. Chen, R. H. Fu, and C. W. Tsai, "Induction of Pi form of glutathione S-transferase by carnosic acid is mediated through PI3K/Akt/NF-κB pathway and protects against neurotoxicity," *Chemical Research in Toxicology*, vol. 27, no. 11, pp. 1958–1966, 2014.

[122] K. Chinnadurai, H. K. Kanwal, A. K. Tyagi, C. Stanton, and P. Ross, "High conjugated linoleic acid enriched ghee (clarified butter) increases the antioxidant and antiatherogenic potency in female Wistar rats," *Lipids in Health and Disease*, vol. 12, no. 1, article 121, 2013.

[123] E. B. Froyen, J. L. R. Reeves, A. E. Mitchell, and F. M. Steinberg, "Regulation of phase II enzymes by Genistein and daidzein in male and female Swiss Webster mice," *Journal of Medicinal Food*, vol. 12, no. 6, pp. 1227–1237, 2009.

[124] J. L. Perez, G. K. Jayaprakasha, A. Cadena, E. Martinez, H. Ahmad, and B. S. Patil, "In vivo induction of phase II detoxifying enzymes, glutathione transferase and quinone reductase by citrus triterpenoids," *BMC Complementary and Alternative Medicine*, vol. 10, article 51, 2010.

[125] J. R. Barrett, "The science of soy: what do we really know?" *Environmental Health Perspectives*, vol. 114, no. 6, pp. A352–A358, 2006.

[126] H. Wiegand, C. Boesch-Saadatmandi, I. Regos, D. Treutter, S. Wolffram, and G. Rimbach, "Effects of quercetin and catechin on hepatic glutathione-s transferase (GST), NAD(P)H quinone oxidoreductase 1 (NQO1), and antioxidant enzyme activity levels in rats," *Nutrition and Cancer*, vol. 61, no. 5, pp. 717–722, 2009.

[127] M. B. Gomes and C. A. Negrato, "Alpha-lipoic acid as a pleiotropic compound with potential therapeutic use in diabetes and other chronic diseases," *Diabetology & Metabolic Syndrome*, vol. 6, no. 1, article 80, 2014.

[128] Linus Pauling Institute, *Lipoic Acid*, Micronutrient Information Center, Corvalis, Ore, USA, 2012, http://lpi.oregonstate.edu/infocenter/othernuts/la/.

[129] R. W. Kalpravidh, N. Siritanaratkul, P. Insain et al., "Improvement in oxidative stress and antioxidant parameters in beta-thalassemia/Hb E patients treated with curcuminoids," *Clinical Biochemistry*, vol. 43, no. 4-5, pp. 424–429, 2010.

[130] M. I. Lucena, R. J. Andrade, J. P. de la Cruz, M. Rodriguez-Mendizabal, E. Blanco, and F. Sánchez de la Cuesta, "Effects of silymarin MZ-80 on oxidative stress in patients with alcoholic cirrhosis," *International Journal of Clinical Pharmacology and Therapeutics*, vol. 40, no. 1, pp. 2–8, 2002.

[131] R. A. Santana-Martínez, S. Galván-Arzáte, R. Hernández-Pando et al., "Sulforaphane reduces the alterations induced by quinolinic acid: modulation of glutathione levels," *Neuroscience*, vol. 272, pp. 188–198, 2014.

[132] M. F. Chen, L. T. Chen, and H. W. Boyce Jr., "Cruciferous vegetables and glutathione: their effects on colon mucosal glutathione level and colon tumor development in rats induced by DMH," *Nutrition and Cancer*, vol. 23, no. 1, pp. 77–83, 1995.

[133] E. M. El Morsy and R. Kamel, "Protective effect of artichoke leaf extract against paracetamol-induced hepatotoxicity in rats," *Pharmaceutical Biology*, vol. 53, no. 2, pp. 167–173, 2015.

[134] H. A. Brauer, T. E. Libby, B. L. Mitchell et al., "Cruciferous vegetable supplementation in a controlled diet study alters the serum peptidome in a GSTM1-genotype dependent manner," *Nutrition Journal*, vol. 10, no. 1, article 11, 2011.

[135] T. Hofmann, A. Kuhnert, A. Schubert et al., "Modulation of detoxification enzymes by watercress: *in vitro* and *in vivo* investigations in human peripheral blood cells," *European Journal of Nutrition*, vol. 48, no. 8, pp. 483–491, 2009.

[136] H. J. Forman, H. Zhang, and A. Rinna, "Glutathione: overview of its protective roles, measurement, and biosynthesis," *Molecular Aspects of Medicine*, vol. 30, no. 1-2, pp. 1–12, 2009.

[137] J. K. Kern, D. A. Geier, J. B. Adams, C. R. Garver, T. Audhya, and M. R. Geier, "A clinical trial of glutathione supplementation in autism spectrum disorders," *Medical Science Monitor*, vol. 17, no. 12, pp. CR677–CR682, 2011.

[138] P. G. Paterson, A. W. Lyon, H. Kamencic, L. B. Andersen, and B. H. J. Juurlink, "Sulfur amino acid deficiency depresses brain glutathione concentration," *Nutritional Neuroscience*, vol. 4, no. 3, pp. 213–222, 2001.

[139] A. T. Treweeke, T. J. Winterburn, I. Mackenzie et al., "N-Acetylcysteine inhibits platelet-monocyte conjugation in patients with type 2 diabetes with depleted intraplatelet glutathione: a randomised controlled trial," *Diabetologia*, vol. 55, no. 11, pp. 2920–2928, 2012.

[140] L. Galluzzi, I. Vitale, L. Senovilla et al., "Prognostic impact of vitamin B6 metabolism in lung cancer," *Cell Reports*, vol. 2, no. 2, pp. 257–269, 2012.

[141] J. M. Howard, S. Davies, and A. Hunnisett, "Red cell magnesium and glutathione peroxidase in infertile women—effects of oral supplementation with magnesium and selenium," *Magnesium Research*, vol. 7, no. 1, pp. 49–57, 1994.

[142] D. F. Child, P. R. Hudson, H. Jones et al., "The effect of oral folic acid on glutathione, glycaemia and lipids in type 2 diabetes," *Diabetes, Nutrition and Metabolism—Clinical and Experimental*, vol. 17, no. 2, pp. 95–102, 2004.

[143] H. Ansar, Z. Mazloom, F. Kazemi, and N. Hejazi, "Effect of alpha-lipoic acid on blood glucose, insulin resistance, and glutathione peroxidase of type 2 diabetic patients," *Saudi Medical Journal*, vol. 32, no. 6, pp. 584–588, 2011.

[144] R. S. Lord and J. A. Bralley, Eds., *Laboratory Evaluations for Integrative and Functional Medicine*, Genova Diagnostics, Duluth, Ga, USA, 2nd edition, 2012.

[145] University of Maryland Medical Center, Glutamine, University of Maryland Medical Center, Baltimore, Md, USA, 2014, http://umm.edu/health/medical/altmed/supplement/glutamine.

[146] S. I. Makarova, "Human N-acetyltransferases and drug-induced hepatotoxicity," *Current Drug Metabolism*, vol. 9, no. 6, pp. 538–545, 2008.

[147] K. Kohalmy and R. Vrzal, "Regulation of phase II biotransformation enzymes by steroid hormones," *Current Drug Metabolism*, vol. 12, no. 2, pp. 104–123, 2011.

[148] J. D. Yager, "Mechanisms of estrogen carcinogenesis: the role of E2/E1-quinone metabolites suggests new approaches to preventive intervention—a review," *Steroids*, 2014.

[149] J. Busserolles, W. Zimowska, E. Rock, Y. Rayssiguier, and A. Mazur, "Rats fed a high sucrose diet have altered heart antioxidant enzyme activity and gene expression," *Life Sciences*, vol. 71, no. 11, pp. 1303–1312, 2002.

[150] Z. Y. Su, L. Shu, T. O. Khor, J. H. Lee, F. Fuentes, and A. N. T. Kong, "A perspective on dietary phytochemicals and cancer chemoprevention: oxidative stress, Nrf2, and epigenomics," *Topics in Current Chemistry*, vol. 329, pp. 133–162, 2013.

[151] K. Chan, X. D. Han, and Y. W. Kan, "An important function of Nrf2 in combating oxidative stress: detoxification of acetaminophen," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 98, no. 8, pp. 4611–4616, 2001.

[152] V. Calabrese, C. Cornelius, C. Mancuso et al., "Cellular stress response: A novel target for chemoprevention and nutritional neuroprotection in aging, neurodegenerative disorders and longevity," *Neurochemical Research*, vol. 33, no. 12, pp. 2444–2471, 2008.

[153] S. S. Boyanapalli, X. Paredes-Gonzalez, F. Fuentes et al., "Nrf2 knockout attenuates the anti-inflammatory effects of phenethyl isothiocyanate and curcumin," *Chemical Research in Toxicology*, vol. 27, no. 12, pp. 2036–2043, 2014.

[154] S. K. Niture, R. Khatri, and A. K. Jaiswal, "Regulation of Nrf2—an update," *Free Radical Biology and Medicine*, vol. 66, pp. 36–44, 2014.

[155] Y. Xie, Q. Y. Zhao, H. Y. Li, X. Zhou, Y. Liu, and H. Zhang, "Curcumin ameliorates cognitive deficits heavy ion irradiation-induced learning and memory deficits through enhancing of Nrf2 antioxidant signaling pathways," *Pharmacology Biochemistry and Behavior*, 2014.

[156] V. Soetikno, F. R. Sari, A. P. Lakshmanan et al., "Curcumin alleviates oxidative stress, inflammation, and renal fibrosis in remnant kidney through the Nrf2-keap1 pathway," *Molecular Nutrition & Food Research*, vol. 57, no. 9, pp. 1649–1659, 2013.

[157] H. J. He, G. Y. Wang, Y. Gao, W. H. Ling, Z. W. Yu, and T. R. Jin, "Curcumin attenuates Nrf2 signaling defect, oxidative stress in muscle and glucose intolerance in high fat diet-fed mice," *World Journal of Diabetes*, vol. 3, no. 5, pp. 94–104, 2012.

[158] E. O. Farombi, S. Shrotriya, H. K. Na, S. H. Kim, and Y. J. Surh, "Curcumin attenuates dimethylnitrosamine-induced liver injury in rats through Nrf2-mediated induction of heme oxygenase-1," *Food and Chemical Toxicology*, vol. 46, no. 4, pp. 1279–1287, 2008.

[159] Z. Zhang, S. Wang, S. Zhou et al., "Sulforaphane prevents the development of cardiomyopathy in type 2 diabetic mice probably by reversing oxidative stress-induced inhibition of LKB1/AMPK pathway," *Journal of Molecular and Cellular Cardiology*, vol. 77, pp. 42–52, 2014.

[160] G. K. McWalter, L. G. Higgins, L. I. McLellan et al., "Transcription factor Nrf2 is essential for induction of NAD(P)H:quinone oxidoreductase 1, glutathione S-transferases, and glutamate cysteine ligase by broccoli seeds and isothiocyanates," *Journal of Nutrition*, vol. 134, no. 12, supplement, pp. 3499S–3506S, 2004.

[161] I. C. Lee, S. H. Kim, H. S. Baek et al., "The involvement of Nrf2 in the protective effects of diallyl disulfide on carbon tetrachloride-induced hepatic oxidative damage and inflammatory response in rats," *Food and Chemical Toxicology*, vol. 63, pp. 174–185, 2014.

[162] R. Padiya, D. Chowdhury, R. Borkar, R. Srinivas, M. Pal Bhadra, and S. K. Banerjee, "Garlic attenuates cardiac oxidative stress via activation of PI3K/AKT/Nrf2-Keap1 pathway in fructose-fed diabetic rat," *PLoS ONE*, vol. 9, no. 5, Article ID e94228, 2014.

[163] T. Gómez-Sierra, E. Molina-Jijón, E. Tapia et al., "S-allylcysteine prevents cisplatin-induced nephrotoxicity and oxidative stress," *Journal of Pharmacy and Pharmacology*, vol. 66, no. 9, pp. 1271–1281, 2014.

[164] C. F. Chang, S. Cho, and J. Wang, "(-)-Epicatechin protects hemorrhagic brain via synergistic Nrf2 pathways," *Annals of Clinical and Translational Neurology*, vol. 1, no. 4, pp. 258–271, 2014.

[165] C. C. Leonardo, M. Agrawal, N. Singh, J. R. Moore, S. Biswal, and S. Doré, "Oral administration of the flavanol (-)-epicatechin bolsters endogenous protection against focal ischemia through the Nrf2 cytoprotective pathway," *European Journal of Neuroscience*, vol. 38, no. 11, pp. 3659–3668, 2013.

[166] K. Kavitha, P. Thiyagarajan, J. Rathna, R. Mishra, and S. Nagini, "Chemopreventive effects of diverse dietary phytochemicals against DMBA-induced hamster buccal pouch carcinogenesis via the induction of Nrf2-mediated cytoprotective antioxidant, detoxification, and DNA repair enzymes," *Biochimie*, vol. 95, no. 8, pp. 1629–1639, 2013.

[167] Z. A. Shah, R.-C. Li, A. S. Ahmad et al., "The flavanol (–) -epicatechin prevents stroke damage through the Nrf2/HO1 pathway," *Journal of Cerebral Blood Flow and Metabolism*, vol. 30, no. 12, pp. 1951–1961, 2010.

[168] N. Tamaki, R. Cristina Orihuela-Campos, Y. Inagaki, M. Fukui, T. Nagata, and H. Ito, "Resveratrol improves oxidative stress and prevents the progression of periodontitis via the activation of the Sirt1/AMPK and the Nrf2/antioxidant defense pathways in a rat periodontitis model," *Free Radical Biology and Medicine*, vol. 75, pp. 222–229, 2014.

[169] G. Sadi, D. Bozan, and H. B. Yildiz, "Redox regulation of antioxidant enzymes: post-translational modulation of catalase and glutathione peroxidase activity by resveratrol in diabetic rat liver," *Molecular and Cellular Biochemistry*, vol. 393, no. 1-2, pp. 111–122, 2014.

[170] H. Chen, J. Fu, Y. Hu et al., "Ginger compound [6]-shogaol and its cysteine-conjugated metabolite (M2) activate Nrf2 in colon epithelial cells *in vitro* and *in vivo*," *Chemical Research in Toxicology*, vol. 27, no. 9, pp. 1575–1585, 2014.

[171] M. J. Bak, S. Ok, M. Jun, and W. S. Jeong, "6-shogaol-rich extract from ginger up-regulates the antioxidant defense systems in cells and mice," *Molecules*, vol. 17, no. 7, pp. 8037–8055, 2012.

[172] Y. D. Xi, X. Y. Li, H. L. Yu et al., "Soy isoflavone antagonizes the oxidative cerebrovascular injury induced by β-Amyloid Peptides 1–42 in Rats," *Neurochemical Research*, vol. 39, no. 7, pp. 1374–1381, 2014.

[173] R. Li, T. Liang, L. Xu, N. Zheng, K. Zhang, and X. Duan, "Puerarin attenuates neuronal degeneration in the substantia nigra of 6-OHDA-lesioned rats through regulating BDNF expression and activating the Nrf2/ARE signaling pathway," *Brain Research*, vol. 1523, pp. 1–9, 2013.

[174] S. J. V. Vicente, E. Y. Ishimoto, and E. A. F. S. Torres, "Coffee modulates transcription factor Nrf2 and highly increases the activity of antioxidant enzymes in rats," *Journal of Agricultural and Food Chemistry*, vol. 62, no. 1, pp. 116–122, 2014.

[175] B. D. Sahu, U. K. Putcha, M. Kuncha, S. S. Rachamalla, and R. Sistla, "Carnosic acid promotes myocardial antioxidant response and prevents isoproterenol-induced myocardial oxidative stress and apoptosis in mice," *Molecular and Cellular Biochemistry*, vol. 394, no. 1-2, pp. 163–176, 2014.

[176] T. R. Balstad, H. Carlsen, M. C. W. Myhrstad et al., "Coffee, broccoli and spices are strong inducers of electrophile response element-dependent transcription in vitro and in vivo—studies in electrophile response element transgenic mice," *Molecular Nutrition and Food Research*, vol. 55, no. 2, pp. 185–197, 2011.

[177] Y. P. Wang, M. L. Cheng, B. F. Zhang et al., "Effect of blueberry on hepatic and immunological functions in mice," *Hepatobiliary and Pancreatic Diseases International*, vol. 9, no. 2, pp. 164–168, 2010.

[178] A. Bishayee, D. Bhatia, R. J. Thoppil, A. S. Darvesh, E. Nevo, and E. P. Lansky, "Pomegranate-mediated chemoprevention of experimental hepatocarcinogenesis involves Nrf2-regulated antioxidant mechanisms," *Carcinogenesis*, vol. 32, no. 6, pp. 888–896, 2011.

[179] M. A. Esmaeili and M. Alilou, "Naringenin attenuates CCl4-induced hepatic inflammation by the activation of an Nrf2-mediated pathway in rats," *Clinical and Experimental Pharmacology and Physiology*, vol. 41, no. 6, pp. 416–422, 2014.

[180] C. K. Singh, M. A. Ndiaye, I. A. Siddiqui et al., "Methaneseleninic acid and γ-tocopherol combination inhibits prostate tumor growth in vivo in a xenograft mouse model," *Oncotarget*, vol. 5, no. 11, pp. 3651–3661, 2014.

[181] M. J. M. Magbanua, R. Roy, E. V. Sosa et al., "Gene expression and biological pathways in tissue of men with prostate cancer in a randomized clinical trial of lycopene and fish oil supplementation," *PLoS ONE*, vol. 6, no. 9, Article ID e24004, 2011.

[182] C. Manach, A. Scalbert, C. Morand, C. Rémésy, and L. Jiménez, "Polyphenols: food sources and bioavailability," *The American Journal of Clinical Nutrition*, vol. 79, no. 5, pp. 727–747, 2004.

[183] P. Delmonte and J. I. Rader, "Analysis of isoflavones in foods and dietary supplements," *Journal of AOAC International*, vol. 89, no. 4, pp. 1138–1146, 2006.

[184] S. Chian, R. Thapa, Z. Chi, X. J. Wang, and X. Tang, "Luteolin inhibits the Nrf2 signaling pathway and tumor growth in vivo," *Biochemical and Biophysical Research Communications*, vol. 447, no. 4, pp. 602–608, 2014.

[185] R. Marina, P. González, M. C. Ferreras, S. Costilla, and J. P. Barrio, "Hepatic Nrf2 expression is altered by quercetin supplementation in Xirradiated rats," *Molecular Medicine Reports*, vol. 11, no. 1, pp. 539–546, 2015.

[186] H. Zhou, Z. Qu, V. V. Mossine et al., "Proteomic analysis of the effects of aged garlic extract and its fruarg component on lipopolysaccharide-induced neuroinflammatory response in microglial cells," *PLoS ONE*, vol. 9, no. 11, Article ID e113531, 2014.

[187] V. Calabrese, C. Cornelius, A. T. Dinkova-Kostova, E. J. Calabrese, and M. P. Mattson, "Cellular stress responses, the hormesis paradigm, and vitagenes: novel targets for therapeutic intervention in neurodegenerative disorders," *Antioxidants & Redox Signaling*, vol. 13, no. 11, pp. 1763–1811, 2010.

[188] C. A. Houghton, R. G. Fassett, and J. S. Coombes, "Sulforaphane: translational research from laboratory bench to clinic," *Nutrition Reviews*, vol. 71, no. 11, pp. 709–726, 2013.

[189] A. L. Stefanson and M. Bakovic, "Dietary regulation of Keap1/Nrf2/ARE pathway: focus on plant-derived compounds and trace minerals," *Nutrients*, vol. 6, no. 9, pp. 3777–3801, 2014.

[190] G. K. Andrews, "Regulation of metallothionein gene expression by oxidative stress and metal ions," *Biochemical Pharmacology*, vol. 59, no. 1, pp. 95–104, 2000.

[191] P. Lichtlen and W. Schaffner, "Putting its fingers on stressful situations: the heavy metal-regulatory transcription factor MTF-1," *BioEssays*, vol. 23, no. 11, pp. 1010–1017, 2001.

[192] M. Sato and M. Kondoh, "Recent studies on metallothionein: protection against toxicity of heavy metals and oxygen free radicals," *Tohoku Journal of Experimental Medicine*, vol. 196, no. 1, pp. 9–22, 2002.

[193] Y. Pan, J. Huang, R. Xing et al., "Metallothionein 2A inhibits NF-κB pathway activation and predicts clinical outcome segregated with TNM stage in gastric cancer patients following radical resection," *Journal of Translational Medicine*, vol. 11, no. 1, article 173, 2013.

[194] J. J. Lamb, V. R. Konda, D. W. Quig et al., "A program consisting of a phytonutrient-rich medical food and an elimination diet ameliorated fibromyalgia symptoms and promoted toxic-element detoxification in a pilot trial," *Alternative Therapies in Health and Medicine*, vol. 17, no. 2, pp. 36–44, 2011.

[195] T. B. Aydemir, R. K. Blanchard, and R. J. Cousins, "Zinc supplementation of young men alters metallothionein, zinc transporter, and cytokine gene expression in leukocyte populations," *Proceedings of the National Academy of Sciences of the United States of America*, vol. 103, no. 6, pp. 1699–1704, 2006.

[196] T. P. J. Mulder, A. van der Sluys Veer, H. W. Verspaget et al., "Effect of oral zinc supplementation on metallothionein and superoxide dismutase concentrations in patients with inflammatory bowel disease," *Journal of Gastroenterology and Hepatology*, vol. 9, no. 5, pp. 472–477, 1994.

[197] R. Hu, V. Hebbar, B. R. Kim et al., "In vivo pharmacokinetics and regulation of gene expression profiles by isothiocyanate sulforaphane in the rat," *Journal of Pharmacology and Experimental Therapeutics*, vol. 310, no. 1, pp. 263–271, 2004.

[198] T. Kimura, F. Okumura, A. Onodera, T. Nakanishi, N. Itoh, and M. Isobe, "Chromium (VI) inhibits mouse *metallothionein-I* gene transcription by modifying the transcription potential of the co-activator p300," *The Journal of Toxicological Sciences*, vol. 36, no. 2, pp. 173–180, 2011.

[199] C. J. Weng, M. J. Chen, C. T. Yeh, and G. C. Yen, "Hepatoprotection of quercetin against oxidative stress by induction of metallothionein expression through activating MAPK and PI3K pathways and enhancing Nrf2 DNA-binding activity," *New Biotechnology*, vol. 28, no. 6, pp. 767–777, 2011.

[200] M. Singh, R. Tulsawani, P. Koganti, A. Chauhan, M. Manickam, and K. Misra, "Cordyceps sinensis increases hypoxia tolerance by inducing heme oxygenase-1 and metallothionein via Nrf2 activation in human lung epithelial cells," *BioMed Research International*, vol. 2013, Article ID 569206, 13 pages, 2013.

[201] N. M. R. Sales, P. B. Pelegrini, and M. C. Goersch, "Nutrigenomics: definitions and advances of this new science," *Journal of Nutrition and Metabolism*, vol. 2014, Article ID 202759, 6 pages, 2014.

[202] U. Lim and M. A. Song, "Dietary and lifestyle factors of DNA methylation," *Methods in Molecular Biology*, vol. 863, pp. 359–376, 2012.

[203] I. A. Lang, T. S. Galloway, A. Scarlett et al., "Association of urinary bisphenol A concentration with medical disorders and laboratory abnormalities in adults," *The Journal of the American Medical Association*, vol. 300, no. 11, pp. 1303–1310, 2008.

[204] R. Rezg, S. El-Fazaa, N. Gharbi, and B. Mornagui, "Bisphenol A and human chronic diseases: current evidences, possible mechanisms, and future perspectives," *Environment International*, vol. 64, pp. 83–90, 2014.

[205] S. Mostafalou and M. Abdollahi, "Pesticides and human chronic diseases: evidences, mechanisms, and perspectives," *Toxicology and Applied Pharmacology*, vol. 268, no. 2, pp. 157–177, 2013.

[206] D. J. Magliano, V. H. Y. Loh, J. L. Harding, J. Botton, and J. E. Shaw, "Persistent organic pollutants and diabetes: a review of the epidemiological evidence," *Diabetes & Metabolism*, vol. 40, no. 1, pp. 1–14, 2014.

[207] S. Agarwal, T. Zaman, E. M. Tuzcu, and S. R. Kapadia, "Heavy metals and cardiovascular disease: results from the National Health and Nutrition Examination Survey (NHANES) 1999–2006," *Angiology*, vol. 62, no. 5, pp. 422–429, 2011.

[208] E. F. Rissman and M. Adli, "Minireview: transgenerational epigenetic inheritance: focus on endocrine disrupting compounds," *Endocrinology*, vol. 155, no. 8, pp. 2770–2780, 2014.

[209] D. M. Walker and A. C. Gore, "Transgenerational neuroendocrine disruption of reproduction," *Nature Reviews Endocrinology*, vol. 7, no. 4, pp. 197–207, 2011.

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ONDAMED:
A Non-Disease Label Approach to Improving Body Functions Versus Treating Disease

By Rolf D. Binder, Inventor, & Silvia Binder, N.D., Ph.D.

SUMMARY
Disease labels do not help us cure our patients. Imagine an approach that would rapidly allow you to find the hidden physiological and emotional cause of your patient's symptoms, while simultaneously stimulating your patient's nervous system with focused therapeutic electromagnetic fields. This is a non-invasive method to help you, the therapist, find the source of your patient's symptoms within minutes, while simultaneously treating and stabilizing your patient.

OVERVIEW
The human body works on the basis of biophysics and biochemistry. While traditional medicine has much to offer in the chemical sense, it lacks the therapeutic approach of physics. Practitioners use the noninvasive ONDAMED technology and the biofeedback loop to scan the body for underlying dysfunctions, such as inflammation, infections, scar tissue, and emotional trauma residing at a cellular level. These areas often prove to be the source of disease and symptoms that might be otherwise difficult to find. Identified areas are treated with focused pulsed electro-magnetic fields to stimulate tissue and the nervous system. Therapy with ONDAMED focused pulsed fields helps reduce local stress and improve metabolism and lymphatic flow resulting in reduced inflammation, pain and edema, while improving stress tolerance by reducing cortisol levels and by influencing the nervous system.

MORE SPECIFICALLY:
ONDAMED is very unique in its ability to deliver specific resonant frequencies to the source of illness. While other devices deliver either a pulsed electromagnetic stimulus to a symptomatic region in order to reduce pain and swelling or affect abnormal brain electrophysiology, the ONDAMED approach is focused on what we discover about the illness and its location. Once discovery is completed, ONDAMED accurately delivers focused pulsed fields to the dysfunctional cellular/tissue areas which are found with the unique biofeedback loop.

ONDAMED's emotionally driven feedback helps locate the patient's weakened or dysfunctional areas such as inflammation, degenerated tissue or even more critical areas linked to experienced traumas, residing at a cellular level. Traumas that reside on a cellular level often prove to be the primary cause of disease and dysfunction.

It is quite impossible for either the practitioner or the patient to find such areas by themselves. The solution is "Emotional Biofeedback", which an ONDAMED practitioner receives when stimulating the patient's nervous system with specifically selected pulsed fields at an area which may be linked to an either recent or even old physiological, mental, or emotional trauma.

It is thought that by stimulating areas connected with experienced traumas, the focused fields reanimate the areas' functions.

Reanimating these areas' functions may help patients resolve the secondary indication or symptom(s), for which the patients had originally come to seek help. ONDAMED may be considered a combination of "emotional feedback therapy" and "focused electro-magnetic stimulus causing an induction within tissue".

Within minutes, the ONDAMED therapist finds the specific treatment stimuli for the patient, finds the actual location that is in most need to receive therapy and treats the discovered area by applying a systemic therapeutic stimulus. The stimulus energizes the flow of electrons across natural immune system inflammation barriers. These barriers are often undetectable or treatable in any other way, and include free radical scavengers.

When placing the nonintrusive applicator to a specific area, electrons and white blood cells are summoned to the area to start the repair process.

ONDAMED, therefore, jumpstarts the body's immune functions and directs the immune response to the area of dysfunction, which is often hidden or in "stealth mode" to the immune system. Cells and tissue in need of therapeutic stimulation can be oscillated by specific resonant frequencies selected from a wide range of 0.1 to 32,000 Hz. In standard electro-medical treatment, the tissue of least resistance will draw the current while potential dysfunctional tissue stays untreated.

ONDAMED applicators emit a focused field, which implements a vector driven current induction to access the tissue of dysfunction.

A vector driven current induction allows stimulation of tissue dependent on the position of the applicator rather than the tissue's structure.

Tissue vibration can enable detoxification of unwanted heavy metals, waste and toxins, potentially resulting in improved metabolic functions. Nutrients, remedies and supplements can then be assimilated by "cleaner", or detoxified tissue and cells.

The lymphatic system (an important part of the immune system) can also be stimulated. Toxins and waste can then be discharged by stool, urine, sweat and the release of fluid in certain areas.

One of the first effects patients usually notice is a general feeling of relaxation due to the influence of ONDAMED's resonant stimulus on the entire central nervous system, particularly when the therapy calls for frequencies in the delta and theta ranges.

ONDAMED's wide range of personalized frequencies enables the targeted therapy of a wide range of issues; often issues with difficult abnormalities otherwise going undetected.

THE ONDAMED COMPLETE SOLUTION

After all, it is the specific tissue of the individual that we treat and not just a symptom or disease. The ONDAMED System enables the practitioner to draw upon four prepared Modules and each Module can be considered application specific:

Module 1:
Selecting and using 2 specific pulsed fields relating to organs and organ systems.

Module 2:
Selecting and using 170 preset protocols to stimulate tissue with pre-programmed frequency combinations.

Module 3:
Selecting and using one (1) highly focused frequency to stimulate immune functions.

Module 4:
Selecting and using nutritionally related resonant frequencies.

From your research, you will find that the ONDAMED technology stands on its own due to its intelligence and personalization to each patient. The use of this 20+ year old invention allows the practitioner to obtain a larger diagnostic perspective of the patient complementing, yet going beyond standard diagnostics and offers the solution as to WHERE treatment is needed on the body and WHICH frequencies prove most significant for the patient.

The ONDAMED epigenetic impact is now being considered, and while we appreciate that no energy system or even medication can bring about a cure of any disease, ONDAMED shows that the body can effectively be stimulated to heal itself.

It has become recognized that the body's DNA, when fully able to express its protective (genes) mode by enabling the reduction of the excessive cellular histone acetylase DNA tightening, may become the 'holy grail' of healing most chronic diseases. Leading scientists are now in hot pursuit to determine if biological energy healing will become the final answer to histone acetylase reduction.

A multi-disciplinary collaborative program between AlfaGene Bioscience Inc., NJ, the Department of Biology, City University of New York and the Ondamed Companies in New York and Germany is now underway to study bio-interactive mechanisms of ONDAMED's focused electromagnetic fields with cell and/or tissue types in the physiological and disease state. Modern bio-medical engineering tools, novel stem cell technology, sophisticated cellular, molecular, and genetic techniques are utilized in our studies. The results will be published in the near future.

Finally, ONDAMED encompasses the individual's specific needs at the time of discovery by finding the patient-specific treatment stimulus, the exact location that needs stimulation and non-intrusively delivers the stimulus during the same session, often providing immediate results.

ONDAMED is both practitioner and patient friendly. ONDAMED "a better way to make you better" couldn't be easier to learn and use.

We invite you to learn more about integrating ONDAMED into your daily practice life.

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Educational Schedule 2018

FEBRUARY

Belmond Charleston Place
Charleston, SC

BHRT Symposium
February 9-11, 2018

Fellowship Modules
February 9-11, 2018

APRIL

Diplomat Resort
Hollywood, FL

Spring Congress
April 12-14, 2018

ABAARM/ABAAHP Written Exams
April 12-14, 2018

ABAARM Oral Exams
April 12-14, 2018

Fellowship Modules
April 12-14, 2018

MAY

Wynn Las Vegas
Las Vegas, NV

A4M Workshop
May 4-5, 2018

AUGUST

Venetian/Palazzo Resort
Las Vegas, NV

Fellowship Modules
August 10-12, 2018

A4M Lab Fundamentals Workshop
August 10-12, 2018

A4M Pellet Therapy Workshop
August 10-12, 2018

SEPTEMBER

Gaylord Opryland
Nashville, TN

BHRT Symposium
September 27-30, 2018

ABAARM/ABAAHP Exams
September 27-30, 2018

Fellowship Modules
September 27-30, 2018

Sexual Health Workshop
September 27-30, 2018

OCTOBER

Westin Galleria Dallas
Dallas, TX

A4M IV/Chelation Workshop
October 19-20, 2018

A4M Weight Management Workshop
October 19-20, 2018

A4M Pellet Therapy Workshop
October 19-20, 2018

DECEMBER

Venetian/Palazzo Resort
Las Vegas, NV

ABAARM/ABAAHP Written Exams
December 12, 2018

ABAARM Oral Exams
December 13-15, 2018

World Congress
December 13-15, 2018

Fellowship Modules
December 13-15, 2018

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