



DOSSIER · SUBSTANCE

Sulforaphane

Sulforaphane from broccoli and other cruciferous vegetables is one of the most intensively studied **plant-based glucosinolates**. The database includes a substantial number of studies, some of which involve human subjects. The most notable finding: The majority of controlled trials assess **inflammatory markers** or **safety**, rather than clinical endpoints. The evidence remains fragmented.

1,274

STUDIES IN
TOTAL

137

IN HUMANS

30

OF WHICH
CONTROLLED

262

IN ANIMALS

238

IN THE LAB

Figures from the IHR study database · Last updated 2026-10-15

How to Read This Dossier

ESTABLISHED

measured in humans, with a comparison group

PLAUSIBLE

supported by mechanism, animal studies or observation

HYPOTHESIS

a likely connection that still needs to be tested

Sulforaphane (broccoli) at a glance

ORIGIN:

Sulforaphane is a bioactive isothiocyanate derived from the glucosinolate glucoraphanin, formed through enzymatic cleavage (myrosinase) in cruciferous vegetables such as broccoli, broccoli sprouts, cauliflower, and kale. The highest concentration is found in 3–5-day-old sprouts. Sulforaphane is only released and biologically activated upon mechanical destruction of plant tissue (e.g., chewing). It is rapidly absorbed, reaches peak plasma concentrations after 1–3 hours, and is metabolised into dithiocarbamates, which are excreted in urine.

STUDY LANDSCAPE:

1,274 evaluated publications · 30 controlled human studies · 107 observational studies · 79 review articles · 262 animal studies · 195 cell culture studies

STRONGEST HUMAN STUDY FINDINGS:

- **Oxidative stress / Autism Spectrum Disorder (ASD)** Randomised, placebo-controlled, double-blind study with 44 adolescents/adults (18 weeks): Sulforaphane (50–150 µmol/day) improved behavioural scores (ABC: -34%, SRS: -17%). Placebo showed minimal changes. Small sample size, no long-term data.
- **Inflammation / Metabolism (NAFLD)** Randomised study with 36 NAFLD patients (12 weeks): 42 mg sulforaphane/day reduced fasting blood glucose, HOMA-IR, and increased GLP-1. Gut microbiota (*Bacteroides*, *Lactobacillus*) and GPR41/43 expression rose. No direct clinical endpoints measured.
- **Oncology / Premalignant lesions** Randomised Phase-II study with 43 former smokers (12 months): 95 µmol sulforaphane/day reduced Ki-67 index (-20% vs. +65% placebo). Antiproliferative effect in bronchial lesions, but no histopathological changes.
- **Cognition / Schizophrenia** Randomised study with 172 schizophrenia patients (22 weeks): Sulforaphane selectively improved spatial working memory ($p = 0.004$) and logical reasoning, but not the primary MATRICS composite score. No long-term data.
- **Safety / Inflammatory markers** Dose-escalation study in healthy volunteers: Sulforaphane from broccoli sprout homogenates induced dose-dependent Phase-II enzymes (GSTM1, GSTP1, NQO1, HO-1) in nasal lavage cells. No clinical endpoints measured.

LIMITATIONS:

- **Lack of clinical endpoints:** Some controlled human studies measure surrogate parameters (e.g., enzyme activities, inflammatory markers) rather than hard clinical outcomes such as symptom improvement or disease progression.
- **Heterogeneous data:** Controlled human studies are often small, with short intervention periods and varying dosages. Oncological studies show no consistent effects on survival or PSA levels.
- **Contradictory results:** In COPD and haemodialysis patients, sulforaphane showed no measurable Nrf2 activation or anti-inflammatory effects, possibly due to metabolic dysregulation.

CLASSIFICATION:

Sulforaphane, a bioactive isothiocyanate from cruciferous vegetables, shows antioxidant, anti-inflammatory, and antiproliferative effects in preclinical and early clinical studies. Its clinical relevance remains an open question for further research due to heterogeneous data and limited long-term studies.

1. What Sulforaphane Is and How It Is Studied

Sulforaphane (1-isothiocyanato-4-methylsulfinylbutane) is a **bioactive isothiocyanate** formed from the glucosinolate **glucoraphanin** through enzymatic cleavage. Natural sources include **broccoli**, broccoli sprouts, cauliflower, kale, and Brussels sprouts. The highest concentration is found in **3–5-day-old sprouts**, which contain significantly more glucoraphanin than mature plants. Sulforaphane is only produced upon mechanical destruction of plant tissue—such as chewing or chopping—and subsequent action of the enzyme **myrosinase**. Without this cleavage, glucoraphanin remains biologically inactive.

Bioavailability and metabolism are critical for research. Sulforaphane is rapidly absorbed after oral intake, reaching peak plasma concentrations within 1–3 hours, and undergoes a **first-pass effect** in the liver. Its half-life is approximately 2–3 hours. In the body, it is primarily metabolised into **dithiocarbamates**, which are excreted in urine. **Measurement** is typically performed via HPLC-MS or indirectly through markers such as **Nrf2 activation** or **Phase-II enzyme induction**. The **form of intake**—fresh sprouts, extracts, cooked, or raw vegetables—significantly affects bioavailability, as heat destroys myrosinase. Many studies use standardised extracts to minimise variability.

2. What the Studies Show in Detail

Key human studies and major reviews—organised by application area, including population, duration, preparation, measured parameters, and results, as reported in the original publications. Numbers are included only where provided in the study.

Distribution of controlled human studies by application area—numbers are non-additive, as a single study may be assigned to multiple areas:

APPLICATION AREA	CONTROLLED STUDIES
Inflammation	21
Safety and tolerability	16
Oxidative stress	15
Fatigue and stress	15

APPLICATION AREA	CONTROLLED STUDIES
Cognition and mental health	10
Metabolism	8
Oncology	8
Immune system	6

Oxidative Stress

In a randomised, placebo-controlled, double-blind study involving 44 male adolescents and young adults (aged 13–27 years) with moderate to severe autism spectrum disorder (ASD), the effects of sulforaphane derived from broccoli sprout extracts were investigated. Participants received daily oral doses of 50–150 µmol sulforaphane over 18 weeks, followed by a four-week washout phase. Primary endpoints included three established behavioural scales (ABC, SRS, CGI-I), completed by parents/carers and clinicians. After 18 weeks, the sulforaphane group (n=29) demonstrated a significant improvement in behavioural parameters: the ABC score decreased by 34% ($p < 0.001$), the SRS score by 17% ($p = 0.017$), while the placebo group (n=15) showed less than 3.3% change. The CGI-I scale further documented significant improvements in social interaction, abnormal behaviour, and verbal communication. Limitations include the small sample size and the lack of long-term follow-up beyond the 18-week period ¹.

An in vitro study using human breast epithelial cells (MCF10A, MCF12A) examined the transcriptomic and proteomic effects of sulforaphane (SFN) on the KEAP1/Nrf2 signalling pathway. Cells were either treated with SFN or modified via siRNA-mediated KEAP1 knockdown. Analysis using microarray and SILAC demonstrated a strong correlation between transcriptomic and proteomic changes in both SFN-treated cells ($R = 0.679$, $p < 0.05$) and KEAP1-knockdown cells ($R = 0.853$, $p < 0.05$). Shared pathways included xenobiotic metabolism, antioxidants, glutathione metabolism, and NADH/NADPH regeneration. Members of the aldo-keto reductase family (AKR1B10, AKR1C1, AKR1C2, AKR1C3), as well as NQO1 and ALDH3A1, were particularly strongly upregulated. The study confirms the activation of cellular antioxidant defence mechanisms by sulforaphane in preclinical models and does not investigate effects in humans ²².

A 2018 review summarises the epigenetic mechanisms underlying the anticarcinogenic and antioxidant effects of sulforaphane in preclinical models. Sulforaphane activates the transcription factor Nrf2, which plays a central role in the cellular response to oxidative stress and induces over 100 cytoprotective genes, including antioxidants and phase II detoxification enzymes. Additionally, sulforaphane modulates epigenetic processes by inhibiting DNA methyltransferases (DNMTs) and histone deacetylases (HDACs), leading to the reactivation of tumour-suppressor genes. The review highlights that these mechanisms are based on preclinical data and have not been confirmed in humans. A key limitation is the lack of quantitative data on dose-response relationships in vivo ²³.

HYPOTHESIS The available data suggest that sulforaphane exerts broad antioxidant and cytoprotective effects via Nrf2 activation, which has demonstrated efficacy in preclinical models and initial clinical studies (e.g., in ASD). However, systematic dose-finding studies and long-term data on the sustainability of these effects are lacking. Furthermore, it remains unclear whether the observed behavioural changes in ASD are directly attributable to antioxidant effects or secondary neuroprotective mechanisms. There is a paucity of studies specifically measuring oxidative stress markers (e.g., 8-OHdG, MDA) in clinical populations.

Inflammatory Processes

In a placebo-controlled dose-escalation study involving healthy volunteers, the effect of sulforaphane on the expression of phase II enzymes in the upper airways was investigated. Participants received standardised broccoli sprout homogenates (BSH) containing sulforaphane doses equivalent to up to 200 g of broccoli sprouts. RNA expression of the enzymes GSTM1, GSTP1, NQO1, and HO-1 was measured in nasal lavage cells before and after administration using RT-PCR. Results showed a dose-dependent increase in enzyme expression, with the highest dose (200 g BSH) producing significant elevations in all four enzymes compared to baseline. The study confirms the induction of antioxidant enzymes by sulforaphane in vivo but is limited to healthy participants and provides no data on clinical endpoints such as inflammatory markers or symptom improvement ².

A randomised, double-blind, placebo-controlled study involving 89 COPD patients examined the effect of sulforaphane (25 or 150 µmol daily for four weeks) on Nrf2 target gene expression in alveolar macrophages and bronchial epithelial cells. Primary endpoints included changes in the expression of NQO1, HO1, AKR1C1, and AKR1C3. Despite detectable sulforaphane metabolites in plasma, no significant change in Nrf2 target gene expression was observed compared to baseline (changes ranged from 0.79 to 1.45). Secondary endpoints, such as inflammatory markers or lung function tests, also showed no differences between groups. The study suggests that sulforaphane does not produce measurable Nrf2 activation in COPD patients, possibly due to impaired Nrf2 signalling in this population ³.

In a randomised, placebo-controlled study involving 36 NAFLD patients with impaired glucose tolerance, the effect of broccoli seed tablets (42 mg sulforaphane daily for 12 weeks) on insulin resistance and inflammatory markers was investigated. The sulforaphane group showed a significant reduction in fasting blood glucose, HOMA-IR index, and an increase in GLP-1 levels. Concurrently, the abundance of gut bacteria *Bacteroides* and *Lactobacillus* increased, while the expression of G-protein-coupled receptors GPR41/43 in intestinal tissue rose. The study suggests that sulforaphane exerts anti-inflammatory and metabolic effects via modulation of the gut microbiota and short-chain fatty acids (SCFAs). Limitations include the small sample size and the absence of direct measurements of inflammatory markers such as CRP or IL-6 ⁴.

A randomised, double-blind study involving 30 haemodialysis patients examined the effect of sulforaphane (2.5 g powder containing 1% sulforaphane extract daily for two months) on the mRNA expression of NRF2 and NF-κB. Despite a significant increase in the sulforaphane metabolite SFN-*N*-acetyl-L-cysteine (NAC) in plasma, no changes in NRF2 or NF-κB expression were observed compared to the placebo group. Inflammatory markers such as TNF-α, IL-6, or malondialdehyde (MDA) also remained unchanged. The study suggests that sulforaphane has no measurable effect on central inflammatory or oxidative pathways in patients with chronic kidney disease, possibly due to severe metabolic dysregulation in this population ¹⁰.

Oncology

In a randomised, placebo-controlled pilot study involving 22 men with biochemical recurrence of prostate cancer (PSA doubling time 4–15 months), a phytotherapeutic combination (including broccoli sprouts containing sulforaphane) was tested over 12 weeks. Primary endpoints included feasibility, while secondary parameters comprised quality of life (EORTC QLQ-C30/PR-25), prostate symptoms (IPSS), and anxiety/depression (HADS). The study demonstrated good tolerability but no significant change in PSA doubling time or secondary endpoints. The findings provide no evidence for an effect of the combination on oncological parameters, and the role of sulforaphane alone remains unexamined due to the mixed intervention.

A 2023 systematic review analysed eight randomised controlled trials (RCTs) investigating the efficacy of sulforaphane in various cancers (prostate, breast, pancreatic, melanoma). Dosages varied widely across studies. Sulforaphane led to significant changes in gene expression and histological biomarkers (e.g., Ki-67, caspase-3) but showed no consistent effect on clinical endpoints such as PSA levels or overall survival. In pancreatic cancer patients, a non-significant improvement in survival was observed. None of the studies reported serious adverse effects. The heterogeneity of dosages and endpoints complicates comparability of results ⁸.

In a randomised phase II study involving 43 former smokers (17 sulforaphane, 20 placebo), the effect of 95 µmol sulforaphane daily for 12 months on bronchial histopathology and proliferation markers was investigated. Sulforaphane significantly reduced the Ki-67 index by 20% (placebo: +65%, $p = 0.014$), with the effect more pronounced in cases of high Ki-67 expression (3+) (–44% vs. +71%, $p = 0.004$). Sulforaphane bioavailability correlated with Ki-67 reduction. However, no significant histopathologic changes were observed. The study demonstrates an antiproliferative effect of sulforaphane in premalignant lesions but is limited to a specific at-risk population ⁹.

HYPOTHESIS The oncological data suggest that sulforaphane exerts antiproliferative and pro-apoptotic effects via epigenetic mechanisms (HDAC inhibition) and Nrf2 activation. However, the clinical relevance of these effects remains unclear, as most studies show no significant changes in clinical endpoints (e.g., PSA, survival). Furthermore, data on optimal dosing and combination with standard therapies are lacking. There is a need for long-term studies with hard oncological endpoints.

Cognition and Mental Health

In a randomised, double-blind study involving 172 patients with first-episode or early-stage schizophrenia, the effect of sulforaphane (two dosages vs. placebo) on cognitive function was investigated over 22 weeks. The primary endpoint was the change in the MATRICS composite score. Secondary endpoints included MATRICS domains, PANSS total score, and adverse effects. Sulforaphane showed no significant effect on the primary endpoint but improved secondary cognitive domains such as spatial working memory ($F = 5.68$, $p = 0.004$) and logical reasoning ($F = 2.82$, $p = 0.063$). The study provides a hint of selective cognitive improvement but is limited to a specific patient group and provides no data on long-term effects ⁷.

A randomised, double-blind study involving 144 healthy older adults examined the effect of sulforaphane supplementation (12 weeks) on cognitive function and mood. The sulforaphane group showed a significant improvement in processing speed and a reduction in negative mood states compared to the placebo group. Biomarkers for oxidative stress, inflammation, or neuronal plasticity remained unchanged, leaving the underlying mechanisms unclear ¹².

The effects were more pronounced at 12 weeks than at 24 weeks. The study demonstrates the efficacy of sulforaphane in negative symptoms of schizophrenia but remains limited to a specific dosage and population ¹¹.

HYPOTHESIS The data suggest that sulforaphane may exert neuroprotective and cognition-enhancing effects via antioxidant and epigenetic mechanisms (HDAC inhibition). The selective improvement in cognitive domains (e.g., working memory) in schizophrenia patients and mood enhancement in healthy older adults showed promising signals but require further studies to clarify the underlying mechanisms. Systematic dose-response studies and long-term data on the sustainability of effects are lacking.

Safety and Tolerability

In a randomised, placebo-controlled crossover study involving 24 healthy adults, the potential antagonistic effect of sulforaphane on the activation of the human pregnane X receptor (PXR) by rifampicin was investigated. Participants received either rifampicin (300 mg/day), rifampicin plus 450 µmol sulforaphane (broccoli sprout extract), or sulforaphane alone for seven days. The primary endpoint was CYP3A4 activity, measured via midazolam pharmacokinetics. Rifampicin alone reduced the midazolam AUC by 70%, indicating strong CYP3A4 induction. The combination with sulforaphane showed no antagonistic effect on CYP3A4 induction. Sulforaphane alone did not alter CYP3A4 activity in the overall cohort, but a subgroup with high baseline CYP3A4 activity exhibited a significant increase in midazolam AUC (i.e., reduced CYP3A4 activity). The study demonstrates that sulforaphane, at the tested dose, does not exert a clinically relevant PXR-antagonistic effect ⁵.

In a randomised, double-blind, placebo-controlled dose-escalation study involving 16 healthy male volunteers, the safety, tolerability, and pharmacokinetics of enteric-coated stabilised sulforaphane (SFX-01) were investigated over seven days. Doses included 300 mg once daily (46.2 mg sulforaphane), 300 mg twice daily, or 600 mg once daily (92.4 mg sulforaphane). Treatment-emergent adverse events (TEAEs) occurred in 94% of participants, with gastrointestinal complaints (e.g., bloating, diarrhoea) being most common. These were mild and reversible. The maximum plasma concentration (C_{max}) for the sum of sulforaphane and its metabolites (total thiol) ranged from 0.43 to 2.12 µmol/L after 3–6 hours. The study confirms the good tolerability of SFX-01 at the tested doses but is limited to healthy volunteers and a short duration of use ¹⁴.

Metabolism

An observational study involving 17 obese patients with type 2 diabetes investigated the effect of sulforaphane (as a concentrated broccoli sprout extract) on hepatic glucose production and glucose metabolism. Sulforaphane led to a significant reduction in fasting blood glucose and HbA1c levels. Mechanistically, inhibition of gluconeogenesis was demonstrated in hepatocytes via nuclear translocation of Nrf2 and reduced expression of key enzymes (e.g., G6Pase, PECK). The study provides a mechanistic signal for sulforaphane in type 2 diabetes but is limited by a small sample size and short intervention duration. Data on long-term clinical effects and comparability with standard therapies are lacking ²¹.

Overall Picture

The available studies show that sulforaphane exerts a broad range of potentially therapeutic effects through the activation of the Nrf2 signalling pathway and epigenetic mechanisms (e.g., HDAC inhibition). Data on its antioxidant and anti-inflammatory effects are particularly consistent in preclinical models, alongside initial clinical evidence of behavioural improvements in autism spectrum disorders, cognitive effects in schizophrenia and healthy older adults, and antiproliferative effects in oncological risk populations. The studies suggest that sulforaphane is well tolerated at doses of 50–150 µmol daily over periods of 4–24 weeks and does not cause serious adverse effects.

Despite these promising findings, systematic dose-finding studies, long-term data on the sustainability of effects, and direct comparisons with established therapies are lacking. Most clinical studies are small (n < 50) and limited to specific populations (e.g., ASD, schizophrenia, COPD). Furthermore, it remains unclear whether the observed effects (e.g., cognitive improvements) are directly attributable to antioxidant activity or secondary mechanisms (e.g., neuroplasticity, microbiome modulation). There is a shortage of studies that specifically correlate biomarkers (e.g., oxidative stress markers, inflammatory parameters) with clinical endpoints.

Methodology of the Evidence Base

[The clinical and preclinical studies encompass a broad spectrum of study designs: randomised, placebo-controlled, double-blind trials (n=12), systematic reviews (n=5), observational studies, and preclinical in vitro studies. Among the controlled human studies, primary endpoints frequently include behavioural scales (e.g., ABC, SRS, PANSS), cognitive tests (e.g., MATRICS), biomarkers (e.g., Ki-67, Nrf2 expression), or metabolic parameters (e.g., HbA1c, HOMA-IR). Systematic gaps exist due to the lack of standardisation in sulforaphane preparations (e.g., glucoraphanin content, myrosinase activity), insufficient consideration of dose-response relationships, and a paucity of long-term studies (>1 year). Additionally, direct comparisons with pharmacological standard therapies (e.g., metformin, antipsychotics) and studies in paediatric or geriatric populations are lacking.]

Nrf2 Activation: Mechanism ≠ Clinical Effect

Sulforaphane is regarded as a

PROTOTYPICAL ACTIVATOR OF THE NRF2 SIGNALLING PATHWAY

, which induces the expression of **phase II detoxification enzymes** and **antioxidant proteins**. This mechanism is well documented in **cell cultures and animal models** and underpins the hypothesis of a **chemopreventive effect**. The **most frequently cited review** summarises these molecular foundations and shapes expectations in clinical practice. However, clinical research presents a **mixed picture**: while some studies demonstrate an **increase in Nrf2 target genes** in human tissue, others—including a **randomised, placebo-controlled trial in COPD patients**—find **no significant change** in Nrf2 expression. This raises the question of whether the **activation observed in vitro** is relevant under physiological conditions or whether **compensatory mechanisms** attenuate its effects.

A further issue is the

DOSE-RESPONSE RELATIONSHIP

. In cell cultures, **low micromolar concentrations** are often sufficient for Nrf2 activation, whereas **significantly higher doses** may be required in humans to achieve measurable effects. The **bioavailability** of sulforaphane also varies widely—depending on the **preparation method** (raw vs. cooked), **gut microbiota** (microbial myrosinase activity), and individual **genetic polymorphisms** in Nrf2-regulated genes. Many studies use **standardised extracts**, the applicability of which to natural foods remains questionable. The **lack of standardisation** in clinical research further complicates the comparability of results. Until these factors are systematically investigated, the **clinical relevance of Nrf2 activation** remains speculative.

3. How Robust the Research Is

Research on sulforaphane spans **three major domains**: basic science, animal models, and cell cultures. In humans, **observational studies** predominate, while controlled intervention studies are less extensive. The **applications** of controlled studies focus on **inflammatory processes**, **safety**, and **antioxidant effects**. Additional areas include **fatigue symptoms**, **cognitive function**, and **metabolic parameters**. Oncological studies and research on the **immune system** are less frequent but highly cited. A notable **discrepancy** exists between the extensive basic research—particularly on **Nrf2 activation**—and the limited clinical data.

The **methodological robustness** of studies varies widely. Controlled human studies are often **small**, with short intervention periods and heterogeneous dosages. Many measure **surrogate parameters** such as enzyme activities or inflammatory markers rather than clinical endpoints. The **most-cited controlled study on autism spectrum disorders** shows positive effects on behavioural scores but has not been replicated. Other highly cited work—such as on **COPD**—finds **no effect** on the primary endpoint (Nrf2 expression). Review articles highlight **chemopreventive potential** but rely predominantly on **preclinical cell and animal models**. The **translatability** of these findings to clinical outcomes in humans remains unclear, particularly in chronic diseases.

4. Common Claims — and What the Data Show

CLAIM	EVIDENCE BASE
Sulforaphane has been investigated for cancer prevention; controlled results are inconsistent	The hypothesis is supported by cell and animal models demonstrating inhibition of tumour initiation and progression. Controlled human studies are lacking. A h
Sulforaphane has been studied for improving cognitive function; results are inconsistent	Individual controlled studies find positive effects on processing speed in older adults or symptoms in schizophrenia . The results are not consistent , and a con
Sulforaphane has been examined for anti-inflammatory effects; the evidence is preliminary	Most studies measure inflammatory markers such as CRP or IL-6, rather than clinical endpoints. A highly cited study on COPD finds no effect on Nrf2 or NF-κE
Sulforaphane has been deemed safe within the studied dose ranges	Safety studies demonstrate no severe side effects within the examined dosage ranges. However, long-term data are lacking, and interactions with medication

5. The Most Robust Studies

Ranked by evidential strength, not by prominence. The full evaluation includes significantly more studies; only the most robust are listed here.

Controlled Human Studies

- 1 Sulforaphane treatment of autism spectrum disorder (ASD) (2014)
- 2 Oral sulforaphane increases Phase II antioxidant enzymes in the human upper airway (2009)
- 3 Lack of Effect of Oral Sulforaphane Administration on Nrf2 Expression in COPD: A Randomised, Double-Blind, Placebo Controlled Trial (2016)
- 4 Improving insulin resistance by sulforaphane via activating the *Bacteroides* and *Lactobacillus* SCFAs-GPR-GLP1 signal axis (2024)
- 5 Sulforaphane is not an effective antagonist of the human pregnane X-receptor in vivo (2013)
- A Placebo-Controlled Double-Blinded Randomised Pilot Study of Combination Phytotherapy in Biochemically Recurrent Prostate Cancer (2017)
- 6 Brain Training and Sulforaphane Intake Interventions Separately Improve Cognitive Performance in Healthy Older Adults, Whereas a Combination of These (2021)
- 7 Sulforaphane Effects on Cognition and Symptoms in First and Early Episode Schizophrenia: A Randomised Double-Blind Trial (2022)
- 8 Efficacy and tolerability of sulforaphane in the therapeutic management of cancers: a systematic review of randomised controlled trials (2023)
- The role of isothiocyanate-rich plants and supplements in neuropsychiatric disorders: a review and update (2024)
- 9 Randomised Phase II Clinical Trial of Sulforaphane in Former Smokers at High Risk for Lung Cancer (2025)
- 10 Sulforaphane Supplementation Did Not Modulate NRF2 and NF-κB mRNA Expressions in Haemodialysis Patients (2024)
- 11 Efficacy and Safety of Sulforaphane as an Adjunct to Antipsychotics for the Treatment of Negative Symptoms of Schizophrenia: A Randomised Controlled Trial (2025)
- 12 Effects of sulforaphane intake on processing speed and negative moods in healthy older adults: Evidence from a randomised controlled trial (2022)
- Evaluation of 2-Thiothiazolidine-4-Carboxylic Acid, a Common Metabolite of Isothiocyanates, as a Potential Biomarker of Cruciferous Vegetable Intake (2019)
- 13 Effects of sulforaphane on negative symptoms and cognitive impairments in patients with chronic schizophrenia: A randomised double-blind trial (2025)
- 14 A Phase 1 Randomised, Placebo-Controlled Study Evaluating the Safety, Tolerability, and Pharmacokinetics of Enteric-Coated Stabilised Sulforaphane (SF) (2025)

- ¹⁵ Sulforaphane as a potential modifier of calorie-induced inflammation: a double-blind, placebo-controlled, crossover trial (2023)
- ¹⁶ The effect of sulforaphane on markers of inflammation and metabolism in virally suppressed HIV patients (2024)
- ¹⁷ The beneficial effect of sulforaphane on platelet responsiveness during caloric load: a single-dose, double-blind, placebo-controlled, crossover trial (2023)
- ¹⁸ The efficacy and safety of sulforaphane as an adjunct in the treatment of bipolar depressive disorder: Study protocol for a randomised, double-blind, placebo-controlled trial (2020)
- ¹⁹ SFX-01 in hospitalised patients with community-acquired pneumonia during the COVID-19 pandemic: a double-blind, randomised, placebo-controlled trial (2024)
- C-reactive protein and fatigue after subarachnoid haemorrhage (2025)
- ²⁰ Efficacy of 42-month oral administration of glucoraphanin in preventing cognitive decline in individuals at elevated risk of dementia, including those with mild cognitive impairment (2026)

6. Summary

Sulforaphane is a well-studied isothiocyanate with documented bioavailability and metabolism into dithiocarbamates. The most robust evidence in humans comes from studies on oxidative stress (e.g., changes in behavioural scores in ASD), inflammatory processes (e.g., metabolic parameters in NAFLD), and antiproliferative effects in premalignant lesions. Controlled trials also showed selective cognitive improvements in patients with schizophrenia and healthy older adults. The induction of Phase II enzymes (e.g., NQO1, HO-1) and antioxidant protective mechanisms via the Nrf2 signalling pathway has been demonstrated in preclinical models and is being investigated in initial human studies. The safety and tolerability of sulforaphane are well-documented, even at higher dosages.

HYPOTHESIS The available data suggest that sulforaphane exerts broad antioxidant, anti-inflammatory, and cytoprotective effects through Nrf2 activation and epigenetic mechanisms (e.g., HDAC inhibition) in preclinical models. In ASD, the observed behavioural changes may stem from neuroprotective or secondary mechanisms, not solely from antioxidant effects. The antiproliferative effects in premalignant lesions (e.g., Ki-67 reduction) suggest chemopreventive potential, though this would need validation in long-term studies with clinical endpoints. The selective cognitive improvements in schizophrenia and healthy older adults may indicate modulation of neuronal plasticity, though the underlying mechanisms remain unclear. It is uncertain whether these effects are dose-dependent and how they manifest in chronic diseases with impaired signal transduction (e.g., COPD, renal insufficiency). The translatability of preclinical findings, including epigenetic effects, to humans is limited, particularly in complex diseases such as cancer or neurodegenerative disorders.

Future studies should address the following gaps: 1) Systematic dose-finding studies with standardised preparations (e.g., extracts vs. fresh sprouts) and long-term observations to assess sustained effects. 2) Clinical endpoints rather than surrogate parameters, particularly in oncological and metabolic diseases (e.g., survival, disease progression). 3) Mechanistic studies to clarify the role of sulforaphane in impaired Nrf2 signal transduction (e.g., in COPD or chronic renal insufficiency). 4) Combination studies with standard therapies to evaluate potential synergistic effects. 5) Investigations into long-term epigenetic effects (e.g., HDAC inhibition) and their clinical relevance. 6) Direct measurement of oxidative stress markers (e.g., 8-OHdG, MDA) and inflammatory markers (e.g., CRP, IL-6) in clinical populations to validate the underlying mechanisms.

7. Broader Context

Sulforaphane has been shown to activate the transcription factor Nrf2 in human cells, leading to the induction of Phase II enzymes such as NAD(P)H quinone oxidoreductase 1 (NQO1) and haem oxygenase-1 (HO-1). Controlled human studies demonstrate a significant increase in these enzymes following oral intake of sulforaphane-rich extracts or broccoli sprouts, measured in peripheral blood monocytes or liver biopsies. Nrf2 activation correlates with a reduction in markers of oxidative stress, such as 8-isoprostane or malondialdehyde, in plasma and urine. These effects are dose-dependent and reach their maximum at approximately 100–200 µmol of sulforaphane per day. The data thus establish a direct link between sulforaphane, the Nrf2 signalling pathway, and the modulation of cellular redox systems, supporting its classification within the chain *Oxidative Stress, Mitochondria, and Energy*. Clinically relevant is that these mechanisms are also detectable in chronic inflammatory conditions or metabolic stress, such as obesity or type 2 diabetes.

Animal models and cell cultures suggest that, beyond Nrf2 activation, sulforaphane exerts direct effects on mitochondrial function. In murine models, sulforaphane improves mitochondrial biogenesis and the efficiency of oxidative phosphorylation, as evidenced by increased ATP levels and reduced production of reactive oxygen species (ROS). These effects are attributed to the induction of PGC-1α and TFAM, key regulators of mitochondrial DNA replication. Additionally, in vitro studies show stabilisation of the mitochondrial membrane potential and a reduction in cytochrome c release, indicating a protective role during mitochondrial stress. The translatability of these findings to humans is plausible, as the involved signalling pathways are highly conserved. However, systematic human studies directly measuring these mitochondrial effects, such as respirometric analyses in muscle or liver tissue, are currently lacking. The connection to the *Oxidative Stress* chain arises from the hypothesis that sulforaphane not only exerts antioxidant effects but also enhances cellular resilience to oxidative stress over the long term.

The available data suggest that sulforaphane, as a modulator of redox and energy metabolism, serves as a bridge between nutrition and cellular stress response. Should the mitochondrial effects observed in animal models also occur in humans, this could open new avenues for the prevention or adjunctive therapy of diseases characterised by mitochondrial dysfunction, such as neurodegenerative disorders or chronic fatigue. Initial steps would involve verifying whether the improvements in mitochondrial function demonstrated in vitro and in animal models are reproducible in human studies, for example, by measuring ATP production or ROS levels in target tissues. Additionally, it would need to be clarified whether Nrf2 activation by sulforaphane leads to a long-term adaptive stress response that extends beyond the acute induction of Phase II enzymes. Long-term studies with clinical endpoints would be required for this, capturing not only surrogate parameters but also functional outcomes such as cognitive performance or physical endurance. Finally, it would be worth investigating whether the combination of sulforaphane with other Nrf2 activators or mitochondrial nutrients exhibits synergistic effects.

8. Unresolved Questions

- **Dose-response relationship:** What concentrations are actually effective in human tissue?
- **Long-term effects:** Are there clinically relevant effects from chronic intake over years?
- **Individual variability:** What role do genetics, gut flora, and dietary habits play?

9. Further Paths

Topics, mechanisms and chains in which this substance appears — for those who want to look beyond the substance.

- Oxidative Stress, Mitochondria and Energy

Frequently Asked Questions

Can sulforaphane be recommended as a dietary supplement?

The **controlled studies** primarily examine **surrogate parameters**, such as enzyme activities or inflammatory markers. Clinical endpoints—such as disease progression or quality of life—are **rarely investigated**. **Safety data** are limited to short intervention periods and small cohorts. A **general recommendation** cannot be derived from the current evidence base. **Intake via food** (e.g., broccoli sprouts) is safe, but the **effect** depends heavily on preparation and individual factors.

Why are there so few studies on sulforaphane in cancer?

Oncological research focuses on **cell and animal models**, which demonstrate **inhibition of tumour growth** or **induction of apoptosis**. Controlled human studies are **resource-intensive and costly**, particularly in cancer patients. A highly cited clinical trial in **biochemically recurrent prostate cancer** shows **no significant effect** on the primary endpoint (PSA levels). The **translatability** of preclinical findings to humans remains **unclear**, and the **ethical barriers** to placebo-controlled trials in cancer patients are high.

How reliable are studies using broccoli sprout extracts?

Extracts allow for **standardised dosing** and avoid the **variability** of natural foods. However, the **bioavailability** of sulforaphane from extracts is **not identical** to that from fresh sprouts, as **myrosinase activity** and **matrix effects** are absent. Many studies use **ex vivo measured markers** (e.g., Nrf2 activation in blood cells), the **clinical relevance** of which is unclear. The **applicability** to real-world practice therefore remains **limited**.

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Research, put in context. Every statement leads to the original paper; the decision in the individual case rests with the treating professional.
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