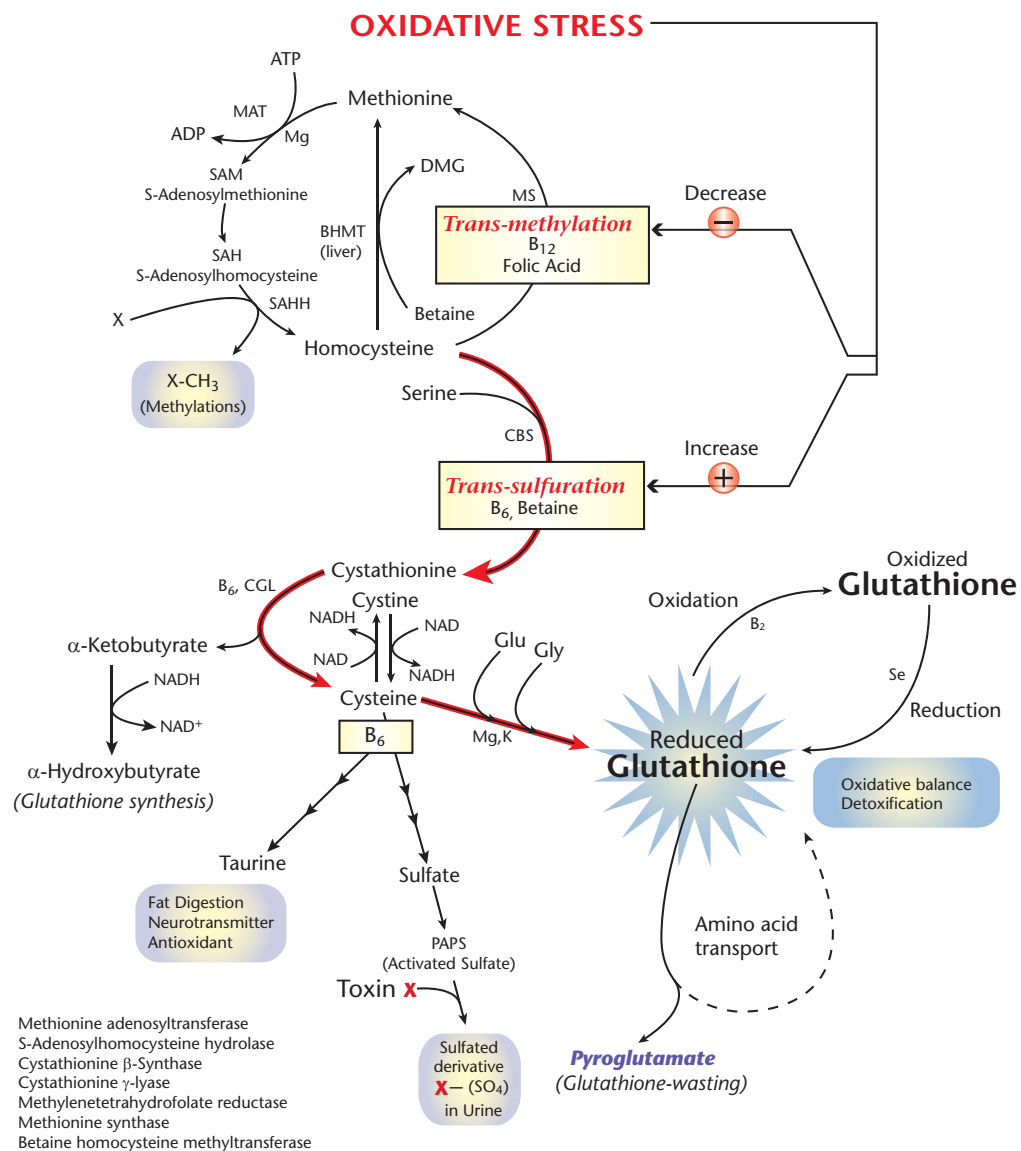


## THE IMPORTANCE OF SULFUR AMINO ACIDS

**Are we getting enough sulfur in our diets?** In a review on the importance of sulfur status, Nimni, M., et. al. (2007) found that a significant portion of the population may not be consuming sufficient amounts. After calcium and phosphorus, sulfur is the most abundant mineral in our body. Sulfur amino acids are important for glutathione production, sulfation (a major pathway for detoxification), protein synthesis, and methylation. Sulfur containing metabolites are used in many essential physiologic pathways and compounds such as, omega-3 fatty acids. Increasing sulfur reserves with supplementation (in the form of methylsulfonylmethane (MSM), glutathione, N-acetylcysteine, or taurine) or by diet is used in several clinical applications, including the treatment of: depression, detoxification impairments, arthritis, diabetes, AIDS, allergy, pain syndromes, skin conditions, and in those with chemical sensitivities.

FIGURE I.



Methionine, cysteine, homocysteine, and taurine are the four common sulfur-containing amino acids, but only the first two are incorporated into proteins. Methionine is the only essential amino acid. It is the essential precursor in the trans-sulfuration pathway in the production of glutathione (see Figure 1).

Low methionine levels may adversely affect these crucial pathways and may reflect a poor-quality protein diet. If methionine is low the trans-sulfuration to glutathione is impaired. Established dietary protein intakes are generally adequate to maintain nitrogen balance, but may not be enough for maintenance of cellular glutathione. Any situation requiring significant or chronic glutathione conjugation or oxidative challenge, such as a detoxification challenge, can lower methionine and lead to low plasma methionine levels. Any dietary excess is readily oxidized to sulfate, excreted in the urine (or reabsorbed depending on dietary levels), or stored in the form of glutathione.

The majority of our sulfur comes from food. Methionine and cysteine intakes are the primary source of dietary sulfur and can increase S-adenosylmethionine (SAME), glutathione, taurine and N- acetylcysteine levels. Foods with the highest methionine content are of animal origin, (see Figure 1). Dietary glutathione is also a source of dietary sulfur, the majority of which comes from fruits and vegetables. The Institute of Medicine and the World Health Organization recommend that a person eats 13 mg/kg of sulfur amino acids (SAA) per day. Thus, a 110-pound adult female has a minimum SAA requirement of 650 mg per day. Generally, 1 gram of protein contains approximately 17 mg of sulfur amino acids. Evaluating methionine status before using aggressive methionine supplementation is advised, as some previous studies found that high-methionine diets could induce hypercholesterolemia in several species. In conclusion, assessing a patient's methionine level can provide significant information about a patient's status, so yes, you should be concerned with your patients' sulfur status. For additional information on amino acids, please refer to the *Laboratory Evaluations for Integrative and Functional Medicine* textbook.

### **Foods highest in methionine per 200 calorie serving:**

1. Egg, white, dried, flakes, glucose reduced Methionine: 1704mg
2. Egg, white, raw, fresh Methionine: 1662mg
3. Fish, halibut, with skin (Alaska Native) Methionine: 1524mg
4. Fish orange roughy, cooked, Methionine: 1386mg
5. Chicken, breast, Methionine: 1308mg
6. Fish, tuna, light, canned in water, Methionine: 1302mg
7. Fish, ling, cooked, dry heat Methionine: 1299mg
8. Turkey, fryer-roasters, light meat, Methionine: 1296mg
9. Fish, pike, northern, Methionine: 1294mg
10. Fish, cod, Pacific, Methionine: 1293mg
11. Fish, cusk, Methionine: 1292mg
12. Fish, sunfish, Methionine: 1291mg
13. Fish, dolphinfish, Methionine: 1289mg
14. Fish, haddock, Methionine: 1288mg
15. Fish, cod, Atlantic, Methionine: 1288mg

### **Vegetables highest in methionine per 200 calorie serving:**

1. Seaweed, spirulina, raw Methionine: 908mg
2. Seaweed, laver, raw Methionine: 828mg
3. Seaweed, spirulina, dried Methionine: 792mg
4. Pumpkin leaves, raw Methionine: 569mg

5. Turnip greens, frozen, cooked, boiled, drained, with salt Methionine: 524mg
6. Spinach, cooked, boiled, drained, with salt Methionine: 478mg
7. Swamp cabbage, (skunk cabbage), raw Methionine: 463mg
8. Broccoli raab, raw [Broccoli rabe, Rapini] Methionine: 436mg
9. Taro leaves, raw Methionine: 376mg
10. Squash, zucchini, baby, raw Methionine: 371mg
11. Watercress, raw Methionine: 364mg
12. Mushrooms, brown, Italian, or Crimini, raw Methionine: 356mg
13. Asparagus, frozen, cooked, boiled, drained, with salt Methionine: 311mg
14. Bamboo shoots, cooked, boiled, drained, with salt Methionine: 309mg
15. Beans, kidney, mature seeds, sprouted, raw Methionine: 303mg

**Nuts and Seeds highest in methionine per 200 calorie serving:**

1. Seeds, sesame flour, low-fat Methionine: 994mg
2. Seeds, sunflower seed flour, partially defatted Methionine: 640mg
3. Nuts, brazil nuts, dried, unblanched Methionine: 307mg
4. Seeds, watermelon seed kernels, dried Methionine: 299mg
5. Seeds, pumpkin and squash seed roasted, [pepitas] Methionine: 283mg
6. Seeds, cottonseed kernels, roasted (glandless) Methionine: 209mg
7. Seeds, sesame butter, tahini, Methionine: 206mg
8. Seeds, sesame seeds, whole, dried Methionine: 205mg
9. Nuts, butternuts, dried Methionine: 200mg
10. Seeds, sunflower seed kernels, dried Methionine: 169mg
11. Seeds, flaxseed Methionine: 139mg
12. Nuts, coconut water (liquid from coconuts) Methionine: 137mg
13. Nuts, cashew nuts, raw Methionine: 131mg
14. Nuts, pistachio nuts, dry roasted, with salt 120 mg
15. Nuts, cashew nuts, oil roasted, without salt Methionine: 115mg

**Legumes highest in methionine per 200 calorie serving:**

1. Soy protein isolate, crude protein basis Methionine: 704mg
2. Soy sauce made from soy (tamari) Methionine: 557mg
3. Tofu, silken, lite extra firm Methionine: 463mg
4. Peanut flour, defatted Methionine: 392mg
5. Soy flour, defatted Methionine: 384mg
6. Tofu, firm, (nigari) Methionine: 314mg
7. Soybeans, mature cooked, boiled, without salt Methionine: 259mg
8. Beans, kidney, cooked, boiled Methionine: 233mg
9. Mungo beans, mature seeds, raw Methionine: 215mg
10. Beans, great northern, cooked, with salt Methionine: 212mg
11. Beans, white, mature seeds, raw Methionine: 211mg
12. Beans, black, cooked, with salt Methionine: 202mg
13. Cowpeas, (blackeyes, crowder, southern), raw Methionine: 199mg
14. Sausage, meatless Methionine: 197mg
15. Natto Methionine: 196mg

## RECOMMENDED READING:

Are we getting enough sulfur in our diet? Nimni, M., Han, B., Cordoba, F. *Nutr Metab*, 2007; 4: 24,  
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