

# The Anti-Inflammatory Diet: What To Consider

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**ACUTE INFLAMMATION IS THE CORNER STONE** of many ailments that brings a patient to a chiropractor, but there is also chronic inflammation, which is the root cause of most age-related diseases such as cardiovascular disease, type 2 diabetes, cancer, and dementia. Many patients seeing a chiropractor have both acute and chronic inflammation. Being overweight or obese causes the body to release inflammatory compounds, which do not subside until weight loss occurs, even with concomitant dietary manipulations. To control inflammation weight loss needs to occur first, followed by consumption of an anti-inflammatory diet. Amelioration of chronic inflammation requires a dietary pattern that reduces excess body fat and contains anti-inflammatory foods. A prudent, nutrient-dense, whole-foods diet satisfies both criteria. Numerous anti-inflammatory dietary approaches are available, but all are not science-based. It is difficult enough for patients to adopt any new dietary change, so imposing those that have no effect, seems pointless. The purpose of this review is to provide evidence-based information about dietary patterns, foods, and specific nutrients that promote weight loss and lower chronic inflammation. Included is a simple rating system to determine the inflammatory impact of a food or meal. Adopting an anti-inflammatory diet will promote weight loss and reduce systemic chronic inflammation.

## INTRODUCTION

Chiropractors treat a myriad of patients, but most have inflammatory conditions like rheumatoid arthritis, ankylosing spondylitis, osteoarthritis, scoliosis, and neuritis.<sup>1</sup> Additionally, they regularly treat individuals with chronic conditions (e.g., obesity, type 2 diabetes, coronary heart disease, cancer, and dementia). Although these conditions do not present as inflammatory (e.g., pain, swelling), they are associated with chronic inflammation.

The relationship between inflammation and health only became realized about 20 years ago with the development of the clinical measurement, highly sensitive C-reactive protein (hs-CRP). Although it originally was an indicator of cardiovascular disease (CVD), today elevated hs-CRP levels represent an increased risk of many chronic diseases like type 2 diabetes, dementia, cancer, and osteoarthritis.<sup>2</sup> Admittedly, other inflammatory markers exist, but they are more likely to be used in research settings. These include: proinflammatory cytokines such as tumor necrosis factor (TNF)- and interleukin (IL)-6, IL-18; soluble adhesion molecules (E-selectin, membrane-bound intracellular adhesion molecule-1 [ICAM-1]; and vascular cell adhesion molecule-1 [VCAM-1]).

Nutritional counseling related to chronic inflammation should first address weight loss, as obesity is its major cause

and main barrier to successful treatment.<sup>3</sup> Secondary issues relate to recommending specific, anti-inflammatory foods as well as pro-inflammatory ones to avoid. However, chiropractors, like medical students, receive very limited nutrition education. Yet despite this, 80% of chiropractors provide nutritional counseling based on a survey of New York chiropractors. Half of the chiropractors felt that nutritional counseling is an important part of their practice.<sup>1</sup>

Given the link between inflammation and diet, it is not surprising that an internet search on the subject reveals more than 11 million hits. Many of the recommendations are not science-based and lead to confusion for prescribing chiropractors, and for patients, who often demand unproven therapies. The purpose of this review is to present scientifically-sound information related to what constitutes an anti-inflammatory diet. In addition, we introduce an Anti-Inflammatory Score Card™ that can be used to assess the effect of a meal on worsening or lessening inflammation. The goal is that chiropractors will use this information in providing nutritional counseling to patients to treat chronic inflammation.

## DISCUSSION

Chronic inflammation is related to diet, but being overweight and obese are more important drivers of it and should

be addressed first. It is unlikely that overweight and obese patients will benefit from any anti-inflammatory dietary manipulations until they lose weight. The good news is that dietary patterns and foods that are associated with reduced inflammation also promote weight loss.

### **The inter-play among inflammation, obesity, and chronic disease**

*Overweight, obesity and inflammation.* Being overweight or obese is the major driver of inflammation. Obesity is the accumulation of excessive fat that may interfere with the maintenance of an optimal state of health.<sup>4,5</sup> Patients with body mass indexes (BMIs) of 25 kg/m<sup>2</sup> or more are considered overweight and at risk of chronic inflammation; those with BMIs of 30 kg/m<sup>2</sup> or greater are obese and at greater risk.

Excessive adipose tissues stimulates the release of inflammatory mediators such as TNF- and IL-6, and reduces production of adiponectin, creating a pro-inflammatory state and oxidative stress.<sup>3</sup> The increased level of IL-6 stimulates the liver to synthesize and secrete C-reactive protein. Chronic inflammation, resulting from excess adipose body fat is a risk factor for: heart disease, metabolic syndrome, and diabetes mellitus; and is also associated with development of non-cardiovascular diseases such as psoriasis, depression, cancer, and renal diseases.

*Diet and chronic disease.* The World Health Organization (WHO) recognizes that the inflammatory impact of the diet plays an important role in the prevention of several non-infectious diseases (e.g., CVD, type 2 diabetes, cancer).<sup>2</sup>

Women following a pro-inflammatory diet have three times more risk for developing type 2 diabetes than those adhering to a low inflammatory diet.<sup>6</sup> Similarly, a pro-inflammatory dietary pattern increases the risk of colon cancer by 32%, compared to a group that follows an anti-inflammatory diet.<sup>7</sup> For women, the likelihood of developing depression increases 30-40% by following an inflammatory diet compared to those who follow an anti-inflammatory one.<sup>8</sup> Diets that are pro-inflammatory are associated with predicting sleep apnea severity, day-time sleepiness, and predicting REM latency. Sleep was enhanced with an anti-inflammatory diet and day-time sleepiness was reduced.<sup>9</sup>

### **Anti-inflammatory and inflammatory dietary patterns**

Much agreement exists about dietary patterns related to the inflammatory effect on the body. A prudent dietary pattern reduces chronic inflammation, and one that is replete with highly processed foods and fast foods increases inflammation, mainly by promoting obesity.

*A prudent diet regimen: anti-inflammatory.* A few studies have described a "prudent diet" being anti-inflammatory.<sup>2,4,5</sup> Such a dietary pattern is characterized by a high intake of fruit, vegetables, legumes, whole grains, poultry, and fish, rich in omega-3 fatty acids. Inclusion of some low-fat dairy products has not been shown to be inflammatory.<sup>10</sup> A prudent diet is associated with reduced plasma inflammatory biomarkers and a lower risk CVD. Unhealthy diets that include a high intake of red and processed meat, sweets like candy, potatoes like French fries, refined grains, and dessert foods are associated with high plasma *hs*-CRP and predisposes the body to degenerative disease.<sup>11</sup>

Another prudent dietary pattern is the Mediterranean diet, which includes the intake of fruit, vegetables, extra virgin olive oil, walnuts, plant-based proteins like legumes, whole grains, fish, cocoa, coffee, tea and wine. This diet is associated with reduced plasma inflammatory biomarkers and a lower risk of chronic diseases.<sup>12</sup> Other anti-inflammatory foods include poultry and fresh herbs and spices.<sup>4,13</sup>

Anti-inflammatory dietary patterns have several things in common:

- Are nutrient-dense
- High in dietary fiber and complex carbohydrates
- Low in saturated fats and sugar
- Protein is mostly from vegetarian sources; limit animal protein

However, the most important aspect of an anti-inflammatory dietary pattern is its high nutrient-density. Church et al. conducted a post hoc subgroup analysis of a randomized, double-blind placebo-controlled trial and reported that obtaining all essential nutrients was shown to reduce CRP levels significantly.<sup>14</sup> Over six months, the placebo group experienced a CRP increase of 0.21 mg/L, while those taking a multivitamin/multimineral supplement, had a decrease of 0.71 mg/L. Statins lower CRP by 14-28%; the nutrient-containing supplement lowered it by 14%.<sup>15</sup> This is impressive as not all subjects were at high risk for heart disease (i.e., CRP > 1.0 mg/L). Those at high risk (CRP > 3.0 mg/L) experienced more of a lowering of CRP, suggesting that those with high CRP levels may benefit from a micronutrient supplementation, consuming a nutrient-dense diet, or both.<sup>14</sup>

Nutrient-dense diets also promote satiety and weight loss and may offer a better alternative to taking multivitamin/multimineral supplements.<sup>16-18</sup> Consumption of a nutrient-rich bar coupled with no other dietary changes resulted in weight loss and improvements in metabolic parameters related to

cardiovascular health and insulin resistance.<sup>18</sup> In a sub-group, who at the onset were deemed inflammatory (i.e., *hs*-CRP  $\geq$  1.5 mg/L), experienced a decrease in *hs*-CRP after two weeks, coupled with improvements in the other metabolic parameters.<sup>18</sup>

Moreover, nutrient-dense diets have been shown to promote significant weight loss after 21 days and a decrease in waist circumference.<sup>16-17</sup> Using weight and waist circumference changes, a subset (33%) reduced their risk of hypertension, cardiovascular disease, and type 2 diabetes. Participants in these studies consumed five nutrient-dense foods daily. They also reported having more energy, sleeping better, and overall feeling better. It is more important to adopt a healthy, nutrient-rich diet than trying to assemble single nutrients that reduce inflammation.<sup>2, 4, 12</sup> In addition, nutrient-dense foods not only reduce inflammation but also promote weight loss and thus a decrease in chronic disease risk.

*Processed foods and fast-food: inflammatory.* Foods found in a prudent dietary pattern are satiating, thereby reducing the likelihood that they will be over-consumed. In contrast, processed foods and fast foods are designed to promote hunger and thus, obesity, leading to chronic inflammation.

**Processed foods.** Processed foods are defined as food and drink products ready to eat, drink, or heat and made predominantly or entirely from processed items extracted or refined from whole foods or synthesized in the laboratory. Consuming a high percentage of calories from processed foods increases the risk of becoming overweight and obese by 25% to 45%, which has the biggest impact on inflammation.<sup>19</sup>

Processed foods are characterized by:

- Having high energy densities, as most of the water is removed to increase shelf-life and decrease the cost of transport.
- Being manufactured by large and powerful transnational companies that focus their marketing on the individual's lack of time compared with the expediency, convenience, and accessibility of these products.
- Being nutritionally unbalanced with a high energy content, mostly from fat; and having added or free sugar, sodium, and chemical additives in addition to being poor in micronutrients and fiber. Saturated fats are inflammatory.<sup>2, 20</sup>
- Being designed to be irresistible and to favor consumption (because of the use of salt, sugar, and fat).

- Having strong marketing and other characteristics such as portion size and convenience, and designed the processing to negate the capacity for self-control.

With certainty, most processed foods are designed to be addictive and non-satiating, leading to over-eating, obesity, and leading to chronic inflammation.

**Ultra-processed foods.** A new, subcategory of processed foods is ultra-processed foods.<sup>19</sup> Like processed foods, they are designed to be flavorful and addictive. The main problem with ultra-processed foods relates to their high added sugar content.<sup>21</sup> Ultra-processed foods contribute about 58% of total caloric goal but 90% of the sugar goal for Americans. Added sugars in ultra-processed foods contributes 21% of total calories yet only about 4% comes from foods that are minimally processed.

Eighty-two percent of those consuming the most ultra-processed foods exceeded their total sugar goal, compared to 26% who consumed the fewest number of ultra-processed foods. Consuming any form of carbohydrate in excess of the basal metabolic rate promotes lipogenesis, which fosters inflammation.<sup>22</sup> Ultra-processed foods have the dubious distinction of being high in total carbohydrates, and of containing highly refined, addictive sources of carbohydrate (e.g., flour, sugar, high fructose corn syrup). Ultra-processed foods creates an inflammatory environment.<sup>5, 22-23</sup> Consuming fewer ultra-processed foods reduces total carbohydrate intake, hunger, obesity, and thus chronic inflammation.

There is a 25% increase in obesity risk between consuming a lot of ultra-processed foods and hardly any at all.<sup>10</sup> This supports a strong relationship between obesity and ultra-processed foods. Processed, and ultra-processed foods, per se, have not been studied in isolation as far as their pro-inflammatory effects.

**Fast-food.** Fast-food, defined as "easily prepared processed food served in snack bars and restaurants as a quick meal or to be taken away," has been positively associated with obesity and daily caloric intake.<sup>24</sup> For each additional meal eaten outside of the home, adult Americans are likely to increase caloric intake by about 100 to 200 kcal/day. One-pound weight gain equals roughly 3,500 calories, so eating out could produce a theoretical gain of 10-20 pounds per year, if people do not eat fewer calories to compensate for the excess consumed outside the home. Today, fast-food is an integral part of the average American diet; it accounted for only 4% of total caloric intake in 1977-1978, but in 2007-2010, it was 11% of daily total caloric intake. Over 30 years, there was a 226% increase in the number of

offerings at fast-food establishments. Increases also occurred in calories, sodium, and calcium in fast-food servings.<sup>24</sup>

In summary, processed foods, ultra-processed foods, and fast-food all are designed to increase appetite, decrease satiety, and promote obesity. These processed foods, themselves, may or may not be directly inflammatory, but all are addictive and lead to weight gain, which is inflammatory.

### COMPONENTS IN FOODS WITH QUESTIONABLE IMPACT ON INFLAMMATION

**Soy protein.** Many think that soy is inflammatory, but just the opposite is true.<sup>25</sup> Women consuming a high-soy diet experienced improvements in key markers of inflammation; IL-6 decreased by 25% and TNF-alpha by 14%.<sup>25</sup> Soy products are rich in anti-oxidants, provide a high-quality protein source, and some contain dietary fiber.

Individuals at risk for CVD participated in a prospective, cross-over study where they consumed a soy nut snack and a control soy-free snack matched for macronutrients.<sup>26</sup> Markers of inflammation did not differ between the groups, but despite this, arterial stiffness significantly improved in the soy group ( $P = 0.03$ ). Thus, in high risk individuals, soy does not worsen inflammation and seems to lower CVD risk.

**Canola oil.** Popular sites on the internet state that canola oil is inflammatory, but don't provide scientifically-sound information to support this contention. Canola oil is not inflammatory and:

- Has the second highest omega-3s of all healthy vegetable oils (flax oil is first, but it is unstable in foods) and is low in omega-6s, yielding a good balance between the two fatty acids
- Has a long shelf life and does not go rancid quickly like flax oil
- Is low in saturated fat, which decreases heart disease risk
- Is high in omega-9 fatty acids just olive oil and avocados, which are cardio-protective.<sup>27</sup>

**Gluten.** No evidence exists that gluten is inflammatory, except for celiac patients and those with non-celiac gluten sensitivity.<sup>28</sup>

**Artificial additives** (e.g., sweeteners, colors, and preservatives). Individual chemical food additives are touted to increase inflammation, but no scientific evidence exists for this assumption. Using PubMed, human studies where artificial additives are inflammatory are nearly non-existent<sup>29,30</sup> (<https://www.ncbi.nlm.nih.gov/pubmed>). Artificial sweeten-

ers (i.e., saccharine and sucralose) are often considered to be inflammatory, but no evidence exists for this in humans.<sup>29</sup> Natural food preservatives like curcumin have been studied for their anti-inflammatory effects.<sup>30</sup> It is the processed foods, and not the artificial additives contained in them, that are known to be inflammatory.

**Naturally occurring compounds.** Some people think that naturally-occurring compounds like lectins, oxalates, and phytates are inflammatory, but this does not make sense.<sup>2,4,12</sup> Prudent diets rich in foods that contain these natural compounds have consistently been shown to be anti-inflammatory.<sup>2,4,12</sup> Also, these naturally-occurring compounds alone have not been shown to be inflammatory.<sup>31-33</sup>

Lectins are found in all foods but are most concentrated in legumes and grains. They can be toxic, but only if the food is consumed raw. Cooking completely denatures lectins; in fact, boiling legumes in water eliminates almost all lectin activity. Legumes and grains are never consumed uncooked, so the concern is mitigated.

There are no clinical studies showing that lectins are inflammatory.<sup>31</sup> In cell lines, exposure to lectins from wheat germ agglutinin (WGA) increases the release of cytokines in immune cells. Admittedly, there is a possibility that lectins are inflammatory because WGA appears in foods – highest concentrations in wheat germ (100-500 g/g), but nearly non-existent in other, more commonly consumed foods (e.g., pasta, cereal, flour).<sup>31</sup> Thus, the inflammatory impact from lectin, if any, would be small.

Oxalates are highest in certain dark, leafy greens like spinach and beet greens; kale and turnip greens have less. Phytates are found whole grains, nuts, seeds, and legumes. Neither are inflammatory. Admittedly, these compounds bind calcium, zinc, and iron, but if these nutrients are consumed in adequate amounts as part of an anti-inflammatory diet, nutrient deficiencies do not develop.<sup>32</sup> Mycotoxins are inflammatory, but can be prevented if foods are stored in cool, dry places, rendering them no longer inflammatory.<sup>33</sup> The most common sources of mycotoxins are grains, sugar, hard cheese, and peanuts.

**Acrylamide.** The major food sources of acrylamide are French fries, potato chips, crackers, bread, cookies, breakfast cereals, canned black olives, prune juice, and coffee.<sup>34</sup> Decreasing cooking times and preventing things like potatoes from getting too crispy reduce acrylamide levels. Whether acrylamide increases cancer risk has not been determined in humans.<sup>35</sup> In a cell line, acrylamide is inflammatory.<sup>36</sup>

## The Anti-Inflammatory Diet: What To Consider

### SIX COMMONLY CONSUMED BREAKFASTS ARE SCORED USING THE ISC.

| Attribute that applies to a meal  | Rating system of inflammation per meal   | Nutrient* <i>Maple Almond Cereal</i> (Scores) | <i>3-egg and cheese omelet and hash browns</i> (Scores)   | <i>2 eggs, 3 bacon, wheat toast, hash browns</i> (Scores)      |
|---|--|---|---|--|
| Nutrient density (nutrients per calorie)  | More than half of all essential nutrients meeting at least 20% Daily Value                               | Yes = 10                                      | No = 1  | No = 1   |
| Contains essential nutrients (i.e., vitamins and minerals)  | All  | All = 10                                      | No = 1  | No = 1   |
| Animal protein  | None   | Small milk protein = 7                        | Yes (mostly animal; some in potatoes) = 1.5               | Yes (mostly animal but some in bread and potatoes) = 2         |
| Total carbohydrate  | Goal is to be less than an average Basal Metabolic Rate (i.e., ~1,200 – 1,400 calories) or ~ < 75 g/meal | Yes = 10                                      | Yes = 10  | Yes = 10   |
| Saturated fat   | The goal is 20 g/day, so per meal, target ~15% of 20 g = 3g  | Yes = 10                                      | More than 3g = 1  | More than 3g = 1   |
| Fiber   | The goal is 25 g/day, so per meal, the goal is 5 g or more   | Yes = 10                                      | Less than 5g; some in potatoes = 2                        | Less than 5g; some in potatoes = 2                             |
| Whole grains  | Low in refined and high-glycemic index carbohydrates   | About half is whole grain = 5                 | High GI for potatoes = 1                                  | High GI for potatoes but has whole wheat bread = 2             |
| Sugar   | The goal is 50 g/day, so less than 10 g  | Yes = 10                                      | Yes = 10  | Yes = 10   |
| Omega 6/omega 3   | Less than 10:1   | Yes = 10                                      | No = 1 (cooked in vegetable oil with not enough omega-3s) | No = 1 (cooked in vegetable oil with not enough omega-3s)      |
| Degree of processing and use of artificial additives that are high in sugar and artificial chemicals. | Low in amount of processed and ultra-processed foods.  | Low processing/no artificial ingredients = 10 | Low processing/no artificial ingredients = 10             | Middle processing/artificial components in bacon and bread = 5 |
| Total Anti-Inflammatory Score Card  | Optimal score for least inflammation = 100   | 92  | 37.5  | 35   |

\*Nutrient: <http://nutrientfoods.com>

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*Trimethylamine N-oxide (TMAO)*. TMAO is a small colorless amine oxide generated from choline, betaine, and carnitine by gut microbial metabolism.<sup>37</sup> However, with ade-

quate fiber consumption, TMAO production is mitigated. In animals, but not humans, TMAO triggers inflammation in blood vessels and creates unstable plaques in artery walls,

| Attribute that applies to a meal  | Rating system of inflammation per meal   | 1 egg + 2 cups fruit | 3 blueberry pancakes + 1 ounce maple syrup | 6 ounces vanilla nonfat Greek yogurt + 1 cup blueberries + 1/4 cup granola |
|---|--|----------------------|--|--|
| Nutrient density (nutrients per calorie)  | More than half of all essential nutrients meeting at least 20% Daily Value                               | No = 1               | No = 1                                     | No = 1   |
| Contains essential nutrients (i.e., vitamins and minerals)  | All  | No = 1               | No = 1                                     | No = 1   |
| Animal protein  | None   | Egg only = 5         | Milk and egg, small amounts = 5            | Yogurt, small amount = 5   |
| Total carbohydrate  | Goal is to be less than an average Basal Metabolic Rate (i.e., ~1,200 – 1,400 calories) or ~ < 75 g/meal | Yes = 10             | Yes = 10                                   | Yes = 10   |
| Saturated fat   | The goal is 20 g/day, so per meal, target ~15% of 20 g = 3g  | Yes = 10             | Yes = 10                                   | Yes = 10   |
| Fiber   | The goal is 25 g/day, so per meal, the goal is 5 g or more   | Yes = 10 (fruit)     | No = 1                                     | Yes = 10 (blueberries)   |
| Whole grains  | Low in refined and high-glycemic index carbohydrates   | No = 1               | No = 1                                     | Some in granola = 5  |
| Sugar   | The goal is 50 g/day, so less than 10 g  | No = 1; fruit        | No = 1; syrup                              | No = 1; fruit  |
| Omega 6/omega 3   | Less than 10:1   | Minimal fat = 10     | Minimal fat = 10                           | Minimal fat = 10   |
| Degree of processing and use of artificial additives that are high in sugar and artificial chemicals. | Low in amount of processed and ultra-processed foods.  | None = 10            | Syrup + pancakes = 1                       | None = 10  |
| Total Anti-Inflammatory Score Card  | Optimal score for least inflammation = 100   | 59                   | 41   | 63   |

thereby potentially raising the risk of heart attack.<sup>37</sup> High saturated fat-containing foods and those low in fiber increase TMAO, and thereby inflammation.

### ANTI-INFLAMMATORY SCORE CARD™

Two groups of investigators have proposed methods to determine the inflammatory impact of food.<sup>38, 39</sup> Both the dietary inflammation rating systems (Dietary Inflammation Index [DII] and the Empirical Dietary Inflammatory Pattern [EDIP]) require completion of an extensive questionnaire about dietary habits. Both indexes (DII and EDIP) relate equally to predicting inflammation as determined by *hs*-CRP.

We propose a simpler method, the Anti-Inflammatory Score Card™ (ISC), which allows for immediate analysis of the inflammatory impact of any food or meal. The ISC uses ten rating factors, using a rating scale of one to ten. Ten represents the least inflammatory, and one indicates the most inflammation. For each meal or food, the best score is 100 (ten attributes and highest score of ten each), and the worst is 10. Admittedly, this approach has not been validated, but the rating system is based on evidence-based scientific research on diet and inflammation. This is an easy tool for busy chiropractors to use in evaluating the diets of their patients.

### CONCLUSION

What we eat is a major contributing factor to the level of inflammation in the body. Obesity alone causes the body to release inflammatory compounds, so weight loss is the first step at reducing inflammation. Most patients seeking chiropractic care have some form of acute inflammation related to pain. In addition, many have common, chronic, inflammatory conditions resulting from excess body weight such as CVD, type 2 diabetes, cancer, and dementia. Adherence to a prudent dietary pattern rich in fruits, vegetables, whole grains, and vegetarian proteins promotes an anti-inflammatory state. Most people do not adhere to this healthy pattern but instead, consume a pro-inflammatory diet rich in processed foods that contain excessive calories especially from fat and sugar. Chiropractors should provide dietary information related to weight loss and the inclusion of anti-inflammatory meals and foods. The Anti-Inflammatory Score Card can help busy practitioners readily determine the inflammatory impact of a meal.

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