Sidelining Soy: The Case for Seaweed Substitutes

May 2021

The Cost of Enjoying Soy

Over the past century, soybeans have dominated the United States' agricultural market. Soybeans represent big business with the market generating $31.2 billion in 2019 (USDA, 2021). Soybeans' chemical and nutrition make-up and unique consistency allow them to be transformed in a variety of ways. Soy can take many forms including oil, flour, and meal, and its multiplicity of uses extend to everyday products such as soaps, cosmetics, plastics, clothing, inks, and glues (Krull, 2018).

Additionally, soy's high protein content makes it a desirable ingredient for food products. Soy provides a complete source of dietary protein, meaning that it contains all the essential amino acids (Barrett, 2006). Today, soy is used in countless food items as well as in animal feed. In fact, 97 percent of soybean yield in the United States is used in animal feed while the other 3 percent is used in food products (Krull, 2018). Soy can be found in a variety of food products such as tofu, soy milk, soy-based infant formula, and meatless "texturized vegetable protein" that comprises many of the veggie burgers on the market (Barrett, 2006).

The versatility and nutritional content of soybeans has caused the soybean market to explode in recent years. The Soyfoods Association of North America reports that U.S. sales of soy foods reached $3.9 billion in 2003, continuing an 11-year trend of 15 percent average annual increases (Barrett, 2006). Also, according to the United Soybean Board's 2004–2005 Consumer Attitudes About Nutrition report, 25 percent of Americans consume soy foods or beverages at least once per week, and 74 percent view soy products as healthy (Barrett, 2006).

However, this "miracle" crop comes with major drawbacks. As the domestic usage of soybeans rises, so too does the concern for their environmental impact. The high demand for soybeans requires millions of acres of land for cultivation in the U.S. alone. In 2020, soybeans are estimated to occupy 83.8 million acres, and this number is expected to increase in subsequent years (USDA, 2021). Soybean farming has one of the greatest deleterious environmental effects of any agricultural product, negatively impacting water and soil composition and acting as a major contributor to deforestation.

There has been a rise in the use of pesticides and insecticides for soybean growth in the U.S. due to the spread of soybean aphids across the country. As a result, soybean's freshwater ecotoxicity impact has increased dramatically (Yang and Suh, 2015). These pesticides and insecticides infiltrate nearby bodies of water, harming aquatic life and threatening human health. Furthermore, soybean production perpetuates soil erosion, loss of organic matter, and acidification as a result of chemicals that are added to the crop (WWF, 2014).

Soybean cultivation also contributes greatly to deforestation. The expansion of mechanized soy farming has been the single most important driver for deforestation in past decades (WWF, 2004). Industrial-scale soy production requires a large supporting infrastructure that leads to further loss of natural ecosystems. This infrastructure includes transport links, processing mills, workers' facilities, and roads networks (WWF, 2014). Soybean production also has indirect impacts leading to deforestation. Large-scale soy farms acquire land from smaller farms, who then buy land in other areas to continue soybean cultivation. Because soy is commonly utilized in cattle feed, more land needs to be cleared to grow the crop for this large industry.

The growing global demand for soy has led to major deforestation in South America. Because the U.S. has limited available arable land for soybean production, land is provided by South American countries like Bolivia, Brazil, and Paraguay. Between 1978 and 2001 Bolivia lost 2.4 million hectares of forest and 0.6 million hectares of bush savannah, and soy production was the main culprit for this deforestation. In East Paraguay, the Atlantic Forest once covered 8.8 million hectares and has since been reduced to just 800,000 hectares (WWF, 2014). The Amazon is home to one in every ten animals on earth and is essential for the regulation of the world's climate. However, more than half of the remaining Amazon Rainforest could be destroyed in the next 20 years as a result of deforestation due to agricultural processes including soy production (WWF, 2014).

Kelp Can Help

Fortunately, there is a healthier and more sustainable alternative to soybeans on the rise: kelp. The seaweed industry is one of the fastest growing maritime industries in New England due to the increasing demand for new protein sources, healthy food supplements, and enhanced food security. Global seaweed aquaculture production eclipsed 30 million metric tons in 2016 with an annual market value of $11.7 billion (FAO, 2018). Currently, over 99 percent of seaweed production occurs in Asia (Kim et al., 2019).

Although seaweed aquaculture is a relatively nascent in the U.S. compared to Asian countries like China and Indonesia, the industry is quickly gaining traction. The commercial cultivation of kelp and other seaweeds began in 2010 in the Gulf of Maine and Long Island Sound (Kim et al., 2019). The most common type of seaweed grown in Long Island Sound is *Saccharina latissima*, also known as Sugar Kelp. As of today, the United States Census of Aquaculture has little data on the amounts of seaweed being pro-

produced annually, however it is estimated that about 1 million pounds of seaweed is currently harvested from US waters with predictions that the market could swell to 4 million pounds per year by 2035 (The Fish Site, 2020).

Sugar Kelp represents a more sustainable alternative to soybeans. Unlike soybean farming, the processes involved in kelp aquaculture are environmentally friendly and sustainable. Sugar Kelp cultivation is low impact, requiring no fertilizers or pesticides that would jeopardize the health of the ocean and surrounding marine habitats. Sugar Kelp aquaculture also does not use freshwater or arable land and therefore does not contribute to the unsustainable use of the earth's resources.

Sugar Kelp requires no feed in order for it to grow because it uses photosynthesis to produce its own food. Due to the autotrophic nature of seaweed, it is responsible for much of the carbon dioxide absorption in marine vegetated habitats through carbon sequestration (Duarte, et al., 2017). This represents an important ecosystem service because the ocean absorbs large amounts of the atmospheric carbon dioxide emissions, which can lead to harmful ocean acidification. However, seaweed can help mitigate the effects of ocean acidification by acting as an effective carbon sink. Kelp forests are also biologically productive habitats that create vital environments for sustaining marine life. They are attractive habitats for fish and small species to thrive and provide surface area for non-mobile species to live as well (Hasselström et al., 2018). Overall, Sugar Kelp can help increases an area's biodiversity by attracting native species.

In addition to providing numerous environmental benefits that are good for the planet, seaweed is also good for the body. Nutritional studies have shown that brown seaweeds like Sugar Kelp and red seaweeds such as *Gracilaria* have been found to have a good nutritional quality and therefore can be used as an alternative source of fiber, protein and minerals (Jiménez-Escrig et al., 2011) Kelp is becoming a more commonly used food source and is being used to make foods products including kelp chips, kelp pasta and kelp salsa. It is also used as an ingredient in foods like ice cream, tea, and also in cosmetics.

Gracilaria is already being used as a major food source around the world in countries like Indonesia, Malaysia, the Philippines and Vietnam where it is collected for food. In Hawaii., fresh *Gracilaria* has been used as a salad vegetable for decades. In southern Thailand, an education program was undertaken to show people how it could be used to make jellies by boiling the extracted agar (Mahadevan, 2015). *Gracilaria*'s is mainly used for the production of agar, providing more than 50 percent of the world's agar supply. (Baweja, et al., 2016). This agar can be used as a replacement for gelatine in products like jellies, cakes, ice creams and also some cosmetic products and shampoos.

Currently, soy is used in many meatless products like vegetarian burgers and in other meat replacement products like tofu. However, a market opportunity exists to use seaweed as a soy substitute in faux meat products. As shown in Table 1, Sugar Kelp and *Gracilaria* are both highly nutritious alternatives to soy. Although soy has the most protein, Sugar Kelp or

Gracilaria are both highly nutritious alternatives to soy. Although soy has the most protein, Sugar Kelp or *Gracilaria* could be used in conjunction with other proteinaceous ingredients to create an environmentally friendly veggie burger. The seaweed product company AKUA has just launched a kelp-based vegan burger that is taking the market by storm. The Long Island Sound Ocean Cluster seeks to jumpstart other seaweed start-ups that are creating innovative and nutritious food products out of locally grown Sugar Kelp.

Authors

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Nutrient Component	Soy	Sugar Kelp	Gracilaria
Serving Size	100g	100g	100g
Calories	173	43	----
Total Fat	9g	0.6g	0.19g
Cholesterol	0g	0g	0g
Sodium	1mg	233mg	290.89mg
Carbohydrates	8.4g	9.6g	63.13g
Potassium	515mg	89mg	1380.42mg
Fiber	6g	1.3g	24.7g
Protein	18g	1.7g	6.9g
Calcium	102mg	168mg	429.11mg
Magnesium	86mg	121mg	463.23mg
Vitamin C	1.7mg	3mg	28.5mg
Iron	5.1mg	2.9mg	15.2mg

Table 1 — Nutritional Comparison: Soy Vs Seaweed

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