

## Review

# The Okinawan Diet: Health Implications of a Low-Calorie, Nutrient-Dense, Antioxidant-Rich Dietary Pattern Low in Glycemic Load

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Residents of Okinawa, the southernmost prefecture of Japan, are known for their long average life expectancy, high numbers of centenarians, and accompanying low risk of age-associated diseases. Much of the longevity advantage in Okinawa is thought to be related to a healthy lifestyle, particularly the traditional diet, which is low in calories yet nutritionally dense, especially with regard to phytonutrients in the form of antioxidants and flavonoids. Research suggests that diets associated with a reduced risk of chronic diseases are similar to the traditional Okinawan diet, that is, vegetable and fruit heavy (therefore phytonutrient and antioxidant rich) but reduced in meat, refined grains, saturated fat, sugar, salt, and full-fat dairy products. Many of the characteristics of the diet in Okinawa are shared with other healthy dietary patterns, such as the traditional Mediterranean diet or the modern DASH (Dietary Approaches to Stop Hypertension) diet. Features such as the low levels of saturated fat, high antioxidant intake, and low glycemic load in these diets are likely contributing to a decreased risk for cardiovascular disease, some cancers, and other chronic diseases through multiple mechanisms, including reduced oxidative stress. A comparison of the nutrient profiles of the three dietary patterns shows that the traditional Okinawan diet is the lowest in fat intake, particularly in terms of saturated fat, and highest in carbohydrate intake, in keeping with the very high intake of antioxidant-rich yet calorie-poor orange-yellow root vegetables, such as sweet potatoes, and green leafy vegetables. Deeper analyses of the individual components of the Okinawan diet reveal that many of the traditional foods, herbs, or spices consumed on a regular basis could be labeled “functional foods” and, indeed, are currently being explored for their potential health-enhancing properties.

## INTRODUCTION

In most postindustrial societies, overeating, inactivity, and obesity have emerged as major public health challenges [1]. Moreover, excessive caloric intake is often seen in dangerous combination with a failure to meet recommended intakes for important nutrients. Therefore it is not surprising that recent U.S. Department of Agriculture (USDA) dietary guidelines recommend that “most people need to choose meals or snacks that are high in nutrients but low to moderate in energy content” and that doing so “offers reduction of risk for a number of chronic diseases that are major public health problems.”

Based on dietary intake data or evidence of public health problems the USDA indicates that many adults lack sufficient amounts of dietary fiber, calcium, magnesium, potassium, and the antioxidant vitamins A (as carotenoids), C, and E [2]. At the same time, the USDA reports that in general, Americans consume too many calories and too much saturated and trans fats, cholesterol, sugar, and salt [2]. Moreover, overconsumption of foods that are calorie-dense, nutritionally poor, highly processed, and rapidly absorbable can lead to systemic inflammation, reduced insulin sensitivity, and a cluster of metabolic abnormalities, including obesity, hypertension, dyslipidemia, and glucose intolerance (commonly known as

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metabolic syndrome), affecting about one third of Americans and an increasingly serious problem in virtually all developed nations [3].

### The Role of Oxidative Stress in the Pathogenesis of Diabetes and Other Chronic Diseases

Although the concept of atherosclerosis as an inflammatory disease is now well established, chronic inflammation is also very likely involved in the pathogenesis of insulin resistance and type 2 diabetes [4] and may represent a common pathogenic step in a host of other chronic diseases [5]. Evidence from studies in both normal subjects and those with diabetes has shown that induced or acute hyperglycemia [6], or meal intake and its accompanying increase in glucose [7], can induce oxidative stress as well as reduce antioxidant defenses. Therefore, high glycemic load (GL) associated with chronic consumption of high Glycemic Index (GI) foods, may lead to chronically high levels of oxidative stress [8].

Pharmacotherapy directed against insulin resistance or postprandial hyperglycemia, and cardiovascular drugs devoid of effects on blood glucose levels such as calcium channel blockers, angiotensin-converting enzyme inhibitors, angiotensin I receptor antagonists, and statins, all share intracellular antioxidant effects as one common mechanism of action. It has been suggested that many of their beneficial ancillary effects, such as a decrease in cardiovascular mortality, are not fully accounted for by their hypotensive or lipid-lowering effects, and instead may be the result of a shared antioxidant effect [5,9].

Moreover, *in vitro* studies and animal models have shown that antioxidants improve insulin sensitivity [10], and several clinical trials have demonstrated the efficacy of treatment with vitamins C or E or glutathione for improving insulin sensitivity in individuals who are insulin resistant [10,11]. The finding that insulin resistance is associated in humans with reduced intracellular antioxidant defense also supports this argument [12]. Several cross-sectional [13–17] and case-control [18,19] studies, as well as some longitudinal studies [20,21], have shown an inverse relationship between antioxidants, such as carotenes, and diabetes, suggesting that antioxidants, in the form of plasma carotenoids, could be related to a reduced risk of dysglycemia.

Although large-scale clinical trials with antioxidants such as beta-carotene or vitamins C and E have been inconclusive, evidence for the efficacy of interventions that increase antioxidant load through the use of traditional antioxidant-rich and anti-inflammatory diets has been accumulating, and recent smaller interventional studies with carefully chosen populations, such as those under high levels of oxidative stress, have yielded largely positive results [22]. Moreover, research on oxidative stress as a therapeutic target to prevent cardiovascular diseases (CVD), diabetes, or other chronic diseases is finally beginning to become more focused, hypothesis-driven,

**Table 1.** Links between Nutritional Factors and Risk of Chronic Disease

Dietary Intake	Disease Risk			
	Cancer	Cardiovascular	Obesity	Diabetes
High calories	↑	↑	↑	↑
High saturated fat	↑	↑	↑	↑
High salt	↑	↑	—	↑
High GI and GL	↑	↑	↑	↑
Low antioxidants	↑	↑	—	↑

Source: Adapted from Deckelbaum et al [25].

and rigorous in clinical trial designs, which should help to clarify the true potential utility of antioxidants as a preventive or therapeutic mechanism [22–24].

### Dietary Patterns and Reduced Risk for Chronic Disease

Although the scientific literature on diet and health is large and unwieldy, until recently, researchers have focused mainly on the effects of individual nutrients or foods. Much less often has the focus been on dietary patterns, in part because of their complexity, although there have been important exceptions such as the Seven Countries Study and groundbreaking work on the Mediterranean, DASH (Dietary Approaches to Stop Hypertension), and Portfolio diets, among others. However, regardless of the diversity in scientific approach, evidence converges around the notion that diets associated with reduced risk of CVD, some cancers, diabetes, and several other chronic diseases are heavy in vegetables and fruit (therefore rich in phytonutrients and antioxidants) but reduced in meat, refined grains, saturated fat, sugar, salt, and full-fat dairy products (Table 1).

Equally notable is the wide variation in other aspects of healthy diets such as macronutrient intake, represented most notably by the healthy traditional Mediterranean diet, which is high in fat (predominantly from monounsaturated and polyunsaturated sources) and lower in carbohydrate, and the healthy Okinawan diet, which is low in fat and high in carbohydrates (mostly from vegetable sources). This suggests that low-energy, nutrient-dense diets with high-quality carbohydrates may be beneficial for reducing the risk of many chronic diseases. Indeed, a low-energy-density diet may have a higher capacity to prevent nutritional deficiency, despite the lower energy content, than a high-energy-density diet [26]. The longevity of Mediterranean and Okinawan populations suggests that such diets may even help to slow the aging process itself [1,27].

## THE TRADITIONAL OKINAWAN DIET: THE BASICS

Although it is well known that the Japanese are the world's longest-lived people, less well known is that there is a

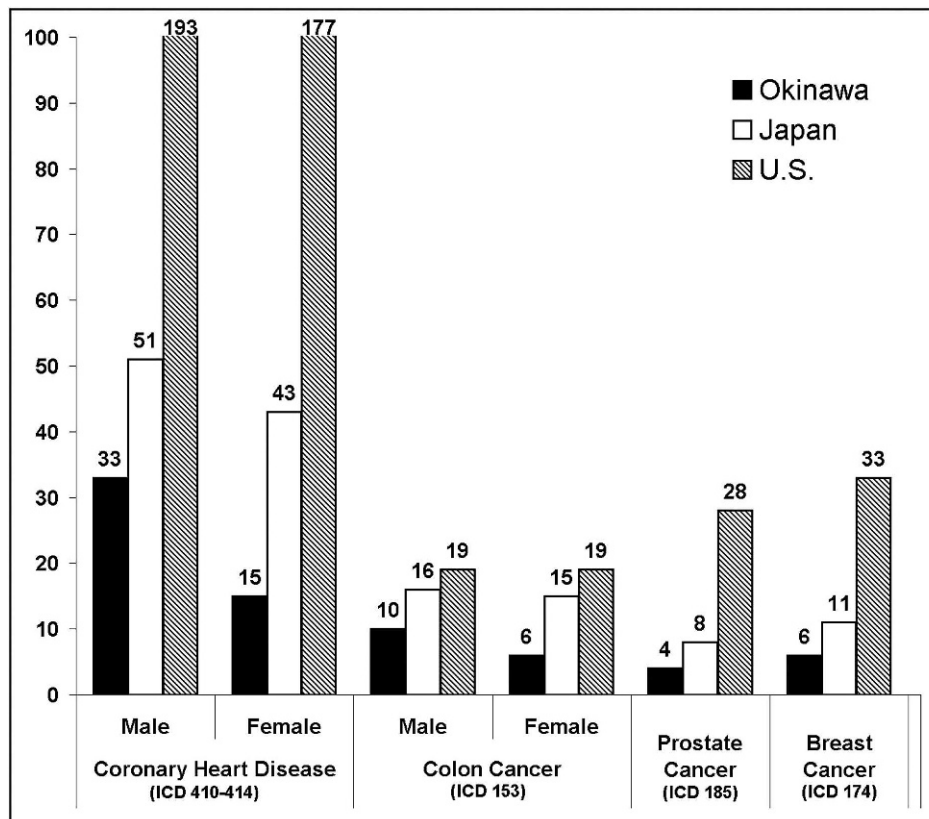


Fig. 1. Mortality rates from coronary heart disease and cancers in Okinawans, Japanese, and Americans [1].

Northeast-to-Southwest gradient in longevity, whereby the longest lived of the Japanese are those that inhabit the southernmost islands, known as the Ryukyu Islands (or Okinawa prefecture). Also known as the 47th prefecture of Japan, the citizens of Okinawa have the longest life expectancy within Japan (and likely the world), mainly because they avoid or delay major age-associated diseases such as cancer, heart disease, stroke, and diabetes (Fig. 1) [28].

Much of the longevity advantage in Okinawa is thought to be related a healthy lifestyle; this includes the traditional diet [29], which is low in calories yet nutritionally dense, particularly with regard to vitamins, minerals, and phytonutrients in the form of antioxidants and flavonoids [1]. However, dietary change since World War II has been largely deleterious, with younger Okinawans developing a higher risk of obesity and other chronic disease risk factors [30,31] versus older Japanese. As a consequence, there has been a resurgence of interest from public health professionals in the health-enhancing effects of the traditional Okinawan diet and a movement to re-educate younger persons in eating the traditional “Okinawa way.”

Insight into what constitutes the traditional Okinawan diet can be gained by examining the contents and cooking style of a traditional Okinawan meal. This would typically begin with

Okinawan-style miso soup (water, miso paste, seaweed, tofu, sweet potato, and/or green leafy vegetables). The staple carbohydrate is the sweet potato (not rice, as in the Japanese diet). The main dish is a stir-fried vegetable dish (called *champuru*), which includes such vegetables as bitter melon (*goya*), accompanied by a side dish, such as konbu seaweed and konnyaku. This is typically simmered with a hint of oil, bonito dashi broth (for flavor), and small amounts of fish or boiled pork. Cooking styles center around vegetables and tofu. Smaller servings of fish, noodles, or lean meats with herbs, spices, and a little cooking oil may accompany these staples. *Nbushi* style uses water rich vegetables such as *daikon* (radish), Chinese okra, and pumpkin; seasons them with miso; and simmers them in their own juices. *Irichi* style uses a combination of simmering and stir-frying with less watery vegetables such as burdock, seaweed, dried *daikon*, or green papaya. The meal would be served with freshly brewed *sanpin* (jasmine) tea, occasionally followed with a small amount of locally brewed *awamori* (millet brandy).

As can be deduced from these descriptions of a typical meal, the traditional dietary pattern in Okinawa has the following characteristics:

- 1) High consumption of vegetables,
- 2) High consumption of legumes (mostly soy in origin),

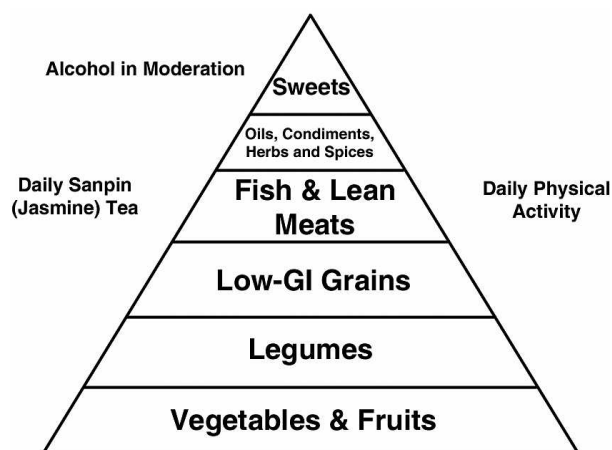


Fig. 2. Traditional Okinawan diet food pyramid.

- 3) Moderate consumption of fish products (especially in coastal areas),
- 4) Low consumption of meat and meat products,
- 5) Low consumption of dairy products,
- 6) Moderate alcohol consumption,
- 7) Low caloric intake,
- 8) Rich in omega-3 fats,
- 9) High monounsaturated-to-saturated-fat ratio, and
- 10) Emphasis on low-GI carbohydrates.

These characteristics are reflected in the food pyramid presented in Fig. 2.

Many of the characteristics of the traditional Okinawan diet are shared with other healthy dietary patterns, such as the traditional Mediterranean diet or the modern DASH diet. Not surprisingly, all three patterns have been found to be cardioprotective [29,32,33], in part because of the low consumption of saturated fat. However, other mechanisms, such as the high contents of phytochemicals, high antioxidant intake, and low GL in these diets, are also likely to be contributing to decreased risk for CVD, some cancers and other chronic diseases through multiple mechanisms, including reduced oxidative stress. A comparison of the nutrient profiles

of the three dietary patterns shows that the traditional Okinawan diet is the lowest in fat intake, particularly in terms of saturated fat, and highest in carbohydrate intake, in keeping with the very high intake of antioxidant-rich yet calorie-poor orange-yellow root vegetables, such as sweet potatoes, and green leafy vegetables (Table 2).

The traditional Okinawan diet has undergone rapid post-World War II Japanization and Westernization, most notably in terms of increased fat intake. There has also been a decrease in carbohydrate quality, with diversification away from the sweet potato as the staple carbohydrate and toward higher consumption of rice and breads (both mostly white) and noodles as carbohydrate sources. This pattern can be witnessed in Fig. 3.

Despite the large increase in fat intake in Okinawa in recent decades, fat intake in the modern Okinawan diet is comparable to that of the DASH diet (at approximately 27% of total daily energy intake) and lower in fat than the traditional Mediterranean diet (42%). Saturated fat still only totals about 7% of total energy intake (versus 6% in DASH and 9% in Mediterranean). Carbohydrate intake (58%) of total calories remains highest (versus 55% for DASH and 42% for Mediterranean) and protein intake falls between the lower Mediterranean (13%) intake and the higher DASH (18%) intake.

Overall, the shared features of the aforementioned dietary patterns far outnumber their differences and include high intake of unrefined carbohydrates (mostly vegetables), moderate to high intake of legumes, emphasis on lean meats and fish, and a healthy fat profile (higher in omega-3 and monounsaturated fats and lower in saturated fat). This is thought to have contributed to low rates of CVD, a decreased risk of certain cancers, and a decreased risk of diabetes and other chronic diseases [1,29,37,38].

A shortfall of East Asian diets in general (and the Japanese diet in particular) has been high sodium content, mainly a result of the high intake of pickled vegetables, soy sauce, miso, and salted fish. Studies support a relationship between higher intakes of sodium and higher rates of cerebrovascular disease [39] and stomach cancer [40,41]. However, salt intake has

Table 2. Estimated Nutrient Composition by Dietary Pattern

	Traditional Okinawa*	Modern Okinawa†	DASH‡	Mediterranean§
Carbohydrate (% kcal)	85%	58%	55%	43%
Protein (% kcal)	9%	15%	18%	13%
Fat (% kcal)	6%	27%	27%	42%
Sat. Fat (% kcal)	2%	7%	6%	9%
Cholesterol (mg/1000 kcal)	—	159 mg	72 mg	75 mg
Sodium (mg/d)	1113 mg	3711 mg	1150 mg	—
Potassium (mg/d)	5199 mg	2155 mg	4700 mg	—

\* Wilcox et al. 2007 [1].

† Okinawa Prefecture, Department of Health and Welfare, Division of Health Promotion, 2007 [34].

‡ Sacks et al. 2001 [35].

§ Kromhout et al. 1989 [36].

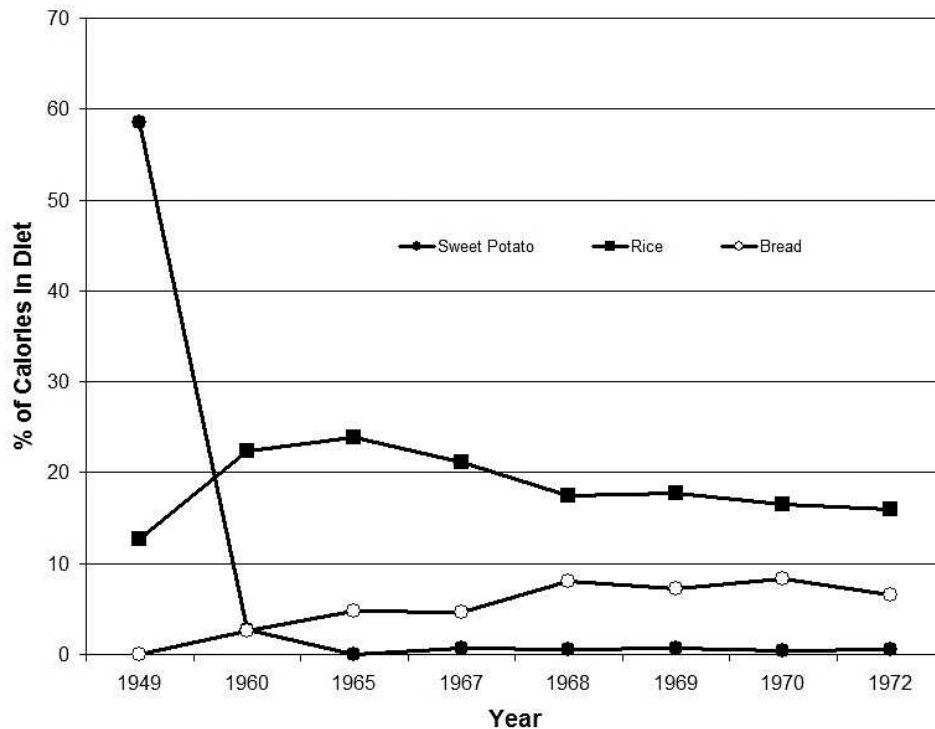


Fig. 3. Post-World War II changes in staple carbohydrate sources in Okinawa [30].

traditionally been much lower in Okinawa (although it is still too high) compared to Japan. Local Okinawan cuisine has strong southern Chinese and Southeast Asian influences (bitter greens, spices, peppers, turmeric), reflecting past participation in the spice trade. This occurred when Okinawa prefecture was an independent kingdom (until 1879) known as the Kingdom of the Ryukyus. Hypertensive effects of high sodium consumption have also been partly attenuated by consumption of vegetables containing antihypertensive minerals such as potassium, magnesium, and calcium, as well as the higher need for sodium when sweating profusely in a hot and humid climate, such as that of subtropical Okinawa.

### The Antioxidant-Rich, Low-GI Sweet Potato

Another benefit of the traditional Okinawan diet is the emphasis on the antioxidant-rich, low-GI sweet potato (*Ipomoea batatas*) as the staple carbohydrate. The sweet potato is a dicotyledonous plant that comes from the family Convolvulaceae. There are more than 50 genera and more than 1000 species in this family, but only *Ipomoea batatas* is a commonly grown root vegetable crop that is widely distributed around the world. The young sweet potato leaves and shoots (known as *kandaba* in Okinawa) are sometimes eaten as greens and often added to miso soup or served as side dishes (mixed with other vegetables) in traditional Okinawan cuisine. Although only distantly related to the potato, which is actually

from the Dioscoreaceae family, the sweet potato is commonly confused with (and called) the “yam” in North America.

As recently as a half century ago, the sweet potato was known as a “poor farmer food” and eaten en masse by necessity, rather than by choice (the upper classes preferred rice). First introduced through trade with China 4 centuries ago, sweet potatoes have become increasingly recognized as a powerfully nutritious food that is helpful in the prevention of chronic disease, with endorsements coming from the American Cancer Society, the American Heart Association, and the Center for Science in the Public Interest, among others. In fact, the Center for Science in the Public Interest has even ranked the sweet potato as the most nutritious of all vegetables, mainly for its content of dietary fiber, naturally occurring sugars, protein content, vitamins A and C, potassium, iron, and calcium, as well as its low amounts of fat (especially saturated fat), sodium, and cholesterol.

Interestingly, what the typical American diet lacks in nutrients (particularly potassium, magnesium, vitamin C, and carotenoids) and fiber seems to be what the sweet potato contains in abundance (Fig. 4). The nutrient deficiencies experienced by many American adults could be largely made up by supplementing the American diet with readily available sweet potatoes commonly raised in the southern United States. Moreover, sweet potatoes also have been utilized as functional foods (traditional medicines) throughout Japan for many years, as will be explained later.



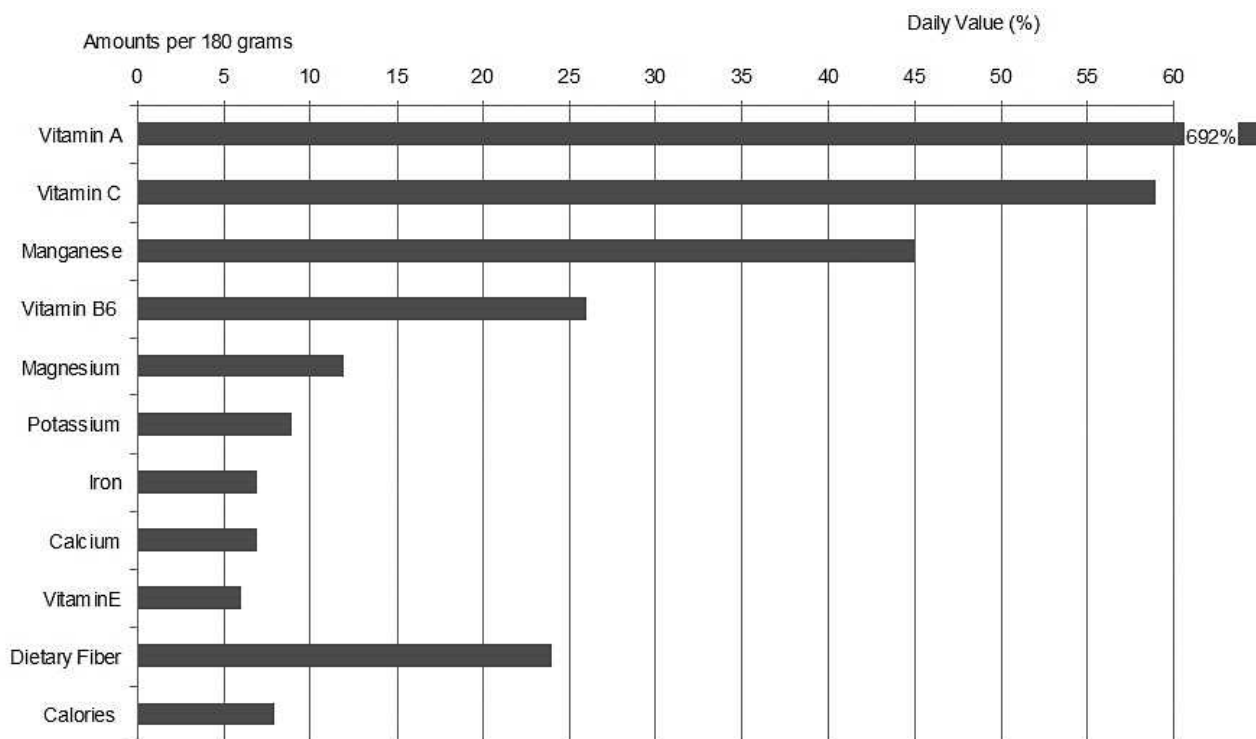


Fig. 4. Nutritional composition of sweet potato as a percentage of daily values [42].

Varieties of the Okinawan sweet potato range in flesh color from yellow-orange to purple-red, and recent research has revealed impressive free radical-scavenging abilities. Sweet potatoes contain root storage proteins, such as trypsin inhibitors, that have significant antioxidant capacities that rival even those of glutathione, one of the body's more potent endogenous antioxidants [43]. Other studies have shown that certain polyphenols (such as 4,5-di-O-caffeoyldaucic acid) contained in sweet potatoes show greater antioxidant activity than such antioxidant standards as l-ascorbic acid, tert-butyl-4-hydroxy toluene, and gallic acid [44]. Anthocyanins from an extract of the tuber of purple sweet potato (*Ipomoea batatas* cultivar Ayamurasaki) have shown stronger radical-scavenging activity than anthocyanins from red cabbage, grape skin, elderberry, or purple corn, and eight major components have shown higher levels of antioxidant activity than ascorbic acid [45]. Polyphenols from the leaves of sweet potatoes have also been shown to suppress the growth of human cancer cells [46].

Moreover, as an excellent source of antioxidant vitamin A (in the form of beta-carotene) and a good source of antioxidant vitamins C and E, sweet potatoes are, overall, potent food sources of free radical quenchers. As shown in Fig. 4, some varieties of sweet potatoes contain many times the daily recommended value of vitamin A. For example, one large baked sweet potato commonly available in North America (the so-called "yam") contains almost 700% of the USDA daily value of vitamin A in the form mostly lacking in the American

diet (carotenoids). It is little wonder that consumption of orange-fleshed sweet potatoes is being touted for the significant role that sweet potatoes can play in developing countries as a viable long-term food-based strategy for controlling vitamin A deficiency in children [47]. Moreover, vitamin E, as a fat-soluble vitamin, is found mainly in high-fat foods, such as oils or nuts; however, the sweet potato is rare in that it provides vitamin E without the accompanying extra fat and calories. Since these nutrients are also anti-inflammatory, they may be helpful in reducing the severity of conditions in which inflammation plays a role, such as asthma, osteoarthritis, and rheumatoid arthritis, or more notably, chronic age-associated diseases such as atherosclerosis, diabetes, and CVD. Indeed, recent research has shown that the sweet potato has significant anti-inflammatory properties [48].

In addition, sweet potatoes are a good source of B vitamins, such as thiamine, riboflavin, and vitamin B6 in particular, the latter of which is needed to convert homocysteine into harmless cysteine. Since high homocysteine levels have been shown to be associated with an increased risk of CVD, it is noteworthy that both homocysteine levels and CVD mortality have been shown to be particularly low in Okinawa [49].

Sweet potatoes have also been consumed in Japan for many years as a folk remedy for anemia, hypertension, and diabetes. Building upon this folk knowledge base, Japanese scientists have made use of extracts of sweet potato for a variety of medicinal purposes. For example, *Caiapo* (white skinned

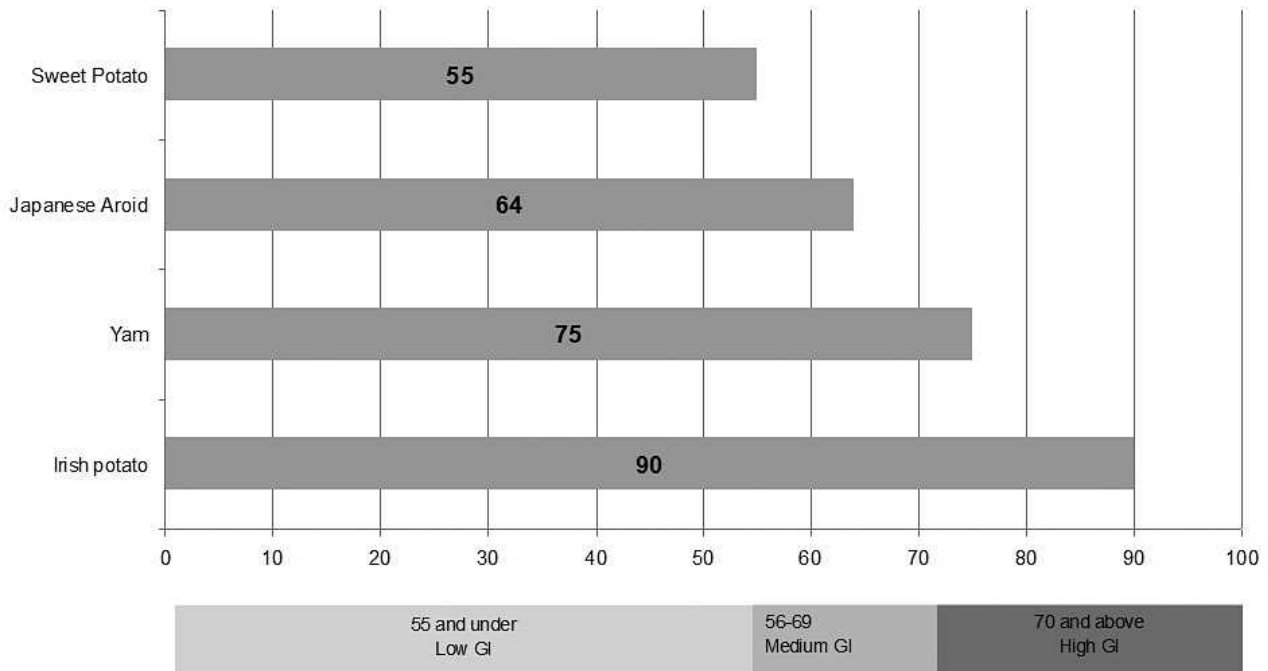


Fig. 5. GI of *Satsuma Imo* (sweet potato) and other potatoes [52].

sweet potato) is sold commercially in Japan without medical prescription as a nutraceutical for the prevention and care of type 2 diabetes. Studies of extracts from the peel of white-skinned sweet potatoes have revealed that this sweet potato has the ability to lower blood glucose by increasing insulin sensitivity without affecting insulin secretion [50]. Beneficial effects of sweet potato on glucose and glycosylated hemoglobin control in diabetic patients are also accompanied by increased levels of adiponectin and a decrease in fibrinogen [48]. Research has also confirmed the beneficial effects of sweet potato on cholesterol levels (total and low-density lipoprotein [LDL]) in patients with type 2 diabetes [51]. Although randomized, placebo-controlled clinical trials are necessary, preliminary research seems to support many of the traditional Japanese medical folk uses of the sweet potato, revealing it to be a natural insulin sensitizer with potential anti-atherogenic and anti-inflammatory properties.

Finally, the GI of the sweet potato ranges from low to medium, depending upon the specific variety of sweet potato as well as the method of preparation (Fig. 5). The most commonly consumed variety of sweet potato in Okinawa, the *Satsuma Imo*, has a GI of 55 (Fig. 5).

## OTHER “FUNCTIONAL FOODS” IN THE TRADITIONAL OKINAWAN DIET

The traditional Okinawan diet has been receiving increasing attention for its health-promoting properties, and a number of studies are being undertaken on the specific components of

the diet and how they affect health status in vitro and in vivo and recently in human clinical trials. The distinction between food and medicine blurs in Okinawa, with commonly consumed “herbs” such as *fuchiba* (mugwort), *kandaba* (sweet potato leaves), *ichoba* (fennel), *aasa* (green seaweed), *ngana* (bitter leaf), and others utilized as both foods and medicine. All contain powerful antioxidants, with high amounts of carotene and other antioxidant properties (*aasa* seaweed has close to 9000 µg of carotene per 100 g). Space limitations preclude an in-depth analysis, but a brief review of some of this interesting work appears below. We have chosen low-GI “functional foods” from the traditional Okinawan diet that are of low caloric density and high nutrient density and that are currently being explored for their potential health benefits in terms of weight control, diabetes prevention and care, and prevention or treatment of other chronic diseases such as cancer or CVD.

### Flavonoid-Rich Tofu and Other Soy Foods

The high legume content in the traditional Okinawan diet is mostly in the form of soy products, and this may be another important factor in the health and longevity of Okinawans. In the traditional diet, soy was the main source of protein, and older Okinawans have arguably consumed as much or more soy in the form of miso soup and tofu than any other population. Our studies show that they eat an average of three ounces of soy products a day, mostly in the form of tofu and miso (soy paste) (unpublished data). Soy is rich in flavonoids, which have antioxidant-like effects, among other health-

promoting properties. The tofu in Okinawa is lower in water content than the Japanese version and higher in healthy fat and protein. This not only increases the flavor of the tofu but also increases the isoflavone content, which may possibly be connected to the extremely low rates of breast and prostate cancer in Okinawa.

**Potential Health Benefits.** Clinical studies have shown that ingestion of soy proteins can reduce risk factors for CVD. This led to the approval of the food-labeling health claim for soy proteins in the prevention of coronary heart disease by the U.S. Food and Drug Administration in 1999. Bearing out these claims, meta-analyses of randomized controlled trials have shown that soy isoflavones can indeed lower serum total and LDL cholesterol in humans [53]. However, evidence for other health claims for soy isoflavones, such as the ability to lessen vasomotor symptoms of menopause or soy's ability to slow postmenopausal bone loss, has been encouraging but less conclusive. Intriguing observational evidence comes from Japan, where soy consumption is high and women have been reported to experience minimal menopause problems and much lower death rates from breast and other hormone-dependent cancers compared to Westerners. However, despite the encouraging ecological evidence and the generally positive results from observational and epidemiological studies indicating that soy food intake reduces breast cancer risk in women [54], the efficacy and safety of soy isoflavones for preventing or treating cancer of the breast, endometrium, and prostate is still under study [55]. While we await more evidence regarding soy isoflavones, there does seem to be strong consensus that soy foods are of potential benefit to cardiovascular and overall health because of their high content of polyunsaturated fats, fiber, vitamins, and minerals and low content of saturated fat [55]. Moreover, recent exciting research in the lab has shown that enzymes from fermented soy (*natto*) may help prevent the buildup of certain plaques in the brain linked to Alzheimer's disease [56]. Finally, soy rates low on the GI, which helps regulate blood sugar and insulin fluctuations.

### Goya (*Momordica charantia*)

In Okinawa, bitter melon is known as *goya*. Goya is a unique-looking gourd, shaped like a cucumber but possessing a rough, pockmarked skin. Goya is a mainstay of Okinawan cuisine. It is used in salads (raw or cooked), stir-fried dishes, sandwiches, tempura, as juice and tea, and even in goya burgers and goya rings at fast food restaurants. A member of the melon family, goya was probably brought to Okinawa from ancient China during one of the many trade exchanges between the Ryukyu Kingdom and the Ming and Manchu dynasties. It is widely available in North America in Chinese markets or Asian food stores, where it is referred to as *goo-fa* or *ku gua*.

**Potential Health Benefits.** Goya is low in caloric density and high in fiber and vitamin C, and it has been used as a medicinal herb in China, Africa, South America, and India, among other places. Folk medical uses include tonics, emetics, and laxatives, as well as teas for colds, fevers, stomachaches, rheumatic pains, and diabetes. As an alternative therapy, bitter melon has primarily been used to lower blood glucose levels in patients with diabetes mellitus.

Antidiabetic properties include charantin, vicine, and polypeptide-p [57], as well as other bioactive components such as antioxidants [58]. Metabolic and hypoglycemic effects of bitter melon extracts have been demonstrated in cell cultures and animal and human studies; however, the mechanism of action, whether it is via regulation of insulin release or altered glucose metabolism and its insulin-like effect, is still under debate [57]. Antiviral (including human immunodeficiency virus) and anticancer activities have also been reported in vitro [59]. Adequately powered, randomized, placebo-controlled trials are needed to properly assess safety and efficacy before bitter melon can be routinely recommended [60].

### Konnyaku (*Amorphophallus konjac*)

Konnyaku is a traditional Japanese jelly made from a yamlike tuber known as *devil's tongue* that likely originated in China, Indochina, or Southeast Asia. It is an ancient food, attested to by references to it in the *Wamyouruijou*, an old Japanese dictionary that first appeared about 1100 years ago (930 AD). Konnyaku lacks flavor but it readily absorbs the flavors of other ingredients in simmered dishes. The flour derived from this Japanese root has become the key ingredient in konnyaku jelly. It is also packaged as small, dense, gelatinous cake and as thick or thin noodles. Reflecting its high fiber content, Okinawans say that konnyaku "cleans your stomach."

**Potential Health Benefits.** Konnyaku is extremely low in calories, high in fiber and calcium, and contains practically no fat, making it an ideal food for weight control. Konnyaku is more than 90% water, and the rest is glucomannan, making it an effective treatment for constipation [61] and a beneficial adjunct dietary therapy for high cholesterol [62,63] and type 2 diabetes (because of its positive effects on blood sugar) [64].

### Shiitake Mushroom (*Lentinus edodes*)

The shiitake is a large, dark brown, umbrella-shaped mushroom widely used for centuries by Asian cultures. Shiitake mushrooms are still a major dietary staple in some parts of China and were once considered a very important source of protein in Japan and other parts of East Asia. In Okinawa, they are often dried, beautifully wrapped, and given as gifts. Dry shiitake mushrooms are ideal ingredients for any



low-fat, low-calorie, healthy dish, as they have practically no calories but are high in protein (containing all 8 essential amino acids), fiber, antioxidants, and vitamins A, niacin, B12, C, and especially vitamin D, a nutrient often lacking in the diets of older Americans.

**Potential Health Benefits.** Shiitake mushrooms appear to have immunomodulatory [65], lipid-lowering [66], antitumor [67], and other beneficial or therapeutic health effects. One of shiitake's constituents is a polysaccharide called lentinan. A highly purified, intravenous form of lentinan is approved for use in Japan as an anticancer drug and has been reported to increase survival for patients with stomach or pancreatic cancer, particularly when used in combination with chemotherapy [68,69]. Because of their potential usefulness in preventing or treating serious health conditions such as cancer and hypercholesterolemia, functional mushrooms deserve more serious investigation [70].

### Gobo (*Arctium lappa*)

Gobo (burdock) is a slender root vegetable with a rusty brown skin and grayish-white flesh that is high in iron, with a sweet, earthy flavor. It is also a popular folk medicine in Okinawa and many parts of the world, renowned as a "blood purifier." Burdock is a member of the *Chrysanthemum* family, whose more familiar members include lettuce, artichoke, sunflower, chamomile, and marigold, among others.

**Potential Health Benefits.** Burdock root is low in caloric density and is high in two kinds of fiber: inulin and a spongy fiber called mucilage, which is a thick, glutinous substance related to the natural gums and used in medicine as an emollient. Inulin extracted from edible burdock has also shown probiotic properties that could promote health by increasing beneficial bacteria in the gut [71]. These properties may help explain burdock's purported soothing effects on the gastrointestinal tract. The high fiber content also explains its popularity as a diet aid in Korea, where raw burdock is cut into thin strips and marinated in vinegar before eating. Although the efficacy of the "burdock and vinegar diet" is yet to be tested, the beneficial effects of fiber on weight loss are well documented. Burdock has also been shown to reduce liver damage in animal experiments [72]. The protective mechanism of burdock could be attributed, at least in part, to its antioxidant properties, which decrease the oxidative stress of hepatocytes, or to other unknown protective mechanisms.

### Hechima (*Luffa cylindrica*)

Hechima, part of the gourd family, was introduced to Okinawa more than 3 centuries ago and is closely related to *Luffa actangula*, which is consumed in Hawaii and parts of

Southeast Asia. People in mainland Japan do not eat much hechima, but they do use its dried outer core as a body or dish scrubber—which is mostly likely why it is also known as "dishcloth gourd." It is usually served with Okinawan tofu in a miso sauce and called *nabera* in the local dialect. It is a very low-calorie vegetable that is high in vitamin C, folate, carotenoids, and some very interesting proteins that could have important health consequences.

**Potential Health Benefits.** Folkloric health claims for hechima center on cancer prevention and its reputation as an immune booster. Indeed, extracts from the gourd family (*Cucurbitaceae* plants, including green and yellow squash) may contain one or more of eight distinct but related proteins that have anticancer, antiviral, and immune-enhancing properties [73,74]. There are more than 20 studies on hechima's special proteins alone, which are called luffin proteins [75].

### Seaweeds

Seaweeds have been a dietary staple in Okinawa, Japan, China, and other parts of Asia for millennia. "Seaweed" is actually a loose colloquial term encompassing macroscopic, multicellular marine algae. The term includes red, brown, and green algae. More than a dozen varieties, including *konbu*, *aasa* (*laver*), *mozuku*, *suunaa*, *hijiki*, *wakame*, *shinomata*, *nori*, and *gaana*, make up an indispensable part of Okinawan cuisine. Seaweeds may harbor medicinal properties, as they have been used to treat arthritis, colds, flu, and even cancer (although most of these claims have yet to be substantiated in clinical trials). The varieties used most in Okinawan cuisine are *kombu*, *mozuku*, *wakame*, *hijiki*, and *aasa*. Along with *katsubushi* (shaved dried bonito), *kombu* is one of the two basic ingredients used for *dashi* (soup broth). *Mozuku* is another brown seaweed that is enjoyed throughout Japan. It is extensively farmed in Okinawa by simply implanting the hypha on a net and then spreading the net over the coral reef on the seabed. It is eaten mainly with vinegar, in noodle dishes, with rice, or as jelly. *Wakame* is a kelp that is blackish in color and leafy and mild in flavor that turns green after soaking. In Okinawa it is traditionally added to miso soup along with tofu, or found in soba noodle dishes, in salads, with other vegetables (hot or cold), and in stir-fried or rice dishes. *Hijiki* is black in color and has a bittersweet taste that some have likened to anise. It comes in short match-size strips. Okinawans like it simmered with vegetables, whole soybeans, and *okara* or as an ingredient in tofu burgers. *Aasa*, or *laver*, is yellow-green and grows on rocks along the tide line on most Okinawan beaches. Gathering the seaweed and storing for later use in soups and tempura dishes is a common weekend activity in Okinawa.

**Potential Health Benefits.** Seaweeds are very low in caloric density; nutrient-dense; high in protein, iodine, folate,

magnesium, iron, calcium, and carotenoids; and contain significant antioxidant capabilities. They represent much untapped potential for therapeutic interventions and the development of new and useful nutraceuticals. For example, in animal models, a seaweed carotenoid, fucoxanthin, has been shown to have multiple beneficial effects on metabolism, significantly reducing blood glucose and plasma insulin levels, increasing the level of hepatic docosahexaenoic acid, and attenuating weight gain, representing a potential dietary intervention for metabolic syndrome [76]. Astaxanthin, a xanthophyll carotenoid, is a powerful, broad-ranging antioxidant from microalgae that also occurs naturally in a wide variety of living organisms such as fungi, complex plants, and crustaceans. Results from multiple species support the antioxidant/anti-inflammatory properties of astaxanthin as a novel potential candidate for development as a therapeutic agent for cardiovascular oxidative stress and inflammation [77]. Fucoidan is a sulfated polysaccharide found mainly in various species of brown seaweed such as kombu, wakame, mozuku, and hijiki. Ongoing research on fucoidan has focused primarily on two distinct forms: F-fucoidan, which is >95% composed of sulfated esters of fucose, and U-fucoidan, which is approximately 20% glucuronic acid. Both U-fucoidan and F-fucoidan are marketed as nutraceuticals in Japan and other nations for their free radical-quenching capabilities [78] and other health-enhancing potential. For example, it may have anticancer properties. A study by Japanese researchers showed that F-fucoidan can induce apoptosis in human lymphoma cell lines [79], and other studies have shown it can inhibit hyperplasia in animal models [80]. The algal and invertebrate polysaccharides are also potent anticoagulant agents of mammalian blood and represent a potential source of compounds for antithrombotic therapies [81].

## TRADITIONAL HERBS AND SPICES

Although the USDA recommends cutting fat, salt, and sugar from the diet for health reasons, this is extremely difficult for most people. All three provide flavor and/or add texture to a meal. One substitute can be herbs and spices. The Okinawans have many favorite herbs, spices, and flavorings in their cuisine that not only provide enhanced taste to foods but have medicinal properties as well. Most have long been used in traditional Chinese or Ayurvedic medicine, both of which have influenced Okinawa throughout the centuries. Many of the traditional herbs and spices contain specific phytochemicals, such as antioxidants and phenolic acids, including tannic, gallic, caffeic, cinnamic, chlorogenic, ferulic, and vanillic acids. Although most of the health claims for these herbs and spices have been drawn from traditional Okinawan folk medicine practice and are untested at this point, the health

benefits of others have been proven in the lab or even in clinical trials. We will discuss some of the more promising herbs and spices in the following.

### Ucchin (*Curcuma longa*)

Turmeric, or *ucchin*, is an herb that every Okinawan is intimately familiar with. Many drink it as a tea and others take it in tablet form to “strengthen the liver,” especially when drinking alcohol (for hangover prevention), but most simply use it in their cooking as a spice for curries, soups, or fish. Its orange-yellow color is derived from curcumin, which gives yellow curries their distinctive hue. Originally from India, turmeric belongs to the ginger family and was likely brought to the Ryukyu Kingdom (Okinawa) through the spice trade. Ayurvedic medicine uses turmeric for a wide variety of diseases and conditions, including those of the skin, pulmonary, and gastrointestinal systems, and for pain, wounds, and liver disorders. Turmeric seems to have become as indispensable to the Okinawan cuisine and apothecary as it is in India. A review of its potential health benefits will explain why.

**Potential Health Benefits.** Turmeric has long been regarded for its folk medicinal properties, especially by traditional medical practitioners; later researchers from India confirmed that it has significant anti-inflammatory actions [82–84]. Turmeric has also shown significant antimicrobial ability [85], which is no doubt one reason that it has been used for centuries to treat infections and wounds as well as associated pain and inflammation. Turmeric has been shown in some studies to be as effective as treatment with nonsteroidal anti-inflammatory drugs (NSAIDs), the usual treatment for pain associated with rheumatologic disorders such as rheumatoid arthritis, osteoarthritis, and postoperative pain. Turmeric even appears to be able to protect the stomach’s mucosal layer against NSAIDs, which are notorious for promoting bleeding of the stomach, one of the major side effects of these medications.

Numerous other potential benefits have been reported, not the least of which include significant antioxidant capacities [86], which may also be related to its purported anticancer effects. Turmeric appears as a potential blocker of cancer cell growth both in vitro and in vivo [87–89]. The activity of curcumin reported against leukemia and lymphoma, gastrointestinal cancers, genitourinary cancers, breast cancer, ovarian cancer, head and neck squamous cell carcinoma, lung cancer, melanoma, neurological cancers, and sarcoma reflects its ability to affect multiple targets [90].

However, cancer is not the only chronic disease for which turmeric holds promise. Dietary components of turmeric, such as curcumin, which inhibits inflammation and amyloid beta oligomerization and consequently increases apoptosis, are of

particular interest with respect to chronic inflammatory response, brain injury, and beta-amyloid-associated pathology in Alzheimer's disease; curcumin has emerged as a candidate in this regard [91]. Not only does curcumin serve as an antioxidant, but it also appears to be a strong inducer of the heat-shock response [92]. Food supplementation with curcumin is therefore being considered as a novel nutritional approach to reduce oxidative damage and amyloid pathology in Alzheimer's disease [92]. While the efficacy and safety of turmeric still needs to be confirmed in interventional, placebo-controlled trials before it can officially be recommended for specific medical purposes, preliminary evidence is promising and worthy of serious attention for several age-associated diseases.

### **Fuchiba (*Artemisia vulgaris*)**

In the past in Okinawa, fuchiba was one of the only readily available treatments for stomach ailments. Fuchiba is known in the West as mugwort and is usually available in liquid or tea form, as well as a dried herb for cooking. Mugwort is frequently used in Okinawan cooking in vegetable pilaf dishes, teas, and fish and other soups; and it gives a fresh spring scent to almost any recipe. Its leaves are dark green in color and it smells a little bit like rosemary. In addition to a medicine for upset stomachs, mugwort also has been used as an herbal therapy for strengthening the liver. Both claims need to be more rigorously scientifically tested.

**Potential Health Benefits.** Fuchiba has very high levels of carotene (upward of 9000 µg/100 g). Folkloric claims include efficacy in treating multiple conditions, such as respiratory ailments, gout, kidney stones or gallstones, infections, gastritis, tuberculosis, and wounds, among others. Roots from mugwort appear to have sedative effects; they are used in traditional Chinese medicine to treat neuroses, depression, irritability, restlessness, insomnia, and anxiety. More than 100 studies have been done on mugwort, many of them supporting its folk uses. One recent study supported the traditional use of *Artemisia* as a stomach protector with regard to ethanol-induced gastric damage in rats [93]. However, among the best evidence for the *Artemisia* class of plants, of which mugwort is a member, is for the treatment of infectious disease, such as malaria [94,95]. Chemically active components are found in its seeds, fresh roots, and leaves that are in the same class of compounds—flavonoids—as are found in ginkgo biloba, green tea, and soy and soy products. Animal experiments with aqueous extract of *Artemisia vulgaris* have resulted in a significant increase in blood glutathione levels, superoxide dismutase activity, and serum ascorbic acid levels, indicating that an aqueous extract of *Artemisia vulgaris* is a potentially powerful source of natural antioxidants [96].

### **Hihatsu (*Piper hancei*)**

The Okinawan pepper can be dried and ground to sprinkle on food and is a prime ingredient in the hot, spicy dishes that came to Okinawa from southern China. The leaves of the plant are also used in tempura dishes, and the herb can often be found in the apothecaries of Okinawan herbalists.

**Potential Health Benefits.** In Okinawan herbal medicine, *hihatsu* has been used to treat stomach problems and gout, among other ailments. Ayurvedic medicine frequently uses peppers, such as *hihatsu*, to “increase metabolism.” There has been some preliminary research support for red peppers' ability to increase oxidation of carbohydrates at rest and during exercise in runners [97] and some exploration of the effects on energy metabolism of adding red pepper to high-fat diets and high-carbohydrate meals in Japanese women [98]. Hot peppers are a good source of dietary antioxidants, encompassing, in addition to widespread compounds (flavonoids, phenolic acids, carotenoids, vitamin A, ascorbic acid, tocopherols), more specific constituents, such as the pungent capsaicinoids (capsaicin, dihydrocapsaicin, and related analogues), which have shown remarkable antioxidant activity and the ability to protect linoleic acid against free radical attack in simple in vitro systems, inhibiting both its auto-oxidation and its iron- or ethylenediaminetetraacetic acid-mediated oxidation [99].

### **Ichoba (*Foeniculum vulgare*)**

Ichoba (also known as fennel) is a tall, hardy, aromatic perennial of the parsley family, and it has been traditionally used in Okinawa both as a vegetable and an herbal medicine. It has also been a popular herb in Europe since ancient times. The Romans called this native Mediterranean plant *foeniculum*, which means “fragrant hay.” Often confused with dill, the stalk looks something like celery. “Fennel seeds,” which are served after dinner in Indian restaurants, much like mints are in the West, are actually the dried fruit of the common fennel. Anise, dill, cumin, and caraway all belong to the same plant family, *Apiaceae*, and have very similar shapes and scents.

**Potential Health Benefits.** Fennel “seeds” have a traditional reputation as an aid to weight loss and longevity. In the Greek legend of Prometheus, fennel granted its user immortality. In Okinawa, ichoba has been used to treat sore throats, colds, and fevers as well as for upset stomach, heartburn, and gas. There may be some basis in Western science for the latter, as fennel has been shown to contain terpenoids in its volatile oils, which inhibit spasms in smooth muscles such as the intestinal tract [100]. This is most likely one of the reasons that this “herb” was formerly classified as an official drug in the United States and listed for use in cases of indigestion [101]. The fruit of ichoba (*Foeniculum vulgare*)

has also been found to exhibit strong anti-inflammatory, analgesic, and antioxidant activities [102].

## A CULTURAL MODEL OF HEALTHY EATING FOR HEALTHY AGING

### Improving Cardiovascular Health

CVD, mainly coronary heart disease and stroke, constitute the most common cause of death in North America. Over half of older Americans (age 65 and beyond) experience arterial stiffening to the degree that it leads to the development of isolated systolic hypertension, a serious risk factor for stroke, coronary artery disease, heart attack, heart failure, and dementia. Risk factors that reflect the health of the arteries, such as cholesterol levels, homocysteine levels, blood pressure, and oxidative stress, are important indicators of CVD risk.

Some of the foods in the Okinawan diet that may be contributing to improved cardiovascular risk factors are phytonutrient-rich foods such as vegetables and legumes. As discussed previously, these foods contain properties that are proving to be important to heart health such as the antioxidant vitamins A, C, and E, anthocyanins and other polyphenols, carotenoids, flavonoids, and more. A recent analysis of the antioxidant activity of vegetables from Okinawa prefecture found high contents of phenolic compounds and strong radical-scavenging activities in many traditional Okinawan vegetables [103]. Carotenoids are found mostly in the brightly colored yellow, orange, and green vegetables that are plentiful in Okinawa. The beta-carotene in carrots and orange sweet potatoes and the lycopene in tomatoes, watermelon, and possibly Okinawan sweet potatoes are the best known of the more than 600 carotenoids. Flavonoids are antioxidant and hormone-like plant compounds that exist in more than 4000 varieties. They are found in soy foods, onions, broccoli, and red wine, and in green, black, and oolong teas, among other foods. Healthy omega-3 fat, found in fish and soy oil, is also an important part of the Okinawan diet, and like the other components mentioned, has been shown in well-conducted studies to play an important role in cardiovascular health.

The importance of these food components in the diet for reducing cardiovascular risk factors has been borne out in recent, well-designed clinical trials, such as that by Jenkins et al., who tested a diet similar in nutrient content to the Okinawan elders' diet and dubbed it the "Portfolio Diet" [104]. It consisted of foods available in regular supermarkets, including common vegetables consumed in Okinawa, such as broccoli, carrots, red peppers, tomatoes, onions, cauliflower, okra, and eggplant. Other "functional" foods included whole grains such as oats and barley, vegetable-based margarine, almonds, and soy protein from products such as soymilk, soy sausages, soy cold cuts, and soy burgers.

The study found that when these phytonutrient-rich foods, which are high in fiber, healthier fats, and soy, were mixed into the diet, LDL cholesterol was reduced by nearly 30% [104]. This finding suggests that a combination of LDL-lowering dietary strategies (e.g., fiber, flavonoids, stanols, vegetable protein) may have additive effects when combined in a healthy diet. This approach proved as effective as statins, which have been the standard drug therapy for high cholesterol for the last couple of decades. A host of other benefits became apparent, too, including lower inflammation (C-reactive protein levels) and weight loss.

Similar reduced risk factors for CVD and diabetes were achieved in a natural experiment by Walford et al. over the first 6 months of the Biosphere 2 Study when subjects ate a "calorically restricted" diet similar to the traditional Okinawan diet. Male subjects lost an average of 18% of their body weight; the women lost 10%. Blood pressure fell 20% on average. Indicators for diabetes, such as blood glucose and insulin levels, decreased by 30% on average, and cholesterol levels fell from an average of 195 to 125 [105].

Interestingly, local researchers (led by Todoriki and his "Champuru Study" team) have recently been carrying out clinical intervention trials utilizing common Okinawan vegetables such as *goya* (*Momordica charantia*), green papaya (*Carica papaya*), *handama* (*Gynura bicolor*), *karashina* (*Brassica juncea*), *njana* (*Crepidiastrum lanceolatum*), *fuchiba* (*Artemisia vulgaris*) and *fundanso* (*Beta vulgaris*), in an attempt to further explore the health promoting properties of the traditional diet in an evidence-based manner. Results so far have been impressive and have revealed that increasing consumption of such vegetables, commonly consumed in the traditional dietary pattern, can increase potassium excretion [106] in normotensive healthy young women as well as raise levels of circulating endothelial progenitor cells [107]. Circulating endothelial progenitor cells are known to play an important role in maintaining the integrity of vascular vessels as well as correlate with atherosclerotic risk factors. Accordingly, changes in the endothelial progenitor cells in these young women also inversely correlated with changes in both serum total cholesterol and LDL cholesterol level. Serum folic acid increases and plasma homocysteine decreases were also observed [107].

### Key Indicators of Healthy Aging

Many hormones decline with advancing age. Interestingly the sex hormones and their precursor hormone (dehydroepiandrosterone [DHEA]) appear to decline more slowly in "calorically restricted" monkeys, highlighting the intimate link between diet and healthy aging [108]. In fact, dietary caloric restriction (CR) is the only experimental intervention conclusively and reproducibly shown to slow aging in mammals. Biomarkers of slower aging in animal models



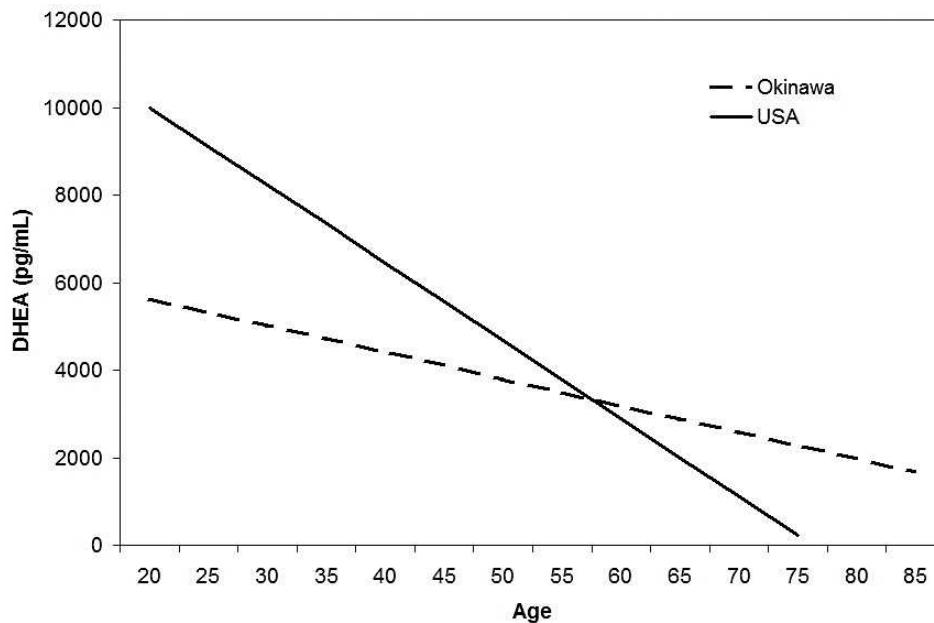


Fig. 6. Trajectories of decline in DHEA levels (ng/mL) with age in Okinawans and Americans [1].

include lower plasma insulin levels and greater sensitivity; lower body temperatures; reduced cholesterol, triglycerides, blood pressure, and arterial stiffness; elevated HDL; and slower age-related decline in circulating levels of DHEA. Collectively, these biomarkers suggest that CR animals (including primates) will be less likely to incur diabetes, cardiovascular problems, and other age-related diseases and may in fact be aging more slowly than their fully fed counterparts.

Evidence from the few human studies of CR also suggests decreased metabolic, hormonal, and inflammatory risk factors for diabetes, hypertension, CVD, and cancer. Humans on CR also show some of the same adaptations that are thought to be involved in slowing aging in animal models. These include a very low level of inflammation, lower fasting insulin levels, and lower body temperatures, among others [109,110]. Data from the Baltimore Longitudinal Study of Aging also support the association between longevity and DHEA(S) levels, with those subjects who exhibited slower age-related DHEA declines having a better chance of living longer than those with a rapid decline [111].

In studies in rhesus monkeys, the DHEA levels of the monkeys who had their calories restricted (equivalent to the difference between Okinawans and Americans) declined at a much slower rate than those in their fully fed counterparts [112]. Although no similar study has been done in humans, we compared DHEA levels in older Okinawans as part of our centenarian study (Fig. 6) and found that older Okinawans appear to have higher DHEA levels than older Americans [1]. This provides suggestive evidence that the Okinawans have aged more slowly. Interventional studies would be required to substantiate this observation.

### The Traditional Okinawan Diet Appears to Be Highly Anti-Inflammatory

Increasing evidence implicates inflammation as playing a key role in the chronic diseases of aging, such as coronary heart disease, cancer, stroke, diabetes as well as in the aging process itself [113]. Reducing inflammation decreases damage to DNA, proteins, cells, and tissues. Cutting back on dietary calories seems to be extremely beneficial. The increase in glucocorticoid hormones produced by lower calorie consumption appears to exert anti-inflammatory effects. These hormones are helpful in decreasing the production of cytokines, proteins that function as immune system messengers and can increase the inflammatory response.

Inflammatory proteins have been implicated in a wide array of human diseases, such as coronary heart disease, cancer, stroke, diabetes, and rheumatoid arthritis. However, certain facets of diet have been shown to be able to influence inflammation-related disease, and many seem to be important components of the Okinawan diet. These include low caloric intake and high intake of phytonutrients; omega-3 fats (from certain plants and fish oils); plant-derived antioxidants (trypsin inhibitors, anthocyanins, carotenoids) such as those found in sweet potatoes and/or green leafy vegetables and seaweeds; flavonoids (mostly from legumes such as soybeans); and anti-inflammatory substances found in popular Okinawan herbs and spices such as curcumin from *ukon* (turmeric). The available evidence indicates that the traditional Okinawan diet is highly anti-inflammatory and is also very likely related to the health and longevity of older Okinawans through reduced risk for age-associated disease. Therapeutic implications point to dietary intervention as an integral part of treatment approaches for multiple chronic diseases.



## CONCLUSIONS AND FUTURE DIRECTIONS

Eating the “Okinawa way” is associated with impressive health benefits, including lower risk for obesity, diabetes, and numerous age-associated diseases such as CVD and certain cancers. Moreover, clinical trials of the effects of the traditional Okinawan diet by Todoriki and his “Champuru Study” team have clearly revealed anti-hypertensive effects (and other decreased risk factors for atherosclerotic disease) and suggested strong similarities between the traditional Okinawan diet and the DASH diet. In contrast to diets designed specifically to reduce risk factors for chronic disease, such as the DASH, the Okinawan diet is a naturally occurring cultural dietary pattern. In this feature it shares much in common with the Mediterranean diet, another cultural model of healthy eating. Lifelong adherents to the Okinawan model, wherever they originally hail from, may also be able to share in the same secrets of healthy aging and longevity as Okinawans.

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