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Why and How to Strengthen Indigenous Peoples' Food Systems With Examples From Two Unique Indigenous Communities

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Indigenous Peoples' food systems contain extensive and sophisticated knowledge that is often undocumented and underutilized in contemporary society that has increasingly poor nutrition and loss of food biodiversity. Indigenous Peoples in all global regions are among the most vulnerable to marginalization, food insecurity and chronic disease and will benefit greatly from strengthening their resource-rich food systems to make them more resilient and sustainable. It is in this spirit that we contribute to the databases of Indigenous Peoples' food system knowledge with information on unique traditional foods from the Nuxalk Nation in British Columbia, Canada, and the Pwo Karen People of Sanephong Community, Thailand. Several publications from these case studies originated from interdisciplinary mixed-method research, in part through the United Nations Food and Agriculture Organization. We highlight selected foods with nutrient data and various qualitative and quantitative methods used to identify and promote their use within these unique communities. Our intent is to stimulate complementary strengthening efforts among other traditional and Indigenous Peoples that will contribute to global intercultural food system evidence and advances.

Keywords: Indigenous Peoples, Indigenous food systems, Nuxalk Nation, Karen, traditional food

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INTRODUCTION AND CONTEXT

The food systems of Indigenous Peoples are known to contain a vast tapestry of riches in food biodiversity, nourishment, and the potential to sustain biocultural knowledge, resilience, and sustainability. However, these internationally recognized and outstanding attributes, historically documented in part, are affected by many challenges of globalization that threaten their loss and eventual disappearance (Kuhnlein et al., 2009, 2013a; FAO, 2021; FAO and Alliance of Bioversity International and CIAT, 2021). With the contemporary advent of the 2021 United Nations Food Systems Summit and recent policies that encourage sustainability we highlight the need to address Indigenous Peoples' food system loss, and how communities can proceed to strengthen continuity and sustainability of their cultural food systems' continuity and sustainability and give impetus to improvement of nutrition and health in their communities, for all humanity, and for the planet.

The term "food system" is defined through several international agencies as the foods originating from forestry, fisheries, aquaculture, and crop and livestock production and the interlinked actors and activities for their processing, distribution, consumption, and disposal that shape

human dietary patterns, food security and nutritional status. Food systems are complex and dynamic interactions and synergies of social, economic, and environmental influences (FAO, 2020; USAID-RFS, 2021; von Braun et al., 2021).

In this contribution we refer to a "traditional food system" of an Indigenous People as all foods within the particular culture that are available from local natural resources and culturally accepted, including the sociocultural meanings, acquisition and processing techniques, use, biological composition and nutritional consequences for the people using the food (Kuhnlein and Receveur, 1996). The contribution of nature and culture to a food system form the complete health picture of the individual and the community—the aspects of physical, emotional, mental, and spiritual health, healing, and protection from disease (Kuhnlein, 2009). Since Indigenous Peoples' worldviews differ from mainstream science, their food systems differ from the above in that they are biocentric and intimately tied to nature and spirituality, rather than to linear value chains (FAO, 2021).

Situation

Recent attention to the world's food systems has highlighted the pressing need to address unsustainable food production and consumption (von Braun et al., 2021). Aimed at addressing the 17 Sustainable Development Goals in 2021, the United Nations Food Systems Summit included virtual presence of national leaders and all United Nations agencies to address global hunger, climate change and biodiversity loss. The Summit had mixed reviews with criticism for obvious private sector control of the agenda and results, and the lack of accountability (Globalagriculture, 2021; International Network of Mountain Indigenous People, 2021; SlowFood, 2021); ultimately a solution cluster and a coalition of Indigenous Peoples developed strategies for accountability (Food Systems Summit, 2021).

Indigenous Peoples are among the most severely in need of meeting the Sustainable Development Goals, especially those related to hunger, poverty, wellbeing, inequality, and justice, which are all affected by climate change and unsustainable global food supplies. The UNFAO published two sentinel documents that creatively describe the depth of needs and strengths of Indigenous cultures and food systems: "The White Whipala Paper" (FAO, 2021) and "Indigenous Peoples' Food Systems-insights on sustainability and resilience from the front line of climate change" (FAO Alliance of Bioversity International and CIAT, 2021).

Indigenous Peoples collectively make up about 5% of the global population with more than 476 million people. There are more than 4000 Indigenous languages over the 6700 globally spoken in 90 countries. The collective experience of Indigenous Peoples is from managing 22% of the world's ecosystems and land mass (Kuhnlein et al., 2019). Their vast traditional knowledge systems that include appreciation of this extensive global food biodiversity is linked to historical culture, way of life, identity, and spirituality (Cunningham, 2017). These rich natural treasures can sustain the planet if appropriately recognized, respected, and used. Many cultures of Indigenous Peoples realize four dimensions of health that include physical, social, mental, and spiritual health, all of which are interlinked in many ways with cultural food system practices that include the biodiversity that is foundational to food system resilience.

Over the past 250 years changes in global food production and distribution have driven large-scale dietary transformations. Communities have foods available from distant places, usually through commercial networks and increasingly through complex international food processing and distribution industries. Dietary change has been heightened by migrations to new areas and from rural to urban settings that present new culinary and dietary practices (Pelto and Pelto, 1983). At the same time, the imperative of colonization took precedence in many areas of the world to subjugate and dispossess Indigenous Peoples and disassociate them from their traditional land, culture, linguistic heritage, and identity to profoundly contribute to gaps in food security, health, and wellbeing (Cunningham, 2009; King et al., 2009; Egeland and Harrison, 2013).

Colonization, Dispossession, and Disparities

The impact of environmental dispossession cannot be underestimated. Indigenous Peoples are acutely aware of forced dietary change brought by environmental change creating overexploitation of fish and wildlife stocks, pollution and degradation of lands and waters, urbanization and loss of cultivatable lands, invasive species, and climate change (Turner et al., 2013a; Batal et al., 2021b). Further, disparities for Indigenous Peoples are also created from effects of several social determinants often created by colonization that led to a decline in dietary quality and nutritional health. Warne and Wescott (2019) describes these determinants for American Indians as forced relocation from ancestral lands to reservations that restricted access to traditional food, thereby creating dependence on federal food subsidies, and the forced attendance of children in distant boarding schools. Both promoted historical trauma contributing to poverty, alcohol and substance abuse, and rampant non-communicable disease (NCDs). For Indigenous Peoples the role of the physical environment is inseparable from issues of identity, balance, and life control (Richmond and Ross, 2009), food security and food sovereignty (Expert Panel on the State of Knowledge of Food Security in Northern Canada, 2014; Delormier and Marquis, 2018). Globally, Indigenous Peoples experience similar disparities in contrast to their national population averages that lead to increased obesity and NCDs) in high-income countries, and increased malnutrition and stunting in low and middle-income countries (LMICs; Anderson et al., 2016). The transition driving malnutrition and increasing NCDs can be reversed with more sustainable food systems that provide lifestyle balance in use of biodiverse food resources, increasing energy expenditure, and reducing exposure to high energy but poor nutrient foods and diets (Popkin, 2001; Batal et al., 2017; Swinburn et al., 2019; Popkin et al., 2020).

Effective Policies Are Needed

The World Health Organization is calling for all nations' policies to address their environments to create more healthy food systems and the populations they sustain; these are policies such as improving food security, reducing food marketing to children, and education to develop public consciousness of healthy foods and diets (World Health Organization, 2017). Barriers created by international trade and investment agreement stakeholders, especially in food and beverage markets in the public and private sectors, are described as accelerating the nutrition transition away from healthy food systems (Garton et al., 2021).

Knowledge systems of Indigenous Peoples embrace the use of food resources known and used in the culture, intergenerational wellbeing, traditional knowledge, and preferences to create food security and food sovereignty (Expert Panel on the State of Knowledge of Food Security in Northern Canada, 2014; FAO, 2021). Policies are needed to protect this knowledge and foster its use to promote wellbeing, which is based on the collective five interrelated human rights recognized in international law: the right to food, the right to health, cultural rights, the rights of the child, and the implied right to a healthy environment (summarized in Swinburn et al., 2019). All human rights are especially relevant for Indigenous Peoples as noted in the UN Declaration on the Rights of Indigenous Peoples (United Nations General Assembly, 2007), and protecting these rights is essential for strengthening Indigenous Peoples' food systems.

Strengthening Indigenous Peoples' Food Systems

This strengthening necessarily includes approaches that broadly stimulate intercultural research and education at several levels: international, regional, national, and within Indigenous communities. Research is needed to fully understand the availability and nutritional potential of biodiverse food resources in Indigenous territories (Kennedy et al., 2021). Intercultural education at all levels includes mutual careful listening and sharing knowledge of commercial food access, its quality and use, and learning the strengths, sustainability, and resilience of cultural resources and practices. Continuity of traditional practices is essential and includes encouraging new ideas and expressions of culture with food, including indigenous cuisines with biodiverse species and preparation techniques. These initiatives require legislation that enables and protects natural resources and their use, and ensures time, funds, and equipment for Indigenous Peoples to reinforce cultural food system access and identity (Kuhnlein and Burlingame, 2013; Delormier and Marquis, 2018; FAO Alliance of Bioversity International and CIAT, 2021).

The goal of strengthening Indigenous Peoples' food systems at the global level is to create the way forward for humanity to progress from our currently unsustainable food systems and ways of life (Argumedo et al., 2021; FAO, 2021). Collectively, Indigenous Peoples contain knowledge of a wealth of cultural diversity in the ingenuity of food systems that are adaptive to the world's diverse ecosystems and climate change. Realizing this goal begins with encouraging and enabling Indigenous communities to fully access and appreciate their local cultural heritage and identity.

In this contribution, we highlight two very different food systems and the partnerships that established essential data as a platform to create positive change. The Nuxalk Nation in the temperate coastal rain forest of British Columbia has a traditional food system based in wild fish and plant harvests that were assessed in 2009 to provide ∼30% of adult dietary energy. The Karen of Kanchanaburi Province, Sanepong Community, in the tropical watershed forest of Thailand have a food system traditionally based in shifting cultivation and wild food harvest that was similarly assessed to provide about 85% of adult daily energy (Kuhnlein et al., 2009; **Figures 1**, **2**). It is our intent to provide these two unique Indigenous Peoples' food system cases, and updates, as stimulation and inspiration for Indigenous communities everywhere to improve use of their traditional food systems, and for policy makers to realize the needs for urgent support of Indigenous communities' food systems at local, national, and international levels.

Both authors contributed substantially over several years to research with large teams in the case study communities. Both authors were involved in data collection to define the

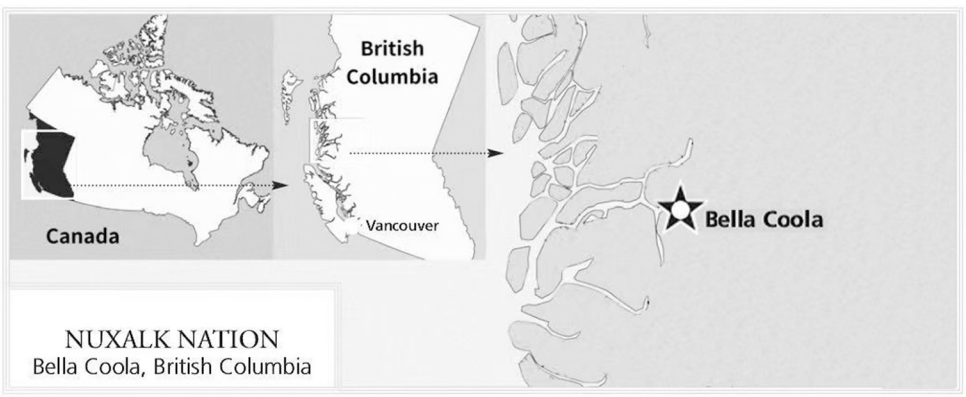

FIGURE 1 | Nuxalk Nation in Bella Coola, British Columbia, Canada.

FIGURE 2 | Karen Community in Sanepong, Kanchanburi Province, Thailand.

foods in the food systems (as reported separately in Kuhnlein et al., 2009), and then to stimulate community empowerment to improve wellbeing using traditional food and food system data. A diversity of research methods was employed using both qualitative and quantitative techniques which were summarized in separate chapters in Kuhnlein et al. (2013a). The data reported here include some from the former publications as well as new perspectives and research for policy considerations and actionable recommendations. Research and policy activities in both Indigenous communities are ongoing.

POLICY OPTIONS AND IMPLICATIONS

Nuxalk Nation of British Columbia, Canada

Setting and Context

The people of the Nuxalk Nation live in the community of Bella Coola and occupy lands on the central west coast of the Province of British Columbia. Their traditional territory extends more broadly in the temperate coastal rain forest of Canada. For tens of thousands of years, they occupied many villages in the region, but the population was decimated during the 1836-7 smallpox epidemic and resettlement of survivors took place in the remote Bella Coola Valley (McIlwraith, 1992). Today ∼1,200 Nuxalk People (*Nuxalkmc*) live in the Bella Coola Valley (about 50% of the valley population) or elsewhere in the province. The traditional Nuxalk language is Salish, and it supports rich cultural activities, although schools, health care, and commerce are conducted primarily in English. The once common extractive industries of logging and commercial fishing are in decline and unemployment and financial poverty are high. Gardening and subsistence traditional Nuxalk food harvesting and use is regularly practiced to supplement food purchased in the two grocery stores and several small outlets in the valley (Kuhnlein, 1992).

Health of Indigenous Peoples in British Columbia and Canada reflects the global circumstances noted earlier, with continuing colonization, poverty, and environmental dispossession. Food insecurity data on record for First Nations in Canada is 41% in contrast to the general population of 7% (Chan et al., 2011; Johnson, 2014), with 49% of 81 random Nuxalk First Nation households reporting food insecurity (FNFNES, 2011). Poor dietary habits result from increasing food insecurity and lead to increasing non-communicable diseases and decreasing quality of life (Thommasen and Zhang, 2006; Batal and Decelles, 2019). Batal et al. (2021a) reported that 73% of all British Columbia First Nations adults sampled in 2011 had overweight or obesity and 10% had diabetes, in contrast to 83 and 21% for First Nations over all regions in Canada; they suggest a protective effect of traditional food, especially fish, against diabetes in First Nations in British Columbia.

Nuxalk Food System Description

Until about 150 years ago Nuxalk families lived in varied environments, with seasonal location and food harvest depending on availability of a range of animal and plant foods from coastal rainforest and sea inlets of central coastal British Columbia to upland lakes and rugged mountains often capped with snow. The Bella Coola Valley, its river and tributaries provide many habitats and food diversity, including five species of Pacific salmon, sea foods, game (rarely found), tree foods, root foods, and a variety of wild fruits and greens (McIlwraith, 1992; Kuhnlein et al., 2013b) (**Table 1**). Harvested food was preserved by dehydration, smoking, fermentation, as jam, or caching. Today berry jam and fish drying and smoking are still common, as are preservation in jars or cans, and using household freezers.

The use of traditional food species by *Nuxalkmc* has been gradually declining. Interviews with three generations of Nuxalk

TABLE 1 | Summary of traditional wild food species harvested by Nuxalk Nation families.

Food type	Number of species
Fish (flesh, roe, oil)	16
Beach foods (shellfish, etc.)	7
Seaweed	3
Sea Mammals (seal)	1
Land mammals	7
Wild birds	5
Wild berries (including rose hips)	22
Roots	5
Greens	7
Tree foods (inner bark, crabapples)	3
Mushrooms	3
Total*	79

From Kuhnlein (1984) and Kuhnlein et al. (2013b).
**Number of species contributing primary foods. There are many food types within each species contributing various parts of the animals or plants to regular diets (Nuxalk Food and Nutrition Program Staff, 1984).*

FIGURE 3 | Harvested eulachon fish, Nuxalk Nation.

FIGURE 4 | Skimming eulachon grease from the surface of the cooking bin, Nuxalk Nation.

women about food use frequency by decade from 1920 to 1980 clearly shows gradually decreasing use of game, berries, greens, roots, and sea foods, with less impact on river fish (Kuhnlein, 1992). More recently, from 1980 to 2009 there has been even more dramatic decline in estimated use of traditional foods attributed to declining local availability and resource collapse of fish species that has increased food insecurity in the community despite families wanting to continue their food use traditions (Kuhnlein et al., 2013b; Batal et al., 2021b). Restoration efforts of salmon species, eulachon (see next section), and gardening have taken place, in particular the strengthening of efforts toward local management of eulachon (Sputc Project Team, 2017; Beveridge et al., 2020).

Here we emphasize the eulachon fish and the collective of berries because of their recognition as such in earlier interviews of Nuxalk women (Kuhnlein and Moody, 1989; Kuhnlein, 1992).

Eulachon Fish and Grease

The eulachon (*Thaleichthys pacificus* Richardson) is a cultural keystone species documented as important to wellbeing and Nuxalk identity (Sputc Project Team, 2017). This nutrient-rich fish is a popular flesh food harvested and prepared in several ways in spring by Indigenous cultures near rivers on the Northwest Coast. Eulachon grease is the fat rendered from the fish that has been a prominent food in itself, and a gift for feasts and many traditional ceremonies as a general sign of prosperity. It can be widely used as a frying medium, a condiment with several foods, or used as an ingredient in bread, salads, or stews; it can also be a preservative covering in containers of dried berries. It has been used as a versatile traditional lubricant for leather and wood, and as a locally important medicine for skin rashes and various ailments.

The preparation of the eulachon (ooligan) grease has specificity by family to yield the preferred flavor and storage capacity. Tradition in the Nuxalk Nation has been to net the anadromous fish from the river in early spring, March or April, and to pack the fish into cedar plank bins 2–3 m square lined with boughs of cedar (*Thuja plicata* Donn) built on the riverbank. The bins are covered, and the contents are left to ripen from 4 to 14 days until judged to be sufficiently decomposed. A second box is then constructed with a metal floor to enable heat from a fire below, and filled with water brought to a gentle simmer. The ripened fish is transferred by shovel into the box, and the rendered oil rises to the surface (see **Figures 3**, **4**). From 300–400 L of oil have been rendered from one box in the family process; the seasonal cooking in 1981 from five family preparations yielded about 2,000 L of grease. Grease was then shared with community households that at the time reported to use from 7 to 40 L/family per year (Kuhnlein, 1982).

The nutritional qualities of the fish and its grease are truly remarkable (**Table 2**). These were first documented in 1982 by Kuhnlein; a larger study was completed in 1996 that included sampling from five coastal First Nations. Analyses included retinol, calcium, iron, and zinc, and a suite of heavy metal and

TABLE 2 | Eulachon (*Thaleichthys pacificus*) fish and grease data summary.

	Fish, raw*	Rendered grease
Fat, mg/100 g ($n = 19$)	16.7	98.0
Retinol RE/100 g ($n = 19$)	3,196	2,400 ± 1,200
Tocopherol mg/100 g	nd**	22.0***
Vitamin K-1 mg/100 g	Nd	1.0***
Saturated fatty acids (g/100 g lipid)	23.5	19 ± 2.6****
Monounsaturated fatty acids (g/100 g lipid)	47.5	36 ± 5.8****
ω-6 Polyunsaturated fatty acids (g/100 g lipid)	2.0	1.1 ± 04****
ω-3 Polyunsaturated fatty acids (g/100 g lipid)	3.6	21 ± 6.8****
Calcium (mg/100 g)	273	nd
Iron (mg/100 g)	1.6	nd
Zinc (mg/100 g)	1.3	nd

Raw fish data from a composite of five fish samples from two British Columbia First Nation communities (Kuhnlein et al., 1996).
**Not detected.*
***Mean of samples from five separate preparations of Nuxalk grease. Tocopherol: (range 14.8–27.9); Vitamin K-1 (range 0.04–1.35) (Kuhnlein et al., 1982).*
****Determined from five separate Nuxalk family grease preparations, representing extract from a total of ∼11,000 kg fish (Kuhnlein et al., 1996).*

FIGURE 5 | Berries harvested in mid-July, Nuxalk Nation.

organochlorine contaminants (Chan et al., 1996; Kuhnlein et al., 1996). None of the contaminants exceeded regulation limits from Health Canada.

T. pacificus is rich in vitamin A expressed as retinol equivalents (RE/100 g). It appears that the ripening/rendering of the fish for grease, as well as smoking and dehydrating the fish creates some loss of this vitamin. Nevertheless, the fish grease is one of the best sources of retinol in British Columbia natural foods. It would fulfill nutrient needs of children and adults, even when consumed in small quantities. Available in spring, when traditional plant sources of carotene are limited to meet vitamin A needs, and because the grease was stored after preparation for annual use, this fat is an important nutrient in the annual traditional diet. Eulachon grease is also an excellent source of polyunsaturated omega-3 and omega-6 fatty acids, meeting human needs with a 20 g. portion. Calcium, iron, and zinc are also present in meaningful amounts in the fish and grease, especially considering that fish bones contributed some of this amount in edible dehydrated/smoked and ripened/rendered fish.

Unfortunately, and sadly for coastal First Nations Peoples, the eulachon has faced serious decline and extirpation, with the last large harvest for *Nuxalmc* in 1996 (Moody, 2008; Beveridge et al., 2020) because of commercial overfishing and shrimp trawl bycatch in the open ocean, and environmental effects such as flooding and silting of the river. Since then, there has been no eulachon fishing by the Nuxalk Nation. However, recognizing the importance of continued grease-making practices for cultural knowledge transmission, single batches of grease have been made in grease camps using fish from more Northern rivers since 2017 (Thompson, 2017). These camps fulfill important cultural and educational purposes, despite a lack of eulachon in the rivers. An annual community ceremony celebrates the time when *sputc* (eulachon) would have annually returned to the Bella Coola River (Moody and Beveridge, 2019). Serious efforts are being made to research and strengthen Indigenous management of this species based on extensive knowledge of the local environment and ecology, with the hope of returning and maintaining this nutrient-rich species into the diets of Nuxalk families (Sputc Project Team, 2017; Moody and Beveridge, 2019; Beveridge et al., 2020).

Wild Berries

The Bella Coola Valley and the coastal rain forest are famous for the diversity and quantity of wild berries available for consumption (Turner, 1995; Moody and Beveridge, 2019). More than 20 species of berries can be harvested at various elevations in the valley from April until frost in the autumn (**Figure 5**). In addition to being eaten fresh singly or in combination or incorporated into breads and salads, berries have traditionally been preserved by dehydration (by sun or smoke) and under a layer of eulachon grease. Recently, preservation is as jam and by freezing.

Use of traditional berries has been declining, as measured by interviews with three generations of Nuxalk women. From the 1920's until the 1980's both fresh and preserved use declined, although use scores of all berry species indicate that at least one fruit was used several times per week during the year (Kuhnlein, 1992). In 1985 family use of berries was roughly 46 kg/yr that was reduced to about 16 kg/yr in 2009. Although

all *Nuxalkcm* still greatly appreciate all their traditional foods, limited access and availability of the food system continue to decline (Kuhnlein et al., 2013b). Sweetened whipped soapberries (*Shepherdia canadensis*) continue to be one of the most popular berries in the Nuxalk Nation, but red huckleberries (*Vaccinium parvifolium*) and salmonberries (*Rubus spectabilis*) are more available than other species.

Nutrient data from species used by *Nuxalkmc* confirm that the array of Nuxalk traditional foods provided the full complement of nutrients essential for human nutrition (Turner et al., 2009; Centre for Indigenous Peoples' Nutrition and Environment, 2011). **Table 3** shows the diversity of berry species, the range of values for micronutrient adequacy, and the berry species with the highest analytical values on record (**Table 3**). Gooseberries and red elderberries had the highest nutrient values for multiple micronutrients: thiamin and niacin (gooseberries) and folate, iron, and phosphorus (red elderberries). Gooseberries and elderberries also had among the lowest taste popularity scores for women (not shown; Kuhnlein, 1989).

Nuxalk Food and Nutrition Program

The Nuxalk Food and Nutrition Program was initiated following identification of rich nutrient resources in traditional Nuxalk foods as detailed above. The program was funded from 1982 to 1986 by agencies within Health Canada, and others, as a demonstration project with objectives to establish the local knowledge of the Nuxalk food system and to then systematically encourage enhanced use of both traditional and nutrient-rich commercial foods to improve health status (Nuxalk Food and Nutrition Program Staff, 1984; Kuhnlein, 1987). With guidance of a committee of Elders, Chiefs and Council, community leaders in the Health Center, and program staff, ambitious and popular educational and assessment activities were conducted with substantial attendance by children and adults (Kuhnlein and Moody, 1989; Kuhnlein and Burgess, 1997). Importantly, the sampling and extensive food analysis provided the backbone of the knowledge platform upon which to base nutrition education activities (Kuhnlein et al., 1982; Kuhnlein, 1984, 1990; Kuhnlein et al., 1996; among others). Over the course of the program there was increased participation in program activities, a significant increase in traditional food use, and reduced commercial food expenditures per family; food use evaluations documented increased family consumption of fish, vegetables, and fruits. Improved retinol, carotene, ferritin and folate status in teens and adults were also documented, as was improved dental health (Kuhnlein and Moody, 1989; Kuhnlein and Burgess, 1997; Turner et al., 2013b). The Nuxalk Food and Nutrition Program emphasized food and nutrition education and development under the leadership described above. The Program was not specifically intended to prevent obesity and other non-communicable diseases, although healthy eating and fitness training and classes were given within the school system and in adult education through the Health Center (Nuxalk Food and Nutrition Program Staff, 1984).

The Nuxalk Food and Nutrition Program was the first community program for First Nations in Canada to document the traditional food system and build awareness and activities to improve overall dietary quality and health. It became a model for other Indigenous communities to promote use of local foods and holistic health and wellbeing (Kuhnlein et al., 2013b). The Nuxalk program was revisited in 2009 and 2013 to document its lasting impact in the Nuxalk Nation (Turner et al., 2009, 2013b; Kuhnlein et al., 2013b). While a greater percentage of Nuxalk families using traditional food increased from 1981 to 2009, the estimated weight of use per family had declined for reasons described above, especially decreased resource availability. Evidence from qualitative interviews and discussions with leaders in both 2009 and 2013 described several initiatives to share elder knowledge about local traditional foods and medicines with the intent to increase their use. The Nuxalk Nation has also been included in several provincial and federal research efforts to document continuing change in food use by First Nations (see following section).

Policies and Activities Affecting the Traditional Food System of the Nuxalk Nation

Global change in food distribution and availability since the mid-1700's, noted earlier, impacted all Indigenous Peoples. In addition, several factors in British Columbia's history have driven movement away from use of traditional food resources: Legislation restricted land and resource access of Indigenous Peoples including Legislative Acts to restrict access to Game, Fisheries, and Forests. Colonial policies beginning in the mid-1800's, such as residential schools, the reserve system, and ban of local cultural practices such as the potlatch had lasting impacts on knowledge transfer to younger generations (Fontaine and Craft, 2015). Environmental degradation and over-fishing because of extractive fisheries and forestry policy as well as widespread dispossession of lands and waters have reduced availability and accessibility of traditional foods (Moody, 2008; Hilland, 2013; Bennett et al., 2018; Beveridge et al., 2020). *Nuxalkmc* maintain that berries are in decline because of massive clear-cut logging blocks. Further, Nuxalk migration from home territory to urban areas and migration of settlers into the Bella Coola Valley brought increasing availability and use of less nutritious commercial foods. Education, social contact, and the media have fostered availability and appreciation of new foods and reduced native food harvesting, as has the impact of employment on time available for local food harvesting and funds generated to purchase mostly unhealthy energy-dense commercial foods. Employment also affected time available for women and men to create a transfer of food harvesting knowledge to younger generations. Few young Nuxalk women (<40 yr) have skills to cut and preserve fish or to harvest and prepare plant foods (summarized by Kuhnlein, 1992).

Since the mid-1990's international, national and local health agencies have embraced the concept of food security and ways to implement it. Attention to the Nuxalk Food and Nutrition Program has inspired traditional food evaluations and analyses, and education activities on benefits of traditional food that included honoring tradition in which food is recognized as

TABLE 3 | Micronutrient-rich Nuxalk wild traditional berries.

Nutrient, unit per 100 g fresh weight	EAR* for adult woman/day	Range of nutrient values**	Species with highest values: English	Scientific names
Thiamine, mg	0.9	nd–0.04	Salmonberry	*Rubus spectabilis*
			Black gooseberry	*Ribes divaricatum*
Riboflavin, mg	0.9	nd–100	Crowberry	*Empetrum nigrum*
			Wild strawberry	*Fragaria vesca*
Niacin, mg	11	nd–0.72	Black gooseberry	*Ribes divaricatum*
Vitamin C, mg	60	3.3–413.8	Rosehips	*Rosa nutkana*
Carotene, RE	Na	0.2–31.4	Salmonberry	*Rubus spectabilis*
Folate, DFE/ug	320	2.8–68.3	Red elderberry	*Sambucus racemosa*
Zinc, mg	6.8	0.1–0.8	Soapberry	*Shepherdia canadensis*
Iron, mg	8.1	0.2–1.1	Red elderberry	*Sambucus racemosa*
Phosphorus, mg	580	11–83	Red elderberry	*Sambucus racemosa*
Magnesium, mg	265	3.7–57.5	Wild strawberry	*Fragaria vesca*
Copper, ug	720	nd−1.3	Kinnickkinnick	*Arctostaphylos uva-ursi*
Manganese, mg	1.8 (AI)	0.01–4.4	Red huckleberry	*Vaccinium parvifolium*

EAR and AI for adult women, IOM (2009).

**Values from: Kuhnlein (1989), Canadian Nutrient File, Turner et al. (2009).*

Berry species analyzed included:

Blackcap–Rubus leucodermis; Black hawthorn–Crataegus douglasii; Bog blueberry–Vaccinium uliginosum; Bunchberry–Cornus canadensis; Crowberry–Empetrum nigrum; Gray blueberry–Vaccinium ovalifolium; Highbush cranberry–Virunum edule; Kinnickkinnick berry–Arctostapylos uva-ursi; Mountain bilberry–Vaccinium membranaceum; Red elderberry–Sambucus racemose; Red huckleberry–Vaccinium parvifolium; Rosehip (seedless)–Rosa nutkana; Salmonberry–Rubus spectabilis; Saskatoonberry–Amalanchier alnifolia; Soapberry–Shepherdia canadensis; Stink current–Ribes bracteosum; Swamp gooseberry–Ribes lacustr; Thimbleberry–Ribes parviflorus; Watery blueberry–Vaccinium alaskense; Wild blue currant–Ribes laxiflorum; Coastal black gooseberry–Ribes divaricatum; Wild raspberry–Rubus idaeus; Wild strawberry–Fragaria vesca.

contributing to social, mental, and spiritual dimensions of health as well as its contribution to nutrition and physical health.

Nuxalk Nation health promotion staff routinely use printed resources from the First Nations Health Authority (fnha.ca) and the Vancouver Coastal Health Authority including printed resources (Traditional Foods Fact Sheets) and dietitian consultations (Food Security Gateway, 2019). The Bella Coola Valley Sustainable Agricultural Society created a community garden, *Putliiux*, to teach and encourage gardening by Nuxalk families. The elementary *Acwsalcta* school has taken over caring for the local garden and a greenhouse, indoor garden, chicken coop and the outdoor garden as part of the school curriculum, as are harvesting and use of traditional foods that is supported by a local Food Security Coordinator. The Nuxalk Nation Health and Wellness Program has a *Nuxalkmc* Nutrition staff member, and the Pregnancy Outreach Program has a registered nutritionist on staff. A local Elder teaches fish-cutting and use of a smokehouse and other *Nuxalkmc* food processing techniques. Nuxalk College supports cultural resurgence activities like the grease-making described above and other traditional food harvesting practices.

Indigenous Services Canada (isc.ca), formerly the First Nations and Inuit Health Branch of Health Canada, funds and supports Indigenous communities and health organizations with food-related activities promoting healthy eating knowledge and food skills; improving access to healthy food, including commercial food and traditional food; improving food environments; and food security planning to support communities in defining ways to address local access to and availability of healthy food. All public health services in Canada now include programs in food security that foster building food knowledge for healthy diets while managing food budgets. Indigenous Peoples' programs include attention to maintaining healthy lands and waters. Many projects have themes and activities for First Nations in British Columbia to improve food security with traditional food, gardens, and community action (see for example Johnson, 2014; Blanchet et al., 2021). All these activities at provincial and federal levels, and their implementation in Indigenous communities, contribute to strengthening the food systems of First Nations in British Columbia.

As noted above, First Nations are supporting their own food security, wellness, and cultural connectedness, and are asserting their own management rights and authority. Parallel activities occur throughout British Columbia (see for example, Kuhnlein et al., 2013b; Jones et al., 2017; von der Porten et al., 2019; Beveridge et al., 2020; Blanchet et al., 2021; Steel et al., 2021).

There have been formidable historical and current challenges by many different constituents (government, resource extraction industries, education, health care, climate change, etc.) to the ability of the Nuxalk Nation to maintain their culture and way of life in their traditional homelands. However, committed Nuxalk leadership and staff together with partnerships with academia and local, provincial, and national resource agencies, have documented local empowerment to retain and use traditional biocultural knowledge for long-term nutrition and health benefits for *Nuxalkcm*.

THE PWO KAREN COMMUNITY OF KANCHANABURI PROVINCE, THAILAND

Setting and Context

Karen is the largest tribe among the Indigenous Peoples in Thailand with some communities located in Sangkhlaburi District, Kanchanaburi Province. Since settlement of the Pwo Karen occurred in Thailand more than 600 years ago, the relationship of the tribe with the Thai nation state has been positive, as the Karen have been seen as guardians of the nation's territory (Deepadung and Khammuang, 1997). The Sangkhlaburi Karen District is in a mountainous area 1,000 m high with the southwestern monsoon providing frequent rainfall throughout the year. The area hence functions as a watershed forest of rivers in both Thailand and Myanmar. The villages are embraced within a thick rainforest, and most of the woodland are mixed forest with flowing streams nurturing communities throughout the year.

A turning point for community life of the Karen People took place when the settlement, which serves as refuge for rare fauna and flora, became a target among frequent hunting groups. In 1964, the National Forest Protection Policy set a clear borderline around protected forest which engulfed the Indigenous community into the protected area (Sueb Nakhasathien Foundation, 2012). The government offered the people a relocation settlement with education services and modernization facilities, but the offer was not accepted. The community leaders strengthened the Indigenous tradition and promoted the uniqueness of the tribe successfully among the public until the present time (Grivijitr, 2019). Various development programs have inevitably influenced their lifestyle. Government and nongovernmental endeavors with different crops and livestock farming practices, modern health care and medical services (especially against malaria), and formal education have been promoted and conducted. Basic supportive education and healthcare services have been provided by the Thai government.

Some development missions had aims that alienated the people without considering their needs and ways of life. Examples are fixed land use indicated by official land marking, which is contradictory to crop rotation and shifting cultivation, the traditional practice accepted as sustainable for the Karen. The enforced radical shift eliminated the crop circle time span with highland plantation and wild product gathering. Further, monetary earning became mandatory as people must pay more for foods and additional expenses for shopping as well as for education, transportation, house-building materials, and health care. The working generation had to migrate to towns for work and income, and migration on to urban areas increased.

The original research for this case study with the Pwo Karen Indigenous Peoples in Sanephong, Thailand, was conducted in two phases: the description of the food system, followed by promoting local traditional food to address malnutrition. Basic principles of these phases are reported in Chotiboriboon et al. (2009) and Sirisai et al. (2013). This contribution elaborates the food system and presents several strategies used to promote and strengthen use of local Karen traditional food.

TABLE 4 | Summary of Karen traditional food species/varieties.

Food type	Number of species/varieties
Plant	321
Grain, Cereal, Seeds, Roots, and Tubers	51
Vegetables	208
Fruits	62
Animal	66
Fish, Shellfish, Shrimp, Snail, Amphibians	31
Land Animals	17
Reptiles	6
Fowl	10
Insects	2
Total	387

Karen Traditional Food System

Study of the Karen community food system was initiated in 2005 to explore information derived from both male and female Karen elders. It revealed knowledge and use of 387 food species: 321 plants (83%) and 66 animals (17%) (**Table 4**). The territory the community relies on is various in nature with hills, flat land, and creeks providing wild foods (187 species) and 183 additional species that were cultivated. Karen food management skills were effectively wise in providing family members with ample foods throughout the year that was sufficient for regularly sharing with Buddhist monks, relatives, and guests (Smitasiri, 2005, unpublished report).

Karen agricultural practices traditionally took place in a circuit of shifting cultivation with rice the most significant crop and staple food. Its value is addressed with local words of traditional wisdom: "The one who does not grow rice, the one who does not know how to grow rice, is not a Karen;" and "In the midst of a storm of might, hold tight to the ear of rice." These mottos reveal the Karen mindset for a strong faith in rice plantation, an essence they could rely on against the adversity of change. The sayings also suggest influences of worldly objects could harm or heal people's life, mind, and their natural resources (Premphund et al., 2016).

The Karen have considerable knowledge of edible vegetation in a large range of territory. There are more than 200 species of flora both in their agricultural fields and in the wild. Plants' roots, bulbs, shoots, stems, vines, young fruits, dry fruits, seeds, blooms, young leaves, and buds are known as parts of their meals, especially to match various chili paste types. Common Karen main dishes are known to contain rice, chili pastes, and fresh vegetables.

Crops of dry beans and sesame could be reserved for future consumption as special treasures reflecting Karen knowledge on crop planting, selection, utilization, and preservation. Karen cooks use beans and sesame as ingredients for curries, soups, and sweets and they are important agents in salt fermented paste, a major component of various dishes.

Diversity of the Karen Meal

With abundance of food types and accumulated knowledge, an array of cooked meals and home processed foods are available.

FIGURE 6 | Typical traditional Karen meal.

Soups, curries, salads, fried dishes, and stir-fried items can be prepared and varied to match family members' preferences, especially in the extended family typical in Karen lifestyle (**Figure 6**). A meal with various dishes holds the elderly, adults, and the young members as one. Chili paste is a core part of meals, as dried and/or wet paste. Karen rice is cooked with a portion of the boiled water saved for the preparation of liquified chili paste. For acidic taste sour cucumber is added–a supplementary crop in the rice field. Young mango, lime, and salacca fruit (palm fruit) are also applied for sharp acidic flavor. Side dishes of vegetables are various in tastes and types: cucumber is plain and refreshing; some flowers and young pods are preferred for their slightly bitter taste; and some sweet fruits [for example, *Myriooteron extensum* (Wight) K. Schum] are served for the same function as accompanying chili pastes. Vegetables are served fresh and boiled, roasted, and/or stir-fried (Sirisai et al., 2008, unpublished report).

Nutrient values assessed for 19 local indigenous foods showed that eight were good sources of vitamins and minerals (Chotiboriboon et al., 2009; **Table 5**). Other than snail, the food items shown are dark green leaves or leaves with shoots. Sanephong Karen use these as fresh, boiled and dipped in chili paste, added to curry, stir-fried with egg, added to fish soup, and added to dried fish curry. An example is the young shoots of fak-kao (*Momordica chochinchinensis* Spreng) that are blanched to create a favorite side dish. Snails are cooked in curry seasoned with roasted rice. Spicy soup is served with fresh leaf-like gawng-chu-na-du (*Erythropalm scandens* Blume) for a harmonious taste, texture, and nutritious dish.

Karen meals are also traditionally diversified with ingredients that may vary due to different ecosystems in various geographical areas. Wild harvests are fresh, toxin-free, and not contaminated with agrochemicals. Karen foods are considered much healthier than those of general Thais who consume commercialized products from monoculture farms that are suppressing consumption of local species and increasing detected contaminants (BIOTHAI, 2015, 2016). Besides the variety of fresh ingredients, the sourcing, gathering, harvesting, cooking, and arrangement of home-cooked foods are skills passed from generation to generation, providing nutritious meals for family and community cultural events (**Figure 7**). Karen food system knowledge of food variety, nutritional values, and traits of food access and use are part of ingenious local wisdom for nutrition and health care in the family, and are factors in environmental protection, knowledge vitalization, and Karen cultural heritage.

Identifying the Need to Improve Malnutrition in Sanephong

From the beginning of the century, Thailand experienced malnutrition in every region. Research included nutritional status assessment, root cause analysis, and cure programs to resolve the severe problems (Viravaidya and Damapong, 2002). Indigenous communities are vulnerable and live at risk with limited access to fundamental healthcare services. Beginning in 2005, a team of multidisciplinary experts from the Institute of Nutrition and the Language Research Institute for Development, Mahidol University, worked with partnership networks and the Karen community in research supported by the Micronutrient Global Leadership Program and the Thai Health Promotion Foundation (Smitasiri, 2005, unpublished report; Sirisai et al., 2008, unpublished report; Sirisai et al., 2013). Research guidelines were from the Centre for Indigenous Peoples' Nutrition and Environment (CINE), McGill University (Canada) for food system documentation and promotion of traditional food for health, wellbeing, and sustainability (Kuhnlein et al., 2006) The research direction emphasized the significance of clear comprehension and strength of the food knowledge of this unique Indigenous community. The study led to the promotion of healthy food and food stability, in particular for community students, and relied on the dialogue and collaboration among community members and researchers, and regular communication addressed the aims and expected results of the study consistently. This healthy cooperation-built trust within the village, creating clear understanding on the research process, and provided information for problem-solving.

Results of the first phase of the study illustrated the community's variety of traditional foods, but community members described a decrease in available and accessible quantities of many species reflecting ecosystem changes that negatively influenced regular consumption of many foods. The effects influenced local wisdom on planting, gathering, identifying of foods, processing, and cooking which were the common knowledge. Most energy-containing foods were traditional items, but half of the money spent on family food was on purchased products, especially snacks and sweetened drinks. Tooth decay and malnutrition problems were present among school-age children (Chotiboriboon et al., 2009).

A nutrition assessment was conducted for the local Karen children and adults by researchers from the Institute of Nutrition, Mahidol University, in collaboration with community members of Baan Sanephong (Baan literally means village), Sangkhlaburi District. It was found that among the children, newborn to

TABLE 5 | Nutrient data for Karen foods and potential dietary contributions for children 6 years and older.

English name	Karen name	Scientific name	Serving size*** (g)	Nutrients per serving (% Thai RDI)				
				Iron (mg)	Calcium (mg)	Vitamin A equivalent**** (μg)	Vitamin C (μg)	Folate (μg)
1. Shellfish	Khlu-mi	Unidentified	35	5.8 **(39)**	112 *(14)*	-	-	-
2. None	Pak-man-mu* or Le-khawng-du	*Gnetum gnemon* L. var. *tenerum* Markgr.	50	0.7 (5)	26 (3)	92 *(15)*	25 **(42)**	35.5 *(18)*
3. None	Kawng-thaing-du*	*Lemmaphyllum carnosum* (J.Sm. ex Hook.) C. Presl	50	1.35 (9)	46 (6)	61 *(10)*	2 (3)	18 (9)
4. None	Sa-ni-wa-du*	Unidentified	50	1.1 (7)	124 *(16)*	19 (3)	2.5 (4)	8 (4)
5. None	Yawd-fak-kao or Bai-khai-du**	*Momordica cochinchinensis* (Lour.) Spreng.	50	0.45 (3)	57 (7)	77 *(13)*	73.5 **(123)**	86.5 **(43)**
6. None	Ther-khu-mai-du**	Luffa cylindrical (L.) M.Roem.	50	1.1 (7)	65.5 (8)	62 *(10)*	2.5 (4)	32 *(16)*
7. Citron	Bai-ma-ngua or Baegu or Sa-zui-la*	*Citrus medica* L. var. medica	50	2.1 *(14)*	373.5 **(47)**	49 (8)	37.5 **(60)**	37 *(19)*
8. None	Gawng-chu-na-du*	Erythropalum scandens Blume	50	0.75 (5)	79 *(10)*	39 (7)	2 (3)	28 *(14)*

Adapted from research results (Chotiboriboon et al., 2009).
**Part of the plant for nutrition value analysis is green leaf.*
***Parts of the plant for nutrition value analysis are both green leaf and shoot.*
****Serving size derived from 24 h dietary recalls of Sanephong children.*
*****Beta-carotene 12 μg = 1 μg Vitamin A.*
⁻Not determined.
Thai Recommended Daily Intakes (Thai RDI) for children 6 or more years of age (Food and Drug Administration of Thailand, 1998).
Food item is considered a good source of a nutrient if one serving meets 10–19% of the Thai RDI and excellent source if one serving.
Meets ≥ 20% of the Thai RDI.
Italic: Good source of the nutrients (10-19 % of Thai RDI).
Bold: High in content of the nutrients (≥ 20% of the Thai RDI).

FIGURE 7 | Karen family cooking session.

12 years of age, there was chronic and acute malnutrition with 20% stunted, 14% underweight, 5% thin, and 1% were overweight (Chotiboriboon et al., 2009). The second phase began immediately with a project to promote traditional foods for healthy nutrition and food security.

Promoting Traditional Foods to Improve Nutrition and Food Security

Presentation of these findings to the villagers was followed by seeking ways to solve these problems. Dynamic conversations among children's caretakers and researchers facilitated community understanding and opportunities to have more traditional foods available for the children. This process was important to present and describe the value of local foods to the community. As a result, various activities were designed with the focus to make a difference in nutrition among the students in grades 4–6. A rationale for the selection of grades 4–6 was the finding of malnutrition among these children (as noted above) and the maturity of the students' thinking skills, decision-making, and their self-direction, all of which were anticipated to be beneficial.

Activities were integrated into community events and school projects, especially the school lunch program. Extra-curricular activities on wise local traditional cooking and informative learning about food and nutrition were also arranged. Resource people for these endeavors were women's groups, local researchers, and visiting researchers.

These activities embraced the exploration of students' perceptions about their community. The young generation realized the richness of natural resources and traditional cultures. They learned of changes because of the obvious decrease in the amount of some vegetables, such as the edible water fern (*Diplazium esculentum* Retz.) which was abundant earlier in village backyards. With promotion of backyard gardens, the number of families participating in the project and the variety of green vegetables consumed increased. Several events with cooking sessions to enrich popularity of local cuisine were held for both the development of traditional main dishes and healthy snacks and sweets. Mothers' groups used various local ingredients to make delicious and colorful dishes which were good for nutritional value and demonstration of practical preparation skills which would ensure the scaling-up process when the dishes were introduced to the community and schools in events such as Kids' Day Camp.

The effort to promote the values of local traditional foods, both knowledge-based sessions and developing and serving healthy dishes, were arranged for mothers' groups and students. This also encouraged the development of presentation skills among session facilitators who could inspire making local food gardens at home. These change agents were informants and speakers spreading information on local traditional food species for audiences within the community and in other venues, both in national and international settings.

It was a challenge sometimes to encourage consumption of local seasonal nutrition-rich foods and well-balanced food for malnutrition prevention because behavior change for a better diet requires changing strategies and suitable approaches in context over time. However, other more promising dimensions of project results included improving the potential of community members in thinking skills, learning ability, openness to conflicting opinions, perception shifts, and collaboration of local members with visiting researchers and other organizations to solve resource-related problems and availability of community assets (Sirisai et al., 2013).

The community mindset, learning capability, and potential were observed during the collaboration with the research visitors in the fieldwork when local researchers and visiting researchers completed assignments together. Karen villagers worked with researchers harmoniously; even though they led a unique lifestyle, believed in different matters, dined with different meals, and had different attitudes and traits, they adapted their way of life to blend in with their peers at work. Their knowledge, especially of the unique traditional food system management, skills, and self-adaptation, were significant human capital of the community.

The adjustment was not an easy flash phenomenon, because some episodes were obstructive. For example, a former research project was carried out in an untrustworthy manner. Researchers would arrive in the village without notice, gather information of their own interest, and then leave the community. The Karen villagers were not acknowledged on the findings and there was no contribution to the development of the local people. When our team of visiting researchers arrived, their intention and attention were questioned by the villagers and the early relationship was pushed away. In order to establish a healthy relationship with the community, the research team designed a transparency process sharing goals and working procedures to the community leaders and encouraged clear communication among villagers and researchers. As villagers assumed roles of local researchers in information gathering, information sharing, and resourceful informing of both the local residents and among public audiences (within the country and also internationally) throughout the 4-year research period, trust among community leaders and the villagers flourished. Regular authentic face-to-face communication among the local people and visiting researchers in nutrition and health status assessment required communal exploration, knowledge exchange, and active research sessions among all project participants. The process contributed and reinforced development of leaders and local researchers. They acquired research skills and confidence in sharing their wisdom with other researchers from other academic communities. Their experience also highlighted and signified the traditional livelihood, way of life, foods, and cuisine of the Karen (Sirisai et al., 2008, unpublished report).

Examples of reflections of community members:

"... why do the instructors from Mahidol University visit us and encourage local cooking and our homeland meals? It shows that there must be lots of good stuff in there. It is good to bring back our own local foods and pass it onto the young generations..." (a male community leader #01).

"…I saw them working on food and nutrition related to edible plants. I learned why the plants are good. The researchers studied child health; do they have anemia, are they underweight, and they record the data while I studied local food plants in the household and in the forest. We collaborated and understood each other better than before when we started the project…" (a male community leader #01).

A senior community interviewee described the project in an interview: As the local people adapted their unique ways of life to work with visiting researchers, they also applied innovative acts relevant to the local research findings. An example was the practice of backyard edible gardens. Certain greens were abundant in the wild setting; hence, they did not cultivate these varieties. Examples were the water fern [*Diplazium esculentum* (Retz.) Sw.] and pak liang (*Gnetum gnemor* L. var. tenerum Markr.). Some villagers believed that growing them at home may bring bad luck, but other villagers perceived this as a miscellaneous myth. Once the idea to grow this vegetable was suggested, some community members wanted to try the plants in their farm garden. Local researchers tried the idea, and the products from the experiment were gifted to neighbors, and the role model farm plot was scaled up among the villagers. The plantation brought the local species close to home, stabilized their availability and enriched this healthy food source sustainably. A traditional greens farm plot also included morning glory, Chinese cabbage, and kale, saving money spent at the market.

"…they are delicious, and good for health. We could grow them ourselves; no need to buy. They are better than the vegetables sold in the market on which they use chemicals. We do not use chemical fertilizer in our home-grown vegetables. Nowadays we bring in more vegetables from home than we did in the past..." (a female student #01).

Another interview story showed how local adaptation took place among the children. The project promoted the growing of local food species, traditional cooking, and healthy consumption of indigenous cuisine among students. Grade 4–6 students joined school/community-based activities which were designed to tackle health problems such as tooth decay, malnutrition, and anemia, for which unhealthy sweets and drinks were the cause. Local researchers cooked healthy snacks as alternatives providing more nutrients, cutting down unnecessary expenses, and revitalizing community food-related culture traits. Local popular greens, such as water fern, were introduced in school through collaborative cooking sessions among the students, mothers' groups, and community leaders. The cooking and dining of local vegetables enhanced the school lunch program and the students learned traditional processes resulting in nutritious meals.

Another part of the program was a school camp in which students presented what they learned and their opinion from their learning experience to their friends, teachers, family, and community leaders. The results were students' inspiration, health awareness, and esteem as they could take care of their own health, realized the value of local foods, protected natural resources, vitalized their unique culture and home community. Moreover, students gained better knowledge on food, nutrition, anemia prevention and appropriate treatment which made use of nutritious local foods. As they engaged in these activities, students' learning potential, ability to take care of their own health, and skills to pass on their knowledge to family and community members were observed. Appropriate learning activities could activate continual learning experience as mentioned by both the students themselves and their caretakers.

"....(I) want a happy village with good culture like it is now. The village should be well-developed. People should not be in pain and not sick. There are kids with anemia in many villages. The remedy is green vegetables which are available as baegu…" (a female student #02).

"…In the old days, we ate baegu. We ate it without any acknowledgment of its nutritional value; what kind of vitamin is in it. Once the researchers visited, we knew that the plant is rich in vitamins; it is good. Our wild stuff is good. If we could get it, we want our children to have a lot of it; this vitamin-rich food." (a parent #01).

The result of the programs to increase use of local species in local backyards was accepted among audiences within the community and outside. It enriched awareness on the significance of local foods to provide knowledge and direction for development of local cuisine, to provide healthy nutritional values among mother groups and students, and to strengthen essential skills of change agents.

Quantitatively, the variety of available food plants in the Sanephong community increased from 81 species to 137, with 119 of these being local species. The nutrition assessments for underweight, stunting, and thinness showed improvements in several percentage points among children aged 0–12 compared to the data of 2005 (Sirisai et al., 2013). Iron status based on hemoglobin also improved among children aged 8–12. There were more children in 2008 with normal levels of hemoglobin and fewer mild cases of low iron status. However, the number of overweight children increased from 0.5 in 2005 to 2.1% in 2008 (Sirisai et al., 2013).

Recognizing the Karen Community Capital

Both the process and the outcome of the research suggested the potential of the community capital which includes natural resource capital, human capital, and social capital. Natural resource capital provided villagers with many wild foods and natural harvest from fields, forests, and creeks. Human capital was the ability of learning from the Indigenous local heritage from hundreds of years in the territory. The intellectual property provided food and environmental protection of the forests and streams, embedded in local traditions and respect for sacred nature in the Karen context. These knowledges did not limit the ability to cope with changes in the community and from outside. The people learned and used their understanding to deal with problems effectively. Once they recognized natural resource degradation and cultural changes affecting students' health and the root causes of the problems, the villagers, community members, leaders, care takers, and the students could collaborate in the program with the community's essential social capital. They shared perspectives and collaborated with visiting researchers to design appropriate development activities based on their knowledge and unity to make a difference as shown in **Table 6**. Karen community strengths were in all three capitals, merging interactively as one (Hayami, 2008) which would work against internal and external negative forces. The collaboration and faith created a strong foundation of Karen self-actualization, and the capacity to strengthen the presence and sustain the development of the traditional food system into the future.

Community capital was an empowering factor enhancing community members' skills on researching, lifelong learning, and problem-solving. The capabilities supported the development of food security, community development, and problem-solving in times of internal conflicts and exogenous shocks. Community capital was a significant factor as it could be developed and transferred from generation to generation (Kirmayer et al., 2009; Green and Haines, 2015; Spring, 2018; Venning, 2021). Though this research was conducted several years ago the results of the systematic and continuity of effort are still applicable. The nature of community capital, the systematic and continual endeavor noted, can provide a clear perspective for policy makers and stakeholder agencies to realize community potential and opportunities of collaborative schemes for Indigenous communities and visiting scholars, both in the community and among external networks.

The continuing conflicting situation between Thai Indigenous communities and other actors concerning community rights to access natural resources for their subsistence is still active. It is important to emphasize that the accepted as sustainable way of life of the people, especially regarding the land conflict in shifting cultivation, is still not recognized as a constructive way of life through the lens of government (Thailand Science Research and Innovation, 2021). Urbanization and modern-day careers are known, as are other conditional factors causing

TABLE 6 | Summary of Karen natural resources capital, human capital, and social capital.

Community capital	Strength	Challenge	Intervention	Results	Community expression
Natural resource capital	- Food diversity on different landscapes	- State regulation - Increasing population - Commercial driven foods - Acceptance of home gardening	- Nutritional value assessment of traditional food and indigenous recipe - Promotion of home gardening	- More variety of home-grown vegetables	…Earlier, we did not grow ivy guard. Now we grow them in the backyard. It is good to have the plant nearby; we could rely on the yield…
Human capital	- Traditional local wisdom (food production and food use)	- Modernization and media influence on food choices and children's eating habits	- Formal/informal educational activities (landscape survey, gardening, cooking, and dinning) based on local wisdom	- Developed recipe with varieties of traditional ingredients	…The visiting researchers told us that our local vegetables hold lots of vitamins. Our wild foods are good. We want our children to eat much of these….
Social capital	- Community members have strong learning ability	- Child rearing tradition may obstruct the effectiveness of the project's intervention for behavioral changes	- Engagement of community leaders and community members in the process of design, education, and learning-by-doing activities	- Confidence of community leaders to educate children and community members	…Working together, we learned from each other (villagers and researchers); an exchange...
	- Plantation knowledge and skills	- In earlier times, people did not grow vegetables in home garden because wild harvest was abundant	- Knowledge provided by researchers on the decrease of some plant species and on nutritional value of Indigenous food	- Home gardening increase from 78 to 85.4%	…The Paco fern was not a farm plant as it is easy to find by any streams. We tried growing them in our farm plot so that it is easier to get, and it went well…
	- School children (older than 9-year-old) to help parents to take care of the young, farm work, and cooking	- Role of parents less influential today as children receive influence of school and time with TV/media			…We eat more vegetable as we realize it is good for our body. We are healthier. Before the research, we did not eat much vegetable for we did not know those essential nutrients in the greens.

changes in lifestyle and the food system, and which can be expressed as malnutrition including over-consumption, and other chronic diseases. In general, however, members of the Pwo Karen community of Sanephong are now more knowledgeable and capable to lead healthy lives by fully engaging with their traditional food system. They demonstrate promising potential to learn and adjust their way of life to collaborate with different agencies that aim to promote sustainable local food systems for health and wellbeing, and to protect against over-consumption and imbalanced diet.

Lessons Learned

The multidisciplinary team working in a relatively small case study in cooperation with a community consecutively for 4 years had multidimensional learning. Experiences reported here can be contributions for strengthening support for food systems of Indigenous Peoples throughout Thailand and in other countries.

The study of local traditional food diversity and nutritional values provided community members with knowledge of the significant health and cultural values of their Indigenous meals which inspired and strengthened community efforts to valorize and advance their food system for sustainable food security. The evidence-based active program over several years empowered the community to confidently cope with change. Improving nutrition with the local food system is complex with impacts from national and local policy, and societal changes in lifestyle and behavior. While improvements in nutrition measures of young children changed only modestly, the improvements were based on local community capital using local resources, and their human and social capital that is valued and trusted by the Karen as living heritage passed through the sacred forests and streams, thinking processes and wisdom, and respectful way of life.

The collaboration among Indigenous Peoples and researchers who valued the local culture was a significant element for trust and synergy and built confidence for the local leaders in their community capital. The outcome was a healthy dynamic cooperation throughout the process of work from data collection, goal setting, research design, problem-solving, and the communication to promote the significance of local food systems.

There is ample evidence from this research with the Pwo Karen in the Sanephong community that government policies to recognize, support, and enhance access to their traditional food resources will promote their health and wellbeing. It is hoped that strategies described here to strengthen the Pwo Karen food system can be usefully engaged by other Indigenous Peoples in similar settings.

ACTIONABLE RECOMMENDATIONS

Indigenous Peoples on all continents have clearly and unequivocally stated their purpose and imperative to assess and reclaim their traditional food systems for the many benefits they provide (Kuhnlein et al., 2009, 2013a; FAO, 2021; FAO Alliance of Bioversity International and CIAT, 2021); among many others). The United Nations Food Systems Summit (2021) affirms the potential of Indigenous Peoples to establish "effective landscape management, rights over land and resources, improved capacity for action, cooperation, and traditional knowledge at the center of sustainable food systems," and provides rationale and suggested solutions for this realization (Food Systems Summit, 2021). All member states of the United Nations are encouraged to affirm the Summit recommendations and develop national strategies for action. Of essential note is the need to address the management rights of Indigenous Peoples to their traditional territories as described in the examples of the Nuxalk eulachon crisis and the Pwo Karen need for access to their farming systems.

This welcomed United Nations development outlines ways to accomplish strengthening of all Indigenous Peoples' food systems along several lines of action for leadership by youth, women, and men and their scientific partners. Importantly, the imperative for documenting Indigenous knowledge with patterns of use of biodiverse traditional Indigenous foods and nutrient analyses is critical to broadly and interculturally share the traditional and scientific knowledge to accelerate change that will strengthen Indigenous Peoples' food systems. Guideline methods on how to do this documentation are widely available (Kuhnlein et al., 2006; McCune and Kuhnlein, 2011; Maundu et al., 2013; McCune et al., 2019). The FAO INFOODS network is a repository for food system information documentation that enables planning and activities in local communities and at national legislative levels.

With respect, recognition, and protection of this knowledge Indigenous Peoples' food systems can and should be actively used for intercultural education on the many health and cultural benefits of traditional foods of Indigenous Peoples. Indigenous and intercultural youth should be encouraged and empowered by understanding the knowledge and benefits of diverse Indigenous food systems and be given the resources to develop leadership for promoting this knowledge and related cultural activities in their communities and at national and broader levels. The school systems in both Nuxalk and Pwo Karen communities, explained above, are shown to encourage this learning in their local education settings to strengthen their food systems, and they have been active in sharing their experiences.

Building Indigenous community food pride, valorization, and stewardship is fundamental to maintaining the many benefits of Indigenous Peoples' food systems. These can be realized with recognition and utilization of the diverse social, natural, human and knowledge capital that develops and maintains culture and food systems in communities (Delormier et al., 2017; Argumedo et al., 2021; Cariño and Ferrari, 2021).

Indigenous community and national action should recognize and share the many benefits of Indigenous knowledge with free, prior, and informed consent. The contributions of Indigenous Peoples' food systems to global knowledge will support biodiversity protection, ensure the umbrella of human rights, and promote environmental sustainability and reduction of ecosystem threats, including climate change.

With this publication that includes detailed case examples of Indigenous People food systems, we hope that national and global support for strengthening Indigenous Peoples food systems will develop further with the recent imperatives of the United Nations Food Systems Summit. Sharing and strengthening the knowledge and values of an intercultural food system movement will develop evidence for effective policies to command overdue and well-deserved essential policy space to foster health and wellbeing of all humankind and the global common good.

Some examples of activities, among many, to strengthen Indigenous food systems suggested during the UN Food Systems Summit and World Food Day discussions are:

- Retain and share seeds of your crops within your community.
- Use your local food to decolonize your taste buds and your kitchen skills; seek and learn from Indigenous chefs to build your own cultural cuisine.
- Youth are encouraged to share and build the future together and pursue justice policies in their communities and with partners for food system sustainability.
- Put a tax on junk food in your communities; build local legislative power.
- Treat your Indigenous food and traditions with love, purpose, and care; teach these values at all levels in your schools and communities.
- Shift the paradigm of colonialism and materialism to build on local traditions and sharing.
- Activate your indigeneity and build food sovereignty and food and nutrition security with grassroots traditional knowledge and food practices of your knowledge keepers and food caretakers who are gifted with this ancestral knowledge.
- Build your education structures to create Indigenous food professionals.
- Bring your Indigenous voice to the table and take strength to avoid the temptations of junk food and other ultra-processed food.
- Reach out to learn and share with international networks for biocultural diversity and food sovereignty for Indigenous Peoples.

With the United Nations Food Systems Summit in the news and public consciousness, this is an exciting time for Indigenous

Peoples to activate their skills and knowledge to strengthen, protect, promote, and transform their food systems for better health and wellbeing.

AUTHOR CONTRIBUTIONS

HK and SC contributed to the overall outline and confirmed accuracy with their community collaborators and agreed on the final text. HK contributed the original section of the Nuxalk Nation text. SC contributed the original section of the Pwo Karen section. Both authors contributed to the article and approved the submitted version.

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