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Use of *Capsicum* on Kosrae Island, Federated States of Micronesia

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Abstract

I surveyed the nomenclature and usage of *Capsicum*, in particular *C. frutescens* on Kosrae Island, Kosrae State, Federated States of Micronesia, to identify the relationship between people and *Capsicum*. Three species of *Capsicum* are cultivated on Kosrae Island: *C. annuum*, *C. frutescens*, and *C. chinense*. Many cultivars of *C. annuum* and one accession of *C. chinense* are thought to have been introduced to Kosrae Island quite recently. In contrast to *C. annuum* and *C. chinense*, *C. frutescens*, especially the green type, is a common seasoning in the daily diet of locals and has become an important and indispensable condiment on Kosrae Island. People called it “Kosraen pepper,” “native,” or “local.” This terminology may imply that people on Kosrae Island are more attached to *C. frutescens* than they are to the other species of *Capsicum*. *Capsicum* peppers are called *pwepuh* on Kosrae Island, which seems to be related to *pf Pfeffer* in German or *pepper* in English. Kosrae Island residents do not have any specific names for the various pungent types of *Capsicum* peppers. They view *Capsicum* peppers in various ways: as a condiment (fresh or salted fruits and hot sauces), vegetable (leaves of *C. frutescens*), and medicine (fruits and/or seeds for toothaches, fruits for diarrhea, and leaves for curing boils and wounds). However, the uses of *Capsicum* spp. as a medicine are very limited on Kosrae Island compared to other small and remote islands in the Pacific, and people there have been eating fewer *C. frutescens* leaves in recent years partly due to modernization of the culture.

Key words: *Capsicum annuum*, *C. chinense*, *C. frutescens*, ethnobotany, leaves as vegetable, medicinal use, naturalized plants

Introduction

Capsicum peppers, approximately 25 species belonging to the Solanaceae family, are native to both tropical and temperate regions of the Americas (ESHBAUGH 1993). *Capsicum frutescens* is a semi-domesticated species characterized by seed dormancy, small fruit size, slow growing, deciduous fruit, and the inhibition of flowering under

prolonged illumination (YAMAMOTO and NAWATA 2006, 2009a, YAMAMOTO *et al.* 2007, 2008). It is widely distributed throughout the tropical and subtropical regions of the world and is economically important as a condiment, vegetable, and medicine.

The Federated States of Micronesia (FSM) consists of four states (Yap, Chuuk, Pohnpei, and Kosrae, from west to east) composed of approximately 600 small islands, which amount to an area of approximately 700 km². However, FSM is spread over more than 2,600,000 km² of the Pacific Ocean and spans approximately 2,500 km from east to west. In the 1950s people in FSM still ate a traditional diet based on starchy staple crops (e.g., bread fruit, root and tuber crops, banana) and marine resources (MURAI 1954), but this began to be replaced by a diet rich in rice, flour, sugar, fatty foods, and other imported or processed foods after the United States Department of Agriculture started its supplementary feeding program in the 1960s (ENGLBERGER *et al.* 2003). This phenomenon accelerated after a Compact of Free Association was signed between FSM and the United States in 1986 (HEZEL 2004). Since then, FSM has faced serious public health problems, such as heart disease, stroke, and diabetes, etc., due to this new diet and other lifestyle changes, and the government, non-governmental organizations (NGOs), and researchers have attempted to promote a return to local foods because of their higher carotenoid and vitamin contents compared to modern foods (e.g., ENGLBERGER *et al.* 2009). However, the outlook for this program is bleak, partly due to local inexperience in cultivating such crops. On small islands and atolls, imported foods and medicines may not arrive for more than a month if a typhoon or an oil crisis occurs. Therefore, it is very important to re-discover plants already naturalized on each island, for food security.

Even though *Capsicum* did not originate in FSM, it has been cultivated and consumed there for an estimated 300–400 years and thus it is reasonable to consider it a traditional local food. The importance of this plant as a nutritious and local food in this region has been largely overlooked despite the fact that the fruits and leaves are rich in carotenoids and vitamins (RESOURCES COUNCIL OF THE SCIENCE AND TECHNOLOGY AGENCY 2001). In addition, information on *Capsicum* usage itself is very limited. Therefore, in the present study, I surveyed the local nomenclature, usage, and distribution of *Capsicum* on Kosrae Island to investigate the relationship between people and *Capsicum* with a focus on ethnobotany and food security and compare these factors to the results of *Capsicum* usage in Pohnpei State (YAMAMOTO 2011) and Chuuk Atoll (YAMAMOTO 2012).

Study Site and Data Collection

Fieldwork was conducted for 2 weeks in June 2012 on Kosrae Island, Kosrae State, FSM. Research consisted of interviewing locals, documenting local knowledge and use of *Capsicum* species, and observing plants. Figure 1 shows the study sites. A total of 22 people (12 males and 10 females in Tafunsak, Lelu, Malem, Utwe, and

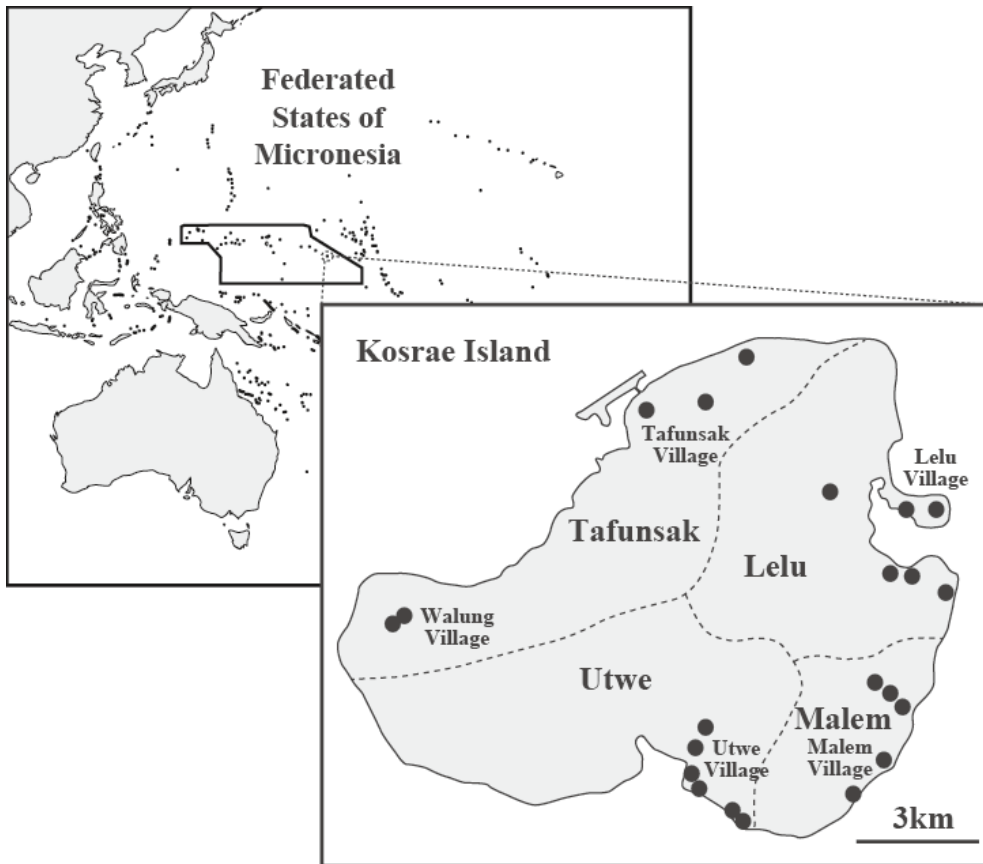


Fig. 1. Study sites (●) on Kosrae Island, Kosrae State, Federated States of Micronesia.

Walung villages) were interviewed regarding the local nomenclature and use of the *Capsicum*, in terms of perception of pungent *Capsicum*; knowledge of weed forms of *C. frutescens*; bird behavior toward fruits of *Capsicum*; usage as a condiment, vegetable, and/or medicine; and popular beliefs, agricultural rituals, and taboos related to this genus. The interviewees were 23 to 81 years old, with a median age of 52. Kosraean words are given following LEE (1976).

Results and Discussion

Local nomenclature for *Capsicum* and perception of pungent *Capsicum* on Kosrae Island

Three species of *Capsicum* are cultivated on Kosrae Island: *C. annum*, *C. frutescens*, and *C. chinense* (morphological characteristics of *Capsicum* species collected on Kosrae Island are shown in Table 1). Compared to several islands in Pohnpei State (YAMAMOTO 2011) and Chuuk Atoll (YAMAMOTO 2012), more pungent

cultivars of *C. annuum* were found on Kosrae Island (Fig. 2A—1 to 2A—3). A non-pungent type, or bell pepper, was also found to be cultivated (Fig. 2A—4). Almost all people who cultivated these cultivars of *C. annuum* reported that they had obtained the seeds or seedlings for \$0.10—0.30/plant from agricultural sections in their municipalities and planted them within 1 year. Some people had gotten seeds of *C. annuum* cultivars recently from Hawai'i or the US mainland from their relatives. A 64-year-old male in Malem said that he had obtained several kinds of *C. annuum* seeds and seedlings from the agricultural section of Kosrae Island 7 years ago. These results suggest that many cultivars of *C. annuum* were probably introduced into Kosrae Island very recently.

Two types of *C. frutescens*, which had a green or greenish-yellow color when immature, respectively, were found on Kosrae island (Fig. 2B—1&2). These two types are also well known in Pohnpei and Chuuk states (YAMAMOTO 2011, 2012). In contrast to *C. annuum*, *C. frutescens*, in particular the green type, is a common seasoning in the daily diet of locals and has become an important and indispensable condiment on the island. Interestingly, *C. chinense* was cultivated in a home garden in Malem (Fig. 2C) although this species has not been reported in other areas in FSM. A 43-year-old male cultivating *C. chinense* plants said that he had never seen it when he was young, which suggests its recent introduction to Kosrae Island.

Capsicum peppers are called *pwepuh* on Kosrae Island. In Marshall, to the east of Kosrae Island, people call them *peybah* or *pepah* (ABO *et al.* 1976: 236, 240). Considering the countries that have colonized Micronesia, these local names seem to be related to *pfeffer* in German or *pepper* in English. YAMAMOTO (2011) reported that local names for *Capsicum* in Pohnpei State, located to the west of Kosrae Island, include *sele* and *jeli*, possibly derived from *chile* in Spanish or English. Other regional names, such as *mwik* (*mwiiik*) in Chuuk State (YAMAMOTO 2012), *t'eebil* in Yap State (JENSEN 1977: 71), and *meringel* in Palau (JOSEPHS 1990: 192), all located to the west of Pohnpei State, are of unknown origin. Further linguistic studies in Micronesia may serve to elucidate the dispersal routes of *Capsicum*.

Among the 22 interviewees, 3 recognized only one kind of pungent *Capsicum* (Table 2), which was a cultivar of *C. frutescens* with small green fruits (Fig. 2B—1). The other 19 interviewees (86%) recognized more than two types of pungent *Capsicum* with the highest number being five types, although they did not have any specific names for each type. This percentage (86%) was much higher than that in Pohnpei State (67%) (YAMAMOTO 2011) and Chuuk Atoll (61%) (YAMAMOTO 2012), which is thought to be the result of the recent and active introduction and promotion of *Capsicum* peppers by Kosrae Island's agricultural sector. Almost all people surveyed thought that the *C. frutescens* cultivar with small green fruits was native to their region and they called it "Kosraen pepper," "native," or "local" — a phenomenon also confirmed in Pohnpei and Chuuk (YAMAMOTO 2011, 2012). These results may imply that people in FSM are more attached to the small fruits of *C. frutescens*. People thought that the other *Capsicum* peppers were introduced from the outside after World

Table 1. Morphological characteristics of genus *Capsicum* collected on Kosrae Island.

Accession No.	Species	Local name	Flower*			Fruit*				Growth type
			Stamen color	Filament color	Spot	Immature fruit color	Fruit shape	Fruit position	Fruit length	
KOS-1	<i>C. frutescens</i>	pwepuh	blue	little purple	no spot	green	elongate	erect	1-2cm	cultivated
KOS-2	<i>C. frutescens</i>	pwepuh	blue	little purple	no spot	green	elongate	erect	1-2cm	cultivated
KOS-3	<i>C. annuum</i>	pwepuh	n.a.	n.a.	n.a.	green	triangular	erect	3-4cm	cultivated
KOS-4	<i>C. annuum</i>	pwepuh	n.a.	n.a.	n.a.	yellowish green	elongate	pendent	10cm	cultivated
KOS-5	<i>C. annuum</i>	pwepuh	n.a.	n.a.	n.a.	green	elongate	pendent	15cm	cultivated
KOS-6	<i>C. frutescens</i>	pwepuh	blue	green	no spot	green	elongate	erect	1-2cm	cultivated
KOS-7	<i>C. frutescens</i>	pwepuh	blue	green	no spot	green	elongate	erect	1-2cm	cultivated
KOS-8	<i>C. annuum</i>	pwepuh	blue	purple	no spot	green	round	erect	1-2cm	cultivated
KOS-9	<i>C. frutescens</i>	pwepuh	blue	green	no spot	green	elongate	erect	1-2cm	cultivated
KOS-10	<i>C. frutescens</i>	pwepuh	blue	green	no spot	green	elongate	erect	1-2cm	spontaneous
KOS-11	<i>C. frutescens</i>	pwepuh	blue	green	no spot	green	elongate	erect	1-2cm	cultivated
KOS-12	<i>C. frutescens</i>	pwepuh	blue	green	no spot	yellowish green	conical	erect	2-4cm	cultivated
KOS-13	<i>C. annuum</i>	pwepuh	blue	purple	purple	green	round	erect	1-2cm	cultivated
KOS-14	<i>C. annuum</i>	pwepuh	n.a.	n.a.	n.a.	green	elongate	pendent	5-7cm	cultivated
KOS-15	<i>C. annuum</i>	pwepuh	n.a.	n.a.	n.a.	green	elongate	erect	3-5cm	cultivated
KOS-16	<i>C. annuum</i>	pwepuh	n.a.	n.a.	n.a.	green	elongate	pendent	5-7cm	cultivated
KOS-17	<i>C. frutescens</i>	pwepuh	blue	green	no spot	green	elongate	erect	1-2cm	spontaneous
KOS-18	<i>C. chinense</i>	bell pepper	blue	green	no spot	yellowish green	campanulate	pendent	3-5cm	cultivated
KOS-19	<i>C. frutescens</i>	pwepuh	blue	green	no spot	green	elongate	erect	1-2cm	cultivated

*referred to YAMAMOTO and NAWATA (2004) and INTERNATIONAL BOARD FOR PLANT GENETIC RESOURCES (1983).



Fig. 2. Use of *Capsicum* peppers on Kosrae Island.

Cultivars of *C. annuum* (A-1: erect fruit, A-2: round fruit, A-3: pendent long fruit, and A-4: bell pepper). A green immature fruit color type (B-1) and a greenish-yellow fruit color type (B-2) of *C. frutescens*. A flower and fruit of *C. chinense* (C). A weed plant of *C. frutescens* found growing on a dead stump (D-1&D-2). Plants of *Capsicum* grown in a field of taro (*Colocasia esculenta*) (E-1) and in a home garden (E-2). Hot sauces (F-1) and salted fruits of *Capsicum* (F-2&F-3) made on Kosrae Island sold in small shops. Materials for hot sauces (F-4).

Table 2. Perception of pungent *Capsicum* on Kosrae Island.

How many kinds of pungent <i>Capsicum</i> do you know?	Questions for 19 interviewees who knew several kinds of pungent <i>Capsicum</i>												
					Which fruits are hotter?			Which fruits smell better?			Which fruits do you prefer to eat?		
	1 ^{*1}	2	more	total	C. f. ^{*2}	C. a. ^{*2}	S ^{*2}	C. f.	C. a.	S	C. f.	C. a.	S
Kosrae	3	9	10	22	18 [GR:18, GY:0] ^{*3}	1	0	8 [GR:8, GY:0]	4	7	12 [GR:12, GY:0]	7	0

*1: people know only *C. frutescens* (small fruits of which immature fruit color was green).

*2: C.f.: *C. frutescens*, C.a.: *C. annuum*, and S: same.

[]*3: GR: small fruits of which immature fruit color was green, GY: fruits of which immature fruit color was greenish yellow.

War II. RAGONE *et al.* (2001) assumed that *C. frutescens* was introduced to Pohnpei Island, FSM, during the early westerner contact period (1830–1886) and also during the American Trust Territory period (1945–1986). However, TAKAYAMA (1993: 248) reported that Japanese castaways, who reached Belau (Palau) in 1821, observed *Capsicum* peppers (it could have been *C. frutescens* because they mentioned that it was a “tree plant”). YAMAMOTO (2011) revealed that at least two kinds of *C. frutescens*, including those with greenish-yellow fruits, were found in Oceania before 1945 during a specimen survey at the Bishop Museum, Hawai`i. Further botanical and literature studies in Micronesia are necessary to elucidate the genetic distribution, diversity, and dispersal routes of *C. frutescens*.

The 19 people who recognized more than two types of pungent *Capsicum* were asked to comment on each pepper’s spiciness and smell, and which pepper they preferred (Table 2). Eighteen people considered *C. frutescens* to be hotter, and all of these people reported that the small, green fruit type (GR) was hotter than the greenish-yellow type (GY). Of the remaining respondent, a 62-year-old male in Lelu, indicated that the round fruit cultivar of *C. annuum* (Fig. 2A–2) was hotter. Many people remarked that smaller fruits were much hotter. These results are very similar to those in Pohnpei and Chuuk (YAMAMOTO 2011, 2012). Regarding aroma, eight people thought that *C. frutescens* smelled better (GR: 8, GY: 0), four thought that *C. annuum* smelled better, and seven thought there was no difference in aroma between the two species. As for preference, 12 people preferred to eat *C. frutescens* (GR: 12, GY: 0) and 7 preferred *C. annuum*. Those who preferred spicy flavors tended to prefer *C. frutescens*, whereas others tended to prefer *C. annuum*.

Weed forms of *C. frutescens* and bird behavior toward fruits

Among three species, *C. annuum*, *C. frutescens*, and *C. chinense*, weed forms of *C. frutescens* are found at forest edge or along roadsides in Asia and Oceania because of its semi-domesticated characteristics, such as small fruit size and deciduous fruit, which are attractive to birds. They were also found along the roadside or around houses on Kosrae Island (Fig. 2D–1&2). More than 81% of interviewees had seen weed forms of *C. frutescens* (Table 3), which was slightly lower than in Pohnpei (100%) and Chuuk (91%) (YAMAMOTO 2011, 2012), and the same percentage knew of or had seen birds

Table 3. Perception of weedy forms of *C. frutescens* and bird behavior toward fruits on Kosrae Island.

	Do you know weedy forms of <i>C. frutescens</i> ?		Do you know birds eat its fruits?		Do you have its plants in your home garden?		How did you get the plants? ^{*1}	
	Yes	No	Yes	No	Yes	No	Seeds or plants from villagers	Weedy forms ^{*2}
Kosrae	18	4	20	2	8	14	6	2

*1: questions for 8 people who had *C. frutescens* plants in their home garden.

*2: including transplantation from weedy forms in home garden or village.

Table 4. Local names of birds that eat fruits of *C. frutescens* on Kosrae Island.

Local name	People answered
<i>chuko</i> (: common domestic fowl)	16
<i>darum</i> (: <i>Zosterops cinerea</i> subspp.)*	7
<i>srisri</i> (: <i>Myzomela cardinalis</i> subspp.)*	6
<i>wac</i> (: <i>Aplonis opacus</i> subspp.)*	3

*referred to ENGBRING *et al.* (1990).

eating fruits of *C. frutescens*. These birds included species known as *chuko* (common domestic fowl), *darum* (*Zosterops cinerea* subspp.), *srisri* (*Myzomela cardinalis* subspp.), and *wac* (*Aplonis opaca* subspp.); the scientific names of these birds are taken from ENGBRING *et al.* (1990); Table 4). These birds are known to disseminate seeds of *C. frutescens* in Pohnpei and Chuuk (YAMAMOTO 2011, 2012), and a common domestic fowl and birds belonging to the genus *Zosterops* are also known as disseminators in Japan (YAMAMOTO 2010a), Taiwan (YAMAMOTO 2009), the Batanes Islands, the Philippines (YAMAMOTO 2010b), and Cambodia (YAMAMOTO *et al.* 2011).

Use of *Capsicum* on Kosrae Island

Fresh or dried fruits

Locals who preferred spicy flavors ate fresh *C. frutescens* fruits raw or together with fried turkey tails. Some added fresh fruits to soups and/or fried food, and some used them to make a dipping sauce (a mix of fruits, salt, soy sauce, and lime juice, occasionally with coconut milk, garlic, onion, and/or black pepper) to eat with raw and fried fish. People throughout Kosrae Island appeared to use dried fruits only rarely, similar to people in Pohnpei and Chuuk (YAMAMOTO 2011, 2012) and the Batanes Islands (YAMAMOTO 2010b). This is likely because the relatively warm temperatures and generally plentiful rainfall throughout the year on Kosrae Island enable people to collect fresh fruits of *Capsicum* peppers, especially *C. frutescens*, year-round.

Processed or preserved fruits

Salted fruits and hot sauces of *Capsicum* peppers were found to be sold in small shops (Fig. 2F—1&2). People mashed fruits and salt together and put the mixture into cups for home consumption and also to sell it (\$4.50/cup; Fig. 2F—3), which is similar to the usage in Pohnpei State (YAMAMOTO 2011). At least two ladies produced

hot sauces of *Capsicum* peppers (\$4.50–5.00/bottle) on Kosrae Island by boiling *Capsicum* fruits with vinegar and other ingredients (Fig. 2F–4). People in Pohnpei and Chuuk states soak *Capsicum* fruits in the fermented water of mature coconuts (YAMAMOTO 2011, 2012), which may be common throughout Oceania, but this condiment was not observed on Kosrae Island in this study.

Use of leaves of C. frutescens

The leaves of *Capsicum*, especially *C. frutescens*, are used in soups and in mixes of vegetables on Kosrae Island; in contrast, no one reported eating the roots as a spice or vegetable. On Kosrae Island, 17 of 22 people indicated that they still use *Capsicum* leaves for food although the frequency was very low (Table 5). YAMAMOTO (2011) reported that, in Pohnpei State, the frequency of using the leaves is much higher in remote atolls, such as Mokil and Pingelap, than on the main island, Pohnpei Island. People in Pohnpei Island said that young people no longer liked to eat the leaves of *C. frutescens* and that people had stopped eating the leaves because they could not find *C. frutescens* plants growing as wild forms around their home or because they could buy other leaf vegetables at the market (YAMAMOTO 2011). This phenomenon was also confirmed in Chuuk Atoll (YAMAMOTO 2012). It is known that the lifestyle on Pohnpei Island is more modernized than that on Mokil and Pingelap atolls (KAWAI *et al.* 2010), which seems to have affected the use of *C. frutescens* leaves. YAMAMOTO (2009) also reported that the indigenous people of Taiwan seem to rarely use the leaves of *C. frutescens* because they can buy other vegetables at markets. These results suggest that the leaves of *C. frutescens* may be used less in modern society.

Medicinal uses of Capsicum

A 54-year-old female in Tafunsak mentioned the consumption of *Capsicum* fruits for treating diarrhea. A similar remedy was also reported in Taiwan, the Batanes Islands (YAMAMOTO and NAWATA 2009b) and Cambodia (YAMAMOTO and MATSUMOTO 2008). Scientific studies have demonstrated that certain extracts and essential oils of *Capsicum* have negative effects on the growth of some bacteria (ABDOU *et al.* 1972, GALLI *et al.* 1985).

Table 5. Use of leaves of *C. frutescens* on Kosrae Island.

	Use of leaves of <i>C. frutescens</i> as vegetable			Frequency of use of leaves of <i>C. frutescens</i> per*2				
				Week		Month		Year
	Yes	No	Total	Several times	One time	Several times	One time	Several times
Kosrae	17 [SO:12, FR:12]*1	5	22	1	0	3	3	10

[]*1: they used leaves for SO: soup and FR: fried vegetables. Results from multiple answer.

*2: questions for 17 people who eat leaves of *C. frutescens*.

A 52-year-old female in Utwe explained that young leaves were mashed and applied to boils and wounds. This remedy is well-known in many parts of Oceania including Pohnpei (YAMAMOTO 2011), Tonga (WHISTLER 1992b), Samoa (UHE 1974, COX 1993), the Cook Islands, Tahiti (WHISTLER 1992a), and Fiji (unpublished data). WHISTLER (1992a) indicated that Polynesians cultivated several species of *Solanum* as condiments before the European Era, but these have been largely neglected and lost, and *Capsicum* peppers have assumed many of their medicinal uses.

The same female from Utwe also mentioned placing seeds near the site of a toothache. This remedy was also reported in Chuuk (YAMAMOTO 2012) and is known in Japan (YAMAMOTO 2010a). In other regions of Oceania, the fruits and/or seeds are used to treat various ailments such as painful joints in Pohnpei (YAMAMOTO 2011), back pain in Samoa (UHE 1974), aching muscles and body pains in Hawai'i (WHISTLER 1992a), sore throats in the Cook Islands (HOLDSWORTH 1990), body pains and aches in the Admiralty Islands (HOLDSWORTH and WAMOI 1982), and aches and pains, especially chest pains, on New Britain Island (HOLDSWORTH 1992). Capsaicin, the pungent ingredient in hot peppers, has a long-lasting suppressive effect on sensory neuron activity, and this compound is used to relieve pain caused by arthritis and pruritus in modern medicines (CRAFT and PORRECA 1992).

Other uses of Capsicum

Nine people responded that they squash the fruits of *Capsicum* and apply the juice to diseased eyes of domestic fowl, which is also known in Pohnpei (YAMAMOTO 2011), Chuuk (YAMAMOTO 2012), Japan (YAMAMOTO 2010a), and Taiwan and the Batanes Islands (YAMAMOTO and NAWATA 2009b). *Capsicum* peppers are also featured in erotic stories using the symbol of *Capsicum*, "hotness." They have been found to play a role in popular beliefs, agricultural rituals, and taboos in many areas of Southeast and East Asia, and they are also used to produce rice malt and in rituals related to rice malt production (YOSHIDA 1993, YAMAMOTO 2009, 2010a). However, in the present survey, there was no evidence of any of these uses on Kosrae Island, as in Pohnpei and Chuuk.

Conclusion

Among *Capsicum* peppers, *C. frutescens* remains a very important spice, vegetable, and medicine on Kosrae Island. However, its use as a medicine is very limited on Kosrae Island compared to other small and remote Pacific islands. Moreover, people on Kosrae Island have been eating less *C. frutescens* leaves in recent years. To improve public health on Pacific islands, there should be a renewed focus on plants that are already naturalized on each island. From this perspective, an important candidate plant is *C. frutescens*, which can serve not only as a spice but also as a vegetable rich in carotenoids and vitamins, because it has long been naturalized in these regions. It is still unclear when *Capsicum* peppers (especially *C. frutescens*) were first introduced

to Micronesia. Further literature reviews including reports in Spanish, German, and Japanese and botanical analyses on *C. frutescens* in Micronesia are necessary to further elucidate its distribution, diversity, and dispersal routes.

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