Chapter 6: Food processing and cooking methods of seed grains

The cereals including millets have formed staple food since ancient times throughout Eurasia. Among millets, common (proso) millet and foxtail millet have been cultivated in areas covering almost the whole oof Eurasia. According to archaeological evidence, these two millets are considered to have been used as the staple food of Neolithic Yan-Shao people of North China and cultivated in Neolithic villages all over Europe through the four millennium B.C. (or 8500 B.P. as another opinion, Jones 2004). These cereals got dispersed from their domesticated regions through the Eurasia land mass during pre-historic and historic ages. Human ancestors had accumulated the cultural diversity based upon the natural diversity on the earth. The civilization has been supported radically by the basic agricultural culture complex which is one of main principles of culture. The processing and cooking of millets are an integral part of this complex as well as the cultivation practice. Therefore, the botanical study on domestication process is supplemented and supported with the comparative study on processing and cooking to help to clarify the geographical origin and dispersal of a given millet (Kimata and Seetharam 1997).

Japanese cooking has developed under the influence of Chinese, Indian, and African agricultural culture complex. Many basic traditional elements of millet processing and cooking methods are found in Japanese methods for cooking grains. Even today, the millet is also a very important crop in semi-arid and mountainous regions including Japan for future utilization.

Generally speaking, the utilization methods of cereal grains are divided into two groups, one for foods and the other for drinks. The former is furth divided into two groups, one for foods and the other for drinks. The former divided into three categories, grain, meal and flour, and the latter into non-alcoholic and alcoholic drinks. Since ancient times many traditional foods and drinks have been made from common millet and foxtail millet extensively in many parts of Eurasia. The preparations of boiled grain, gruel, *mochi* (in Japanese), and alcoholic drinks are popular in East Asia; while meal porridge, bread and non-alcoholic drinks prevail in Southeast Asia and Europe.

The basic processing methods are shown in Figure 43. Our ancestors had caught fire in ancient times, and then their civilization had become developed quickly. Wrangham (2009) summarized as follows.

C. Darwin cooked with hot rocks in an earth oven and called the art of making fire “probably the greatest [discovery], excepting language, ever made by man.” He understood the value of cooked food. But he showed no interest in knowing when fire was first controlled. His passion was evolution, and he thought fire was irrelevant to how we evolved. Most anthropologists have followed Darwin’s assumption that cooking has been a late addition to the human skill set, a valuable tradition without any biological or evolutionary significance.

A century later, cultural anthropologist C.L. Lévi-Strauss produced a revolutionary analysis of human cultures that implicitly supported the biological insignificance of cooking. He was an elite anthropologist, and his implication that cooking had no biological meaning was widely touted. No one challenged this aspect of his analysis. However, the cerebrated French gastronomist J-A Brillat-

Savarin (wrote in 1825) sounded evolutionary. “It is by fire that man has tamed Nature itself.” After our ancestors started cooking, he argued, meat became more desirable and valuable, leading to a new importance for hunting. Cooked food does many familiar things. It makes our food safer, creates rich and delicious tastes, and reduces spoilage. Heating can allow us to open, cut, or mash tough foods. But none of these advantages is as important as a little-appreciated aspect: cooking increases the amount of energy our bodies obtain from our food. We should indeed pin our humanity on cooks. We are tied to our adapted diet of cooked food, and the results pervade our lives, from our bodies to our minds.

This theory proposed by Wrangham (2009) is applied to not only meat but also cereals. Nakao (1972) had written as follows. The issues of processing and cooking have been studied only a little. It was very hard to understand that researchers had been indifferent on processing and cooking. These methods are very important parts in the agricultural culture complex.

There are countless cooking experts everywhere in the world. They have created a huge number of recipes which are brilliant and delicious. On the other hand, I am very interested in the basic and radical processing/cooking methods, that is, such dawn of basic agricultural culture complex including processing/cooking methods as Nakao’s hypothesis (1967, 1972). However, Nakao (1972) had recognized that rice had domesticated in Eastern India. At the present, rice had been domesticated around Peal River in South China based on the detailed results of genetic analysis (Xuehui Huang *et al*. 2012). Therefore, we have need to reconsider his excellent theory on the agricultural culture complex, especially about the dispersal of processing and cooking methods. It has very great reversal on the domestication process of rice and Indian millets companied secondary with rice too.

Processing methods of seed grains

We have two special ways of parboil processing and wet milling methods. Farmers boil the grains of Japanese barnyard millet in Japan, and little millet etc. in India before the de-husking. After the parboiling, we can easily de-husk small grains of millets. They make the flour of grains through the wet milling process to daily use and the offering for their gods in Japan and India. It means that some millets are sacred crops like rice and they are the same status both in Japan and India.

The milling process is done by two methods; dry milling and wet milling. Most grains are made into flour through dry milling method. In rare cases wet milling method is adopted for preparing flour.

Millet cooking was dispersed from the original domesticated zone to various areas together with its cultivars (seeds), their cultivation (tools and techniques), the food processing of seed grains (tools and technique), and the other utilities. In the traditional food processing the parboiling method and wet milling method (*shitogi* in Japanese) are important particularly to clear up the historical relationship between the processing method and domestication process. The parboiling method may be considered as one of the oldest processing techniques of millets and rice grains.

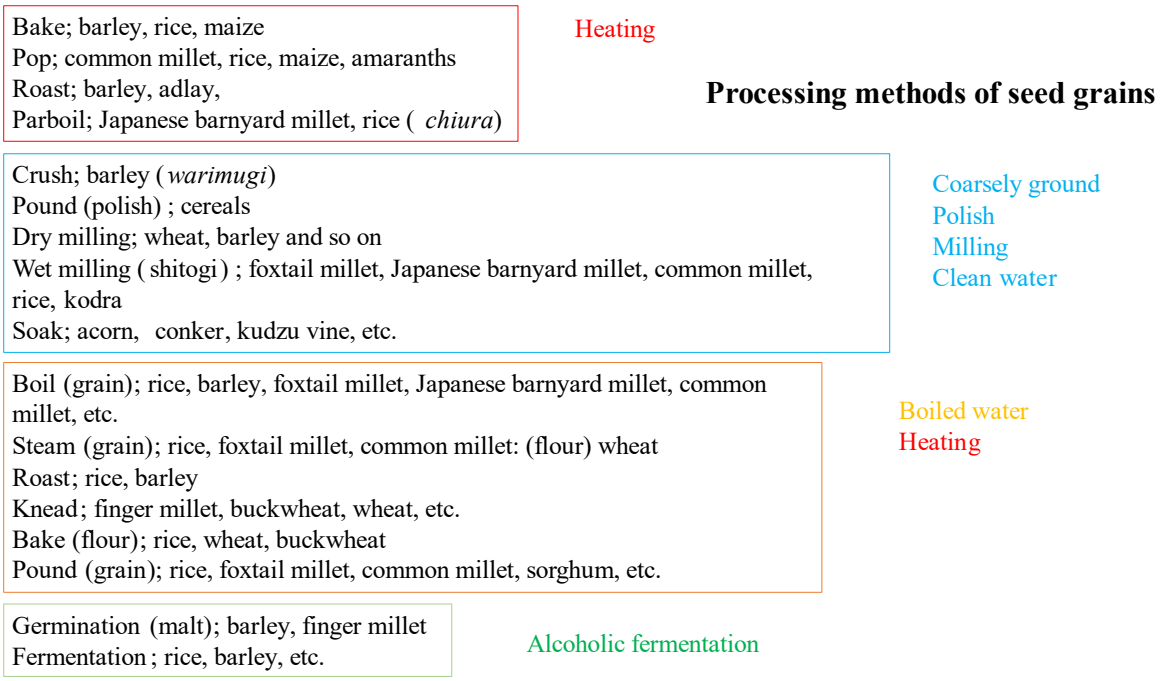


Figure 43. Basic processing methods of seed grains

Wet milling method and flour foods

In Jomon period, our ancestors had gathered many kinds of nuts for food in Japan, for example, *Quercus serrata* (Figure 44a), *Castanopsis sieboldii* (Figure 44b), *Castanea crenata* and so on. Because these nuts are generally bitter, they had removed bitterness by much volume of water in a stream. They had made flour from nuts by water bleaching method. Moreover, our ancestors had collected flour from *Dioscorea* spp., taro, sago palm and so on (Nakao 1967). Jomon people had become easily to get much food materials, and then they had obtained their stable life. Afterwards this water bleaching method could have influenced to *shitogi*, wet milling method of seed grains (Figure 45 and Figure 46).

Figure 44. Nuts, parched grains and barley/wheat fields

a, *Quercus serrata*; b, raw edible nut, *Castanopsis sieboldii*; c, roasted rice; de, roasted barley; f, barley fields; g, a wheat field mixed with many kinds of weed at the Botanical Garden of Free University of Berlin.

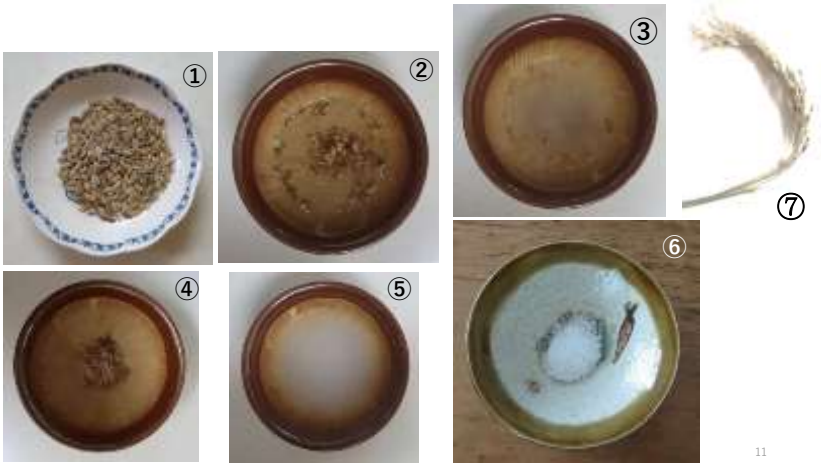


Figure 45. Wet milling method, *shitogi*

①upland rice grains; ②soaking; ③④⑤pounding and removing hull; ⑥drying up *shitogi* flour; ⑦ panicle of upland rice.

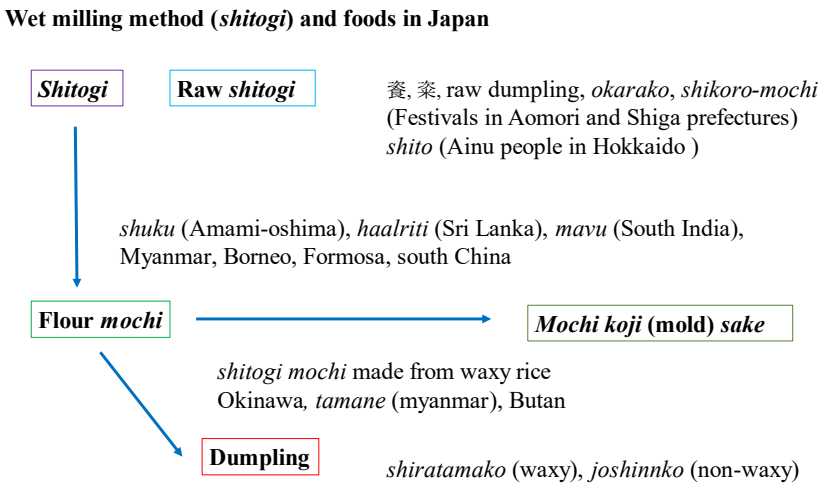


Figure 46. Wet milling method (*shitogi*) and foods in Japan

Kona-mochi (flour) and *Koji-sake* were derived from *shitogi* as shown in Figure 46. Ainu people have made *shito* from some kinds of millet in order to offer it to their god *Kamui* (Figure 47 and 48). The same food had called *shitogi* in Aomori, *shuku* at Amami-oshima, Kagoshima, *shutonpa* made by children at koshiki-jima and generally *nama-dango*, *okarako* or *shikoro-mochi*, etc. (raw dumpling for offering to gods). Villagers have used *shitogi* (raw rice flour) at the festivities.

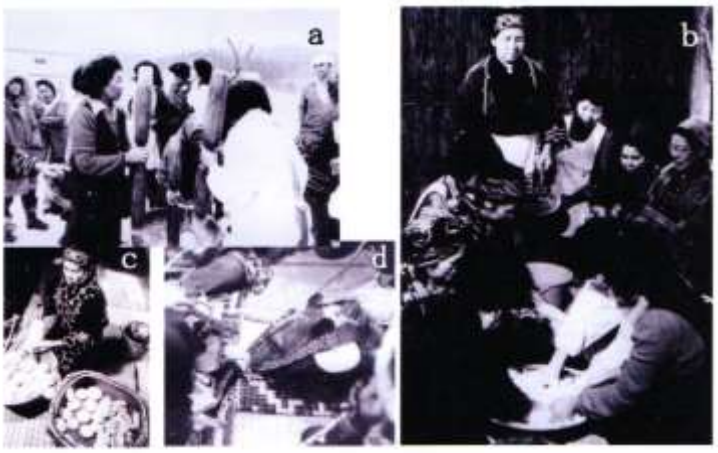


Figure 47. Ainu people have made *shito* from foxtail millet and common millet

a, pounding the polished grains by mortar and vertical pestle; b, kneading flour by hands; c, shaping to disc; d, offer up *shito* to gods *Kamui* through a bear which is the messenger. (Photographs permitted by Kaizawa.)

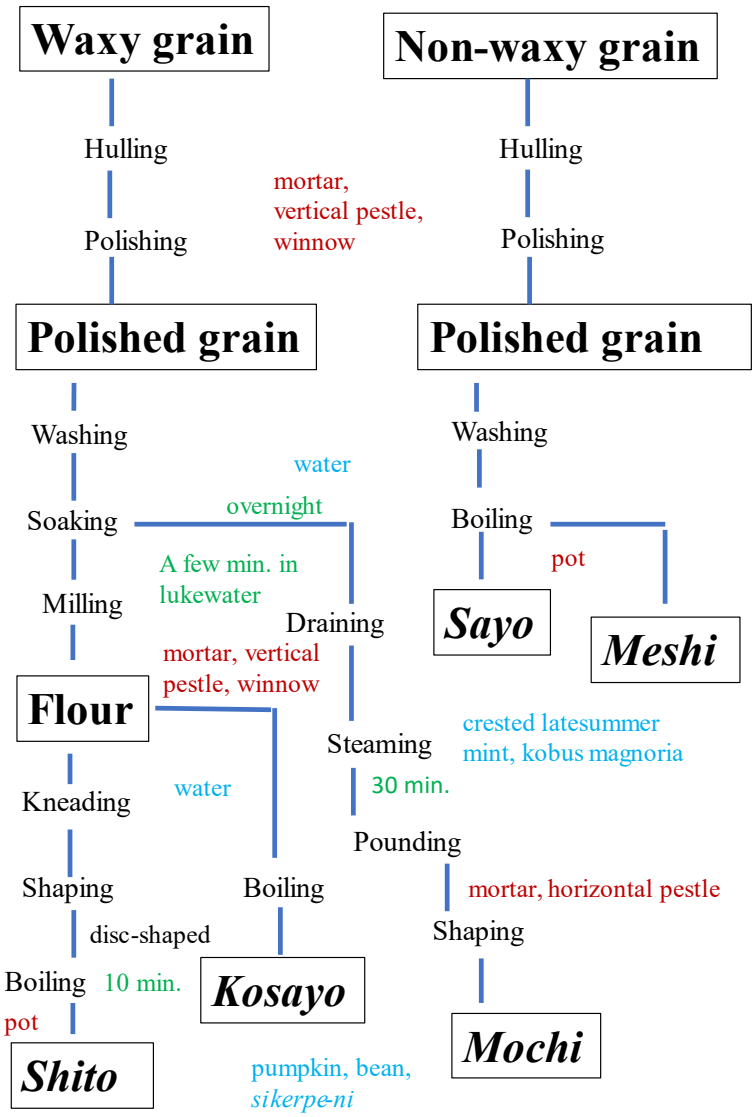


Figure 48. Cooking methods of foxtail millet in Saru river bioregion, Hokkaido

Shitogi had been made from Japanese barnyard millet, foxtail millet, common millet and rice. Ainu people have grown two varieties of Japanese barnyard millet. One is Ainu-bie, and another is Nanbu-bie as shown in Figure 49.

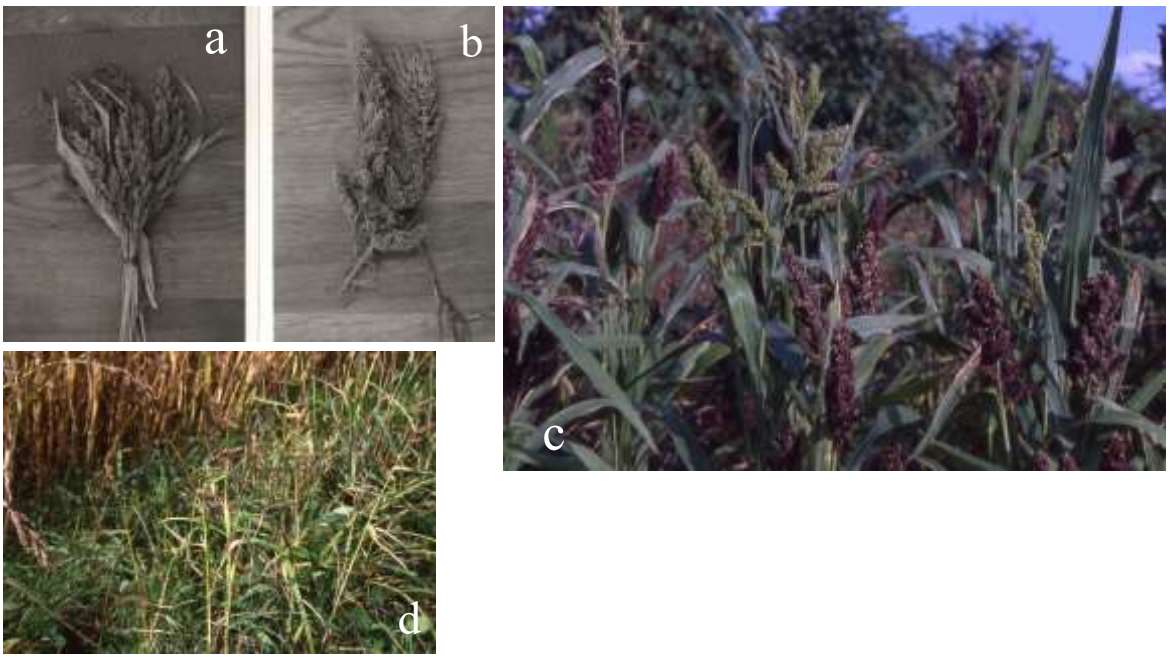


Figure 49. Japanese barnyard millet, *Echinochloa utilis* in Hokkaido, Japan

a, Nanbu bie; b, Ainu bie; c, Nanbu bie on a farm; d, *Echinochloa crus-galli* on a levee of paddy field.

Nakao (1972) had written that he had not seen the food like *shitogi* in India. However, *mavu* in Tamil Nadu, India is a raw flour ball mixed with sugar and honey, and is homologous to *shitogi* in Japan. It is made from the flour of foxtail millet in several villages in Tamil Nadu, as shown in Table 38. This food is offered to the gods and goddesses and then eaten by villagers. *Pidimavu* made from rice flour mixed with *ghee* is a kind of taper offered to the gods and goddesses. The raw flour is made through a primitive method of milling Asian millets and rice using a pounding mortar for the wet milling method. There are many kinds of raw flour food not only in South India, but also in Sri Lanka, Myanmar, Thailand, Laos, Kalimantan, Formosa, South China and Japan.

For example, in Tamil Nadu, *mavu* (syn. *shitogi*) is made from foxtail millet（*S. italica*) and rice (*O. sativa*) for offering gods and goddesses. This wet milling method is a very interesting fact, as compared with the raw *shitogi* made from rice and some Asian millets in Japan. This rice flour is often cooked into *bonda*, a kind of fried ball in India, too.

Figure 50. Wet milling method of rice (same foods as *shitogi* in Japanese) in Andhra Pradesh

a, pounding rice grains; b, soke grains in water; c, dry and filtering; d, *pidimavu*, a kind of light offered for gods and goddess.

Table 38. Cereal cooking styles and their ingredients in Tami Nadu

Material/Cooking	sadamu	uppuma	chapathy	roti	nan	poori	vadai	dosai	idlai	kali	kulu	mavu	Total
Brachiaria sp.													0
Ec. frumentacea	○	△					○			○	○		5
El. coracana	△	○		○			□	○		□	○		7
H. vulgare		○		○				○	□	○	○		6
O. sativa	□	○					○	○		○		△	6
Pan. miliaceum	○	△					△			○	○		5
Pan. sumatrense	○	○					○	○		○	○		6
Pas. scrobiculatum	○									○	○		3
Pe. americanum	○			△						○	△		4
Se. italica	○	△					○	○		○	○	○	7
Se. pumila													0
So. bicolor	○	△		△			○	△		○	○		7
T. aestivum			○					○		○	○		4
T. dicoccum		○											1
T. durum		△	△			△							3
Z. mays		○					△			△	○		4
Total	9	11	2	4	0	1	8	7	1	12	11	2	68

Grain foods and parboiling method

The parboiled method may be considered as one of the oldest processing techniques for millet and rice grains. Most Indian millets and upland rice are frequently parboiled, especially in eastern India (Kimata and Sakamoto 1992). Almost all millets are parboiled before being consumed in Bangladesh. It is very interesting that parboiling developed and is still used in the area from India to Myanmar for domesticated strains of Indian millets and rice (Islam 1993; Muller 1988). About half of rice produced in India is parboiled. In western Africa rice has also been traditionally parboiled.

The method is thought to have diverse effects. First, the parboiled grains are protected from pests and molds, so they can be stored and eaten when needed. Secondly, through the parboiling

process, unripe juicy grains harvested too early become hard enough to hull and polish the grains (Nakao 1967). Thus, this method may have begun as a part of measures against the shattering of crop grains. Because shattering was common at the beginning stage of domestication, ancient farmers had to harvest immature ears before they ripened completely. When hunter-gatherers discovered this processing technique, the number of grains they could collect must have increased dramatically. After a traditional parboiling treatment in Japan, the glumes, lemmas, and paleas of *Echinochloa utilis* can be easily removed (Yabuno 1987). This process is also very useful for *E. furumentacea* and *Pas. scrobiculatum*, because these grains have multi-layer hulls (Malleshi and Hadiwani 1993)

Thirdly, the nutrients contained in the pericarp-testa permeate into the endosperm, the starch changes from a raw to pregelatinized, giving polished grains a high nutritive value, good flavour and the ability to be easily prepared and cooked (Achaya 1984, FAO1985, Malleshi 1989, Muller 1988). Through parboiling, a layer of gelatinized starch forms on the surface of the grain, and this prevents the nutrients from leaching out during boiling. This is a very important treatment in India, because boiled grain is cooked usually with the “draining off” method and the nutrients are thrown away with the excess boiling water.

This process probably has many effects on those grains. For example, through parboiling, 1) the unripe juicy grains become hard when a farmer has harvested the crop a little too early. This is done to escape shattering, so that the grain can then be easily dehusked and polished (Nakao 1967). In Japan, after parboiling of Japanese barnyard millet, the glumes, lemmas, and paleas can be easily removed (Yabuno 1987). 2) The nutrients contained in the seed coat permeate into the endosperm, the starch changes from a raw to a pregelatinized one, turning the polished grains into a very good condition (nutritive value, taste and easy cooking) for eating (Malleshi 1989). 3) The grains are protected from pests and mold, so that they can be stored and eaten when preferred.

Indian millets and upland rice are frequently processed by the parboiled method especially in East India as shown in Table 39, Figures 51 and 52. On the other hand, the other cereals, i.e., African millets, wheat, barley and maize do not need to be processed by the parboiled method because most of these cereals have naked grains except for the covered cultivars of barley. It is very interesting that the parboiled method, one of the oldest processing techniques, is now used in and around the domesticated areas of Indian millets and rice.

Table 39. Number of the cases processed by parboiled method in our survey of India (1985, 1987, 1989)

Species	Maharashutra	Madhya Pradesh	Maharashutra	Karnataka	Tamil Nadu	Andhra Pradesh	Orissa	Bihar	Total
Pan. miliaceum								4	4
Se. italica									0
Brachiaria ramosa									0
Ec. frumentacea							1	1	2
Pan. sumatrense				1	1		3	4	9
Pas. scrobiculatum				1			3	1	5
Se. pumila							1		1
O. sativa				2	2	1	3	7	15
El. coracana									0
Pe. americanum									0
So. bicolor									0
H. vulgare									0
T. aestivum									0
T. dicoccum									0
T. durum									0
Z. mays									0
Total	0	0	0	4	3	1	11	17	36

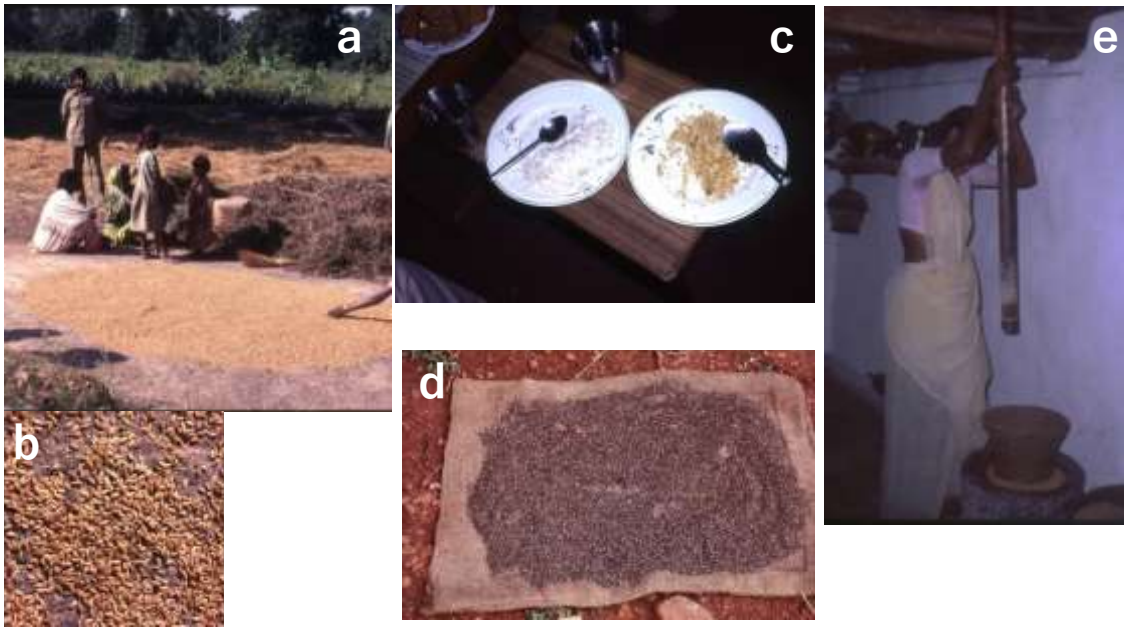


Figure 51. Parboiling method

ab, drying rice grains after boiling; c, *chiura*; d, drying *samai* grains after boiling; e, mortar and pestle for pounding foxtail millet.

Figure 52. Black steaming method of Japanese barnyard millet in Japan

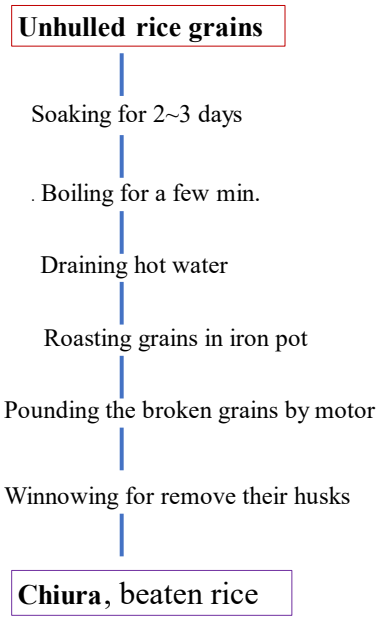


Figure 53. Chiura in India

The physical effect of parboiling for dehulling is shown in Table 40. Ketto TR200 was able to dehull *S. italica* and upland rice. As *E. utilis*, *P. miliaceum*, *Pas. scrobiculatum* and *S. pumila* had very smooth glume and lemma, TR200 was unable to dehull them, but Ketto Pearlest was tried. The parboiled unripe and ripened grains of *S. italica* and the parboiled unripe grains of upland rice were dehulled more easily than grains of their other lots and of the other millets and upland rice. The physical effect was indicated clearly only on *S. italica*, because the broken grain's ratio of both parboiled unripe and ripen grains after the dehulling process by TR200 were considerably lower than those of non-parboiled ones. For the other species, the parboiled grain was more or less broken easily, or did not show a difference among lots, especially when using Pearlest. The dehulling mechanism in TR200 is similar to that in a farmer's dehulling by mortar, while Pearlest has a different grinding mechanism that was mild enough to keep grains away from broken. The parboiling process showed an apparent effect on unripe and ripened grains of *S. italica*, and ripened upland rice grains. Thus, the parboiling process should be carried out as the method for preventing the shattering in ripened grains of these species. However, *S. italica* has not been parboiled traditionally. On the other hand, *Pas. scrobiculatum* has been traditionally parboiled in eastern India, as *E. utilis* has done in Japan (Kimata, M., S. Fuke, and A. Seetharam 1999).

Table 40. Effect of parboiling process on the dehulling and polishing of millet grains (20 g grains)

Species Lot	Hulled grains (g)	Broken grains (g)	Hulls (g)	Grains with hull (g)
TR200				
Setaria italica				
unripe grain	11.14	5.30	2.11	1.48
ripen grain	12.06	4.24	2.80	0
unripen grain parboiled	15.90	1.26	2.83	0
ripen grain parbouled	15.34	1.78	2.89	0
Echinochloa utilis				
unripen grain parboiled	0.14	0.79	1.22	17.85
ripen grain parbouled	0.05	0.86	0.59	18.50
Paspalum scrobiculatum				
ripen grain	2.56	3.40	4.43	9.61
ripen grain parboiled	2.16	4.34	3.61	9.89
Setaria pumila				
ripen grain	2.55	7.17	7.31	2.97
ripen grain parboiled	1.78	9.62	6.48	2.13
Oryza sativa				
unripen grain	11.08	1.54	4.42	2.95
ripen grain	13.37	0.39	3.63	2.61
unripen grain parboiled	12.66	1.12	4.34	1.88
ripen grain parboiled	13.12	0.64	3.58	2.44
Pearlest				
Panicum miliaceum				
unripen grain	15.77	0.13	4.11	not tested
ripen grain	15.52	0.28	4.29	
unripen grain parboiled	15.01	0.40	4.59	
ripen grain parboiled	15.10	0.18	4.71	
Echinochloa utilis				
unripen grain	14.32	0.12	5.56	
ripen grain	14.85	0.21	4.94	
unripen grain parboiled	14.38	0.12	5.51	
ripen grain parboiled	14.97	0.10	4.94	
Paspalum scrobiculatum				
unripen grain	13.04	0.04	6.93	
ripen grain parboiled	13.22	0.06	6.73	
Setaria italica				
unripen grain	11.96	0.29	7.75	
ripen grain parboiled	11.97	0.32	7.71	

The protein contents (%) in the grains of five millets and upland rice after dehulling or polishing grains are presented in Table 41. The grains of *E. utilis*, *Pan. miliaceum* and *S. pumila* contain protein more than 11 % of its dry weight, while *S. italica*, *Pas. scrobiculatum* and upland rice do around 7 %. The protein content of both unripe and ripe grains of *S. italica* increased somewhat through parboiling, but the content of *S. pumila* decreased remarkably. In *E. utilis* and *Pan. miliaceum*, the protein contents of unripe grains changed little through parboiling, while the contents in ripened grains decreased somewhat. *Pas. scrobiculatum* and upland rice showed little change in their protein contents through parboiling. Therefore, the parboiling method has no positive effect on the protein

contents of millets and upland rice except *S. italica*. Free amino acid contents increased in unripe grain of *S. italica* and ripened grains of rice through the parboiling process. Adenine nucleotide contents also increased in unripe grains of *S. italica*, *Echinochlooa utilis* and *Panicum miliaceum*, and ripened grains *Paspalum scrobiculatum* and *S. pumila* (syn. *S. glauca*). However, the parboiling process had no effect conclusively on the nutritive value of amino acid composition in grain proteins.

Table 41. Protein content (%)* of samples used

Species	non-parboiled grains				parboiled grains			
	unripe		ripen		unripe		ripen	
	hulled	polished	hulled	polished	hulled	polished	hulled	polished
Setaria italica	6.88	6.56	7.75	7.69	11.25	10.75	8.94	8.63
Echinochloa utilis	14.88	14.31	18.63	16.88	14.88	14.63	15.56	14.81
Panicum miliaceum	11.69	11.5	13.69	13.63	12.19	11.50	11.88	11.69
Paspalum scrobiculatum	not tested	not tested	7.44	7.38	not tested	not tested	8.00	8.00
Setaria pumila	not tested	not tested	13.13	12.19	not tested	not tested	6.63	6.38
Oryza sativa	6.75	6.69	7.19	6.88	6.56	6.25	7.44	7.31

* (N x 6.25) on dry basis.

Heating grains

Beaten rice (*chiura*, *chura*, *aval*) is expected to be thin, papery, friable and as broad in shape and as white in colour as possible. Paddy is soaked in water for 2 or 3 days till soft, and the same water is brought to the boil for a few minutes and cooled. The swollen grains are next placed in a concave iron or earthenware pan over a strong fire till the grains burst, after which they are pounded with a pestle to flatten the grain and remove the husk, which is thereafter winnowed away (Figure 53, Figure 54) (Nakao 1972, Achaya 1984). Nakao (1972) had written that *Yakigome* is the completely same food as *chiura*, but their cooking processes are different in boiling and parching (Kimata 1991, Nakao 1972). He added that this cooking method had been dispersed from India to Japan at very old times, and then it had disappeared in the intermediate region. Therefore, it had isolated in India and Japan.

In this case, I think that those cooking method had originated independently in Japan (Figure 44cde), and *Yakigome* had not dispersed from India. For example, Popcorn had been very old traditional food for the native American since 3600 BC. The basic cooking methods had been independently begun in many original places, but the conjoint cooking method had been made the agricultural complex with crops under their domestication process, and then it had been dispersed centrally from the original area by our ancestors.

Parched paddy (puffed rice, *muri* or *murmura*) is produced as follow. Parboiled rice is preferred for puffing, and the rice in handfuls is thrown into very hot sand held in *kadai* over the fire. The sand is turned around with a metal ladle, and as soon as the begins to swell and crack, the contents are poured off into a sieve; the puffed rice is collected, and the hot sand retrieved for reuse. Rice steeped in or roasted with salt water is used for parching in eastern India (Figure 54 and Figure 55ac). Commercial units consisting of roasting cylinders through which the rice travels in hot sand, which is sieved through and passes back into the cylinder, are now commonly in operation. White, glistening, plump grains are what the user expects of puffed rice (Achaya 1984). Japanese children

have called it *pakkan* or *ponsen*.

Laja (parched paddy) is a soft, light, whitish, commonly edible food product prepared by roasting paddy. According to Ayurvedic classics, Laja has *deepan*, *laghu*, *grahi*, *snneha*, *kapha-meda-chedak*, *balya*, *rasayan* and *ojo-vardhak* properties and it has been widely used as a remedy for *chardi*. Classical uses of Laja, its method of preparation, difference from parched rice, change in nutritive value during parching and its future research aspect (Awantika, J. et al. 2015).

Wheat that is specially broken, or emerges broken from threshing, is termed *dalia* and is used as a sort of boiled porridge. Like rice, wheat can also be puffed; the friable puffed product can be ground into a flour called *sattu* which being pre-cooked can be rapidly finished into various foods (Figures 54 and 55).

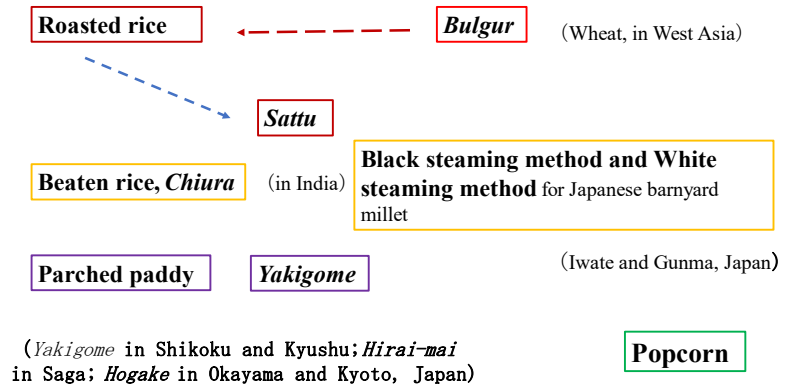


Figure 54. Heating grains by roasting, boiling, and parching

Figure 55. Parched grain of common millet

a, thrown into very hot sand held in *kadai*; b, *upitu*; c, parched rice grain.

Indian food culture

Indian food culture has been a reflection of the people's heritage. It represents India's historical

development, religious beliefs, cultural practices, and above all, geographical attributes (Sahni 1986). In the Indian subcontinent, staple foods made using grain crops are served with various types of spicy curries and legume *dal* stews (*dhal*). Many unique cooking styles can be found for each cereal in any part of the subcontinent (Aziz 1983, Sahni 1986). Cooking of cereals forms an important part of the agricultural culture complex (Maeshwari 1987, Sakamoto 1988).

Several species of millets have formed staple foods since ancient times throughout Eurasia. Especially among them, *Panicum miliaceum* and *Setaria italica* have been cultivated in areas covering almost the whole of Eurasia. According to archaeological evidence, these two kinds of millets are considered to have been used as the staple food of Neolithic Yan-Shao people of North China, and at the same time to have been cultivated in Neolithic villages all over Europe through the fourth millennium BC (Sakamoto 1987a, 1987b).

Foods made using millets

People have cooked many types of food using millets and cereals. Mainly *bhat* (*meshi* in Japanese), *roti* (*pan*), and *mude* (*oneri*) are cooked because they are frequently made using most of the cereals listed in Table 42 (Kimata 1987). *Bhat* is the most popular food, a boiled grain food made using all the ingredients shown in Figure 59ad. *Bhat* originated in ancient China and was brought to the Indian subcontinent via Eastern India. *Roti* is also a popular food made from cereal flour and originated from the cooking of wheat bread in the Fertile Crescent and was brought to the subcontinent via Western India. *Mude* is a popular food made from cereal flour and originated from the cooking of *ugari* brought from Eastern Africa via the Arabian Peninsula. Figure 59 shows cooking methods for cereals in the Indian subcontinent: (a) a traditional boiled rice with *papad* (crispy salted wafer made from *dal,* vegetables, and cereals); (b) *upma* and *kesari bhat*; (c) *dosa*; (d) *mude* and boiled grain made using *Brachiaria ramosa*; (e) *puli*; and (f) *idli*.

Table 42. Millets and their food in Indian subcontinent

Species name	Food								
	Indian name	bhat	upuma	roti	vada	dosa	idoli	mudde	ganji	mave
	Japanese name	meshi		pan	age pan		mushipan	oneri	konagayu	shitogi
Sorghum bicolor		○	○	◎	○	△	○	○	○	
Pennisetum americanum		○	○	◎				○	○	
Eleusine coracana		△	○	○	○	○	○	◎	○	
Setaria italica		◎	△	△	○	○		○	○	○
Panicum miliaceum		◎	△	○	△			○	○	
Panicum sumatrense		◎	○	△	○	○		○	○	
Paspalum scrobiculatum		◎		○				○	○	
Echinochloa flumentacea		◎	△		○			○	○	
Brachiaria ramosa		◎		○	○			○	○	
Setaria pumila		◎		△				△	△	
Digitaria crusiata		◎		○						

◎, main ingradient used; ○, generally; △, rarely or suppliment mixed.

Cooking methods of boiled grains

Anna is a kind of boiled grain and is homologous to the East Asian one, for example, *bhat*, *chawal*, *sadam*, *annamu*, etc. in India; *meshi* in Japan). As shown in Figures 56, 57 and 58 60, anna is made from crop grains in two ways, the “draining off” and parboiling methods in India, while it

is done by the “drying up” method in East Asia. The draining off method is a traditional one in India. The excess hot water when boiling grains is drained off, and thus grains become soft, non-sticky and flavour-full. Indian people like these characters of boiled grains. The parboiled method is maybe considered one of the oldest processing techniques for cereals, especially for millet grains. “Parboiled” means pre-boiling raw grains before polishing them. By this process the grain can easily polished, the nutrients contained in the seed coat permeate into the endosperm, and then the polished grains are in a very good condition for eating. Recently, some urbanized people in India cook rice with the drying up method, because they use rice-cookers to save time and to keep the nutritive value which is lost by draining off the excess hot water.

Anna is eaten with many kinds of curry, *dal*, *sambar* (a kind of spicy stew), *rasam* (spicy soup), pickles, yogurt, salt, plant oil, and so on. There are many variations of rice *anna*, for example *pullao* and *biryani* (rich *pullao*), which are special festival foods in India.

Figure 56. Anna (boiled grain; *bhat*, *chawal* etc.) in India:

a, cooking utensils to the hot water removal method; b, anna made from rice; c, *chawal* made from foxtail millet and sorghum in farmer’s lunch box; d, *chawal* made from *samai* (*Panicum sumatrense*); e, *chawal* on the thali; f, *ketsali bhat* made from rice and *upma* made from *Triticum durum*.

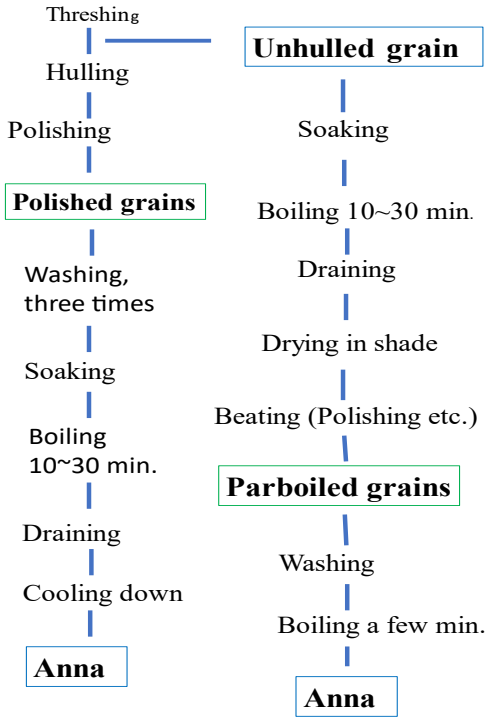


Figure 57. Cooking process of *Anna* (boiled grain) in South India

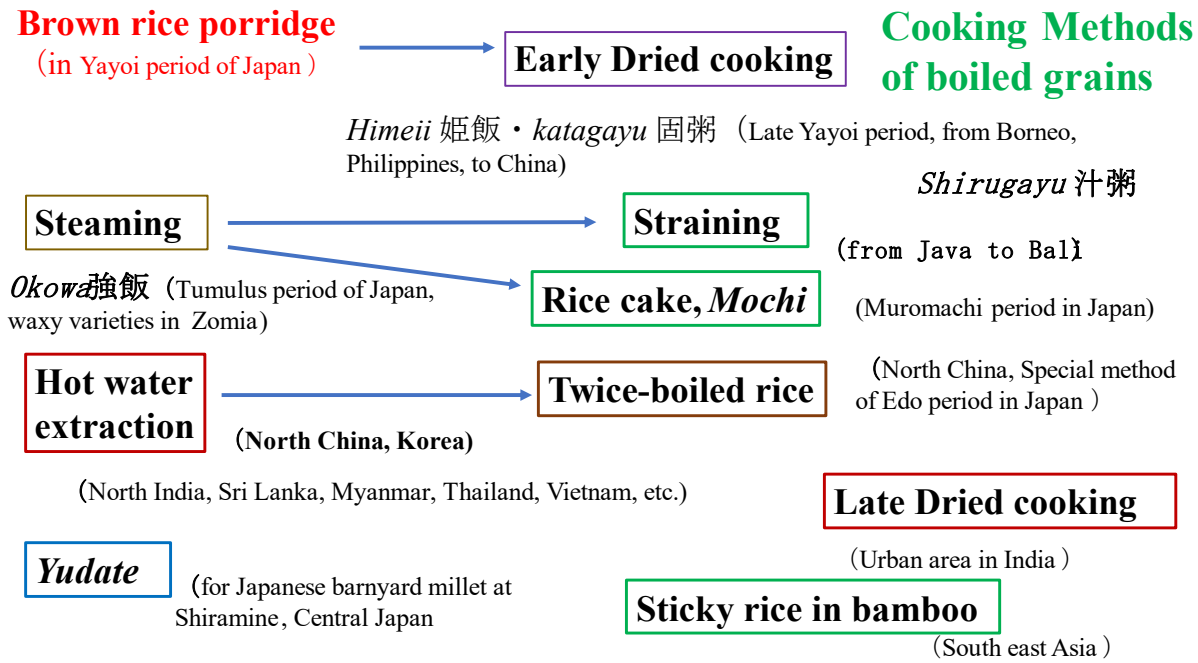
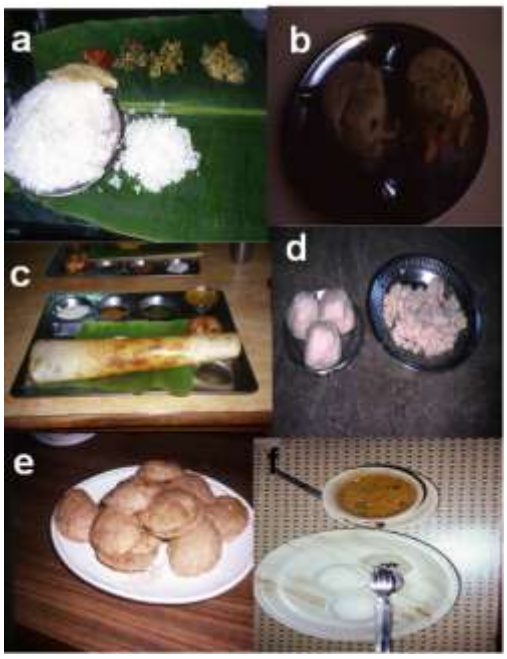


Figure 58. Cooking methods of boiled grains

Upma

Upma is made from ground coarse grains as shown in Figure 59b and Figure 60. This food is eaten mostly at breakfast. *Upma* is a spicy and nice smelling food which is mixed with chilli, ginger, ground nut, and yogurt or lemon juice



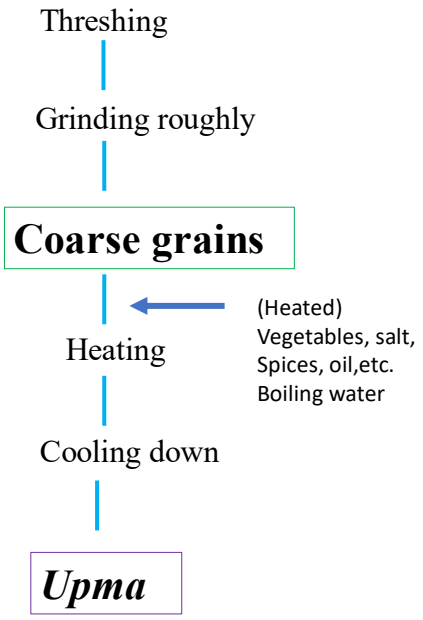


Figure 59. Cookeries of cereal in the Indian subcontinent:

a, a traditional boiled rice (*bhat*) with *papad*; b, *upuma* and *khesari bhat*; c, *dosa*; d, *mude* and boiled grain made from *Brachiaria ramosa*; e, *puli*; f, *idli*.

Figure 60. Cooking *upma*

Chapati, *roti*, and their variations

Chapati is the easiest form of Indian bread and the most familiar among the people (Aziz 1983). *Chapati* is an unleavened bread which is made from whole wheat flour as shown in Figure 62. Indian people wrap chapati in a dishcloth, and keep it warm in moderately heated oven before serving. They eat *chapati* with curry and dal stew (Figure 63a). The difference between chapati and roti is not clear. *Chapati* is called in some parts of India. In some other languages again, *roti* refers only to the loaf of bread bought from shops or delivered to the house from professional bakeries (Rangarao 1968). In this case the author temporarily calls the pancake made from whole wheat flour (*atta*) *chapati* and the others made from millet or bean flour roti.

Parautha is also a variation made from wholemeal flour, much thicker than *chapati* and lightly fried in oil (*ghee*). *Puri* is a deep-fried *chapati* (Figure 61c) and is traditionally eaten with *chenna* chutney made with whole chick peas at breakfast (Aziz 1983).

Nan is a semi-leavened bread made from fine wheat flour (*maida*) as shown in Figures 61a and 64. It had been introduced from West Asia in ancient times. Traditionally, *nan* is the perfect accompaniment to *tandoori* food, it is usually prepared in clay oven known as *tandoor* (Aziz 1983). Therefore, South Indian people seldom make *nan*.

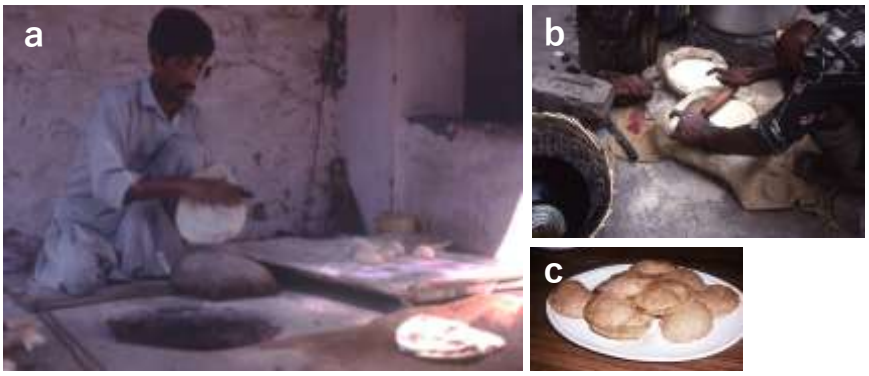


Figure 61. Food made from wheat, *Triticum aestivum*:

a, *nan*; b, *chapati*; c, *puri*.

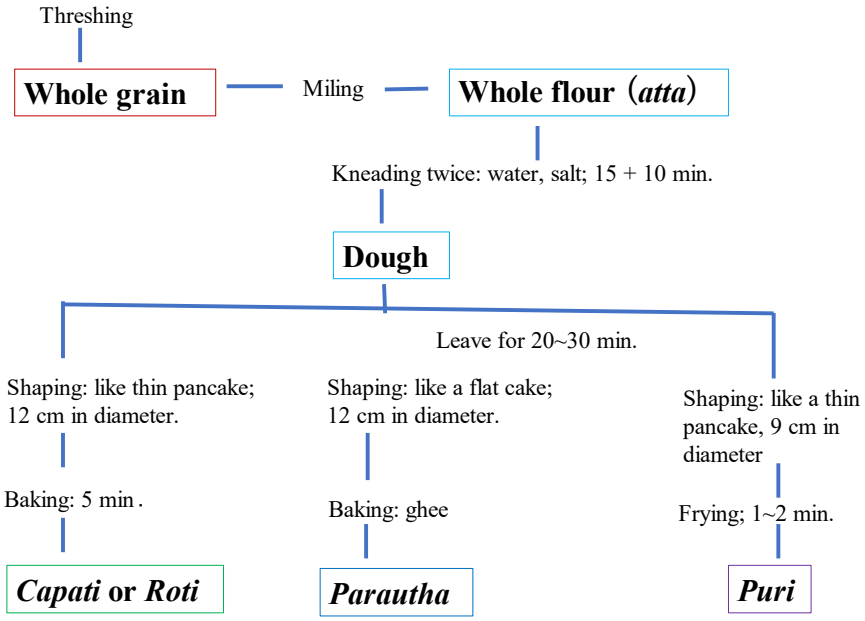


Figure 62. Cooking of *chapati, parautha* and *puri*

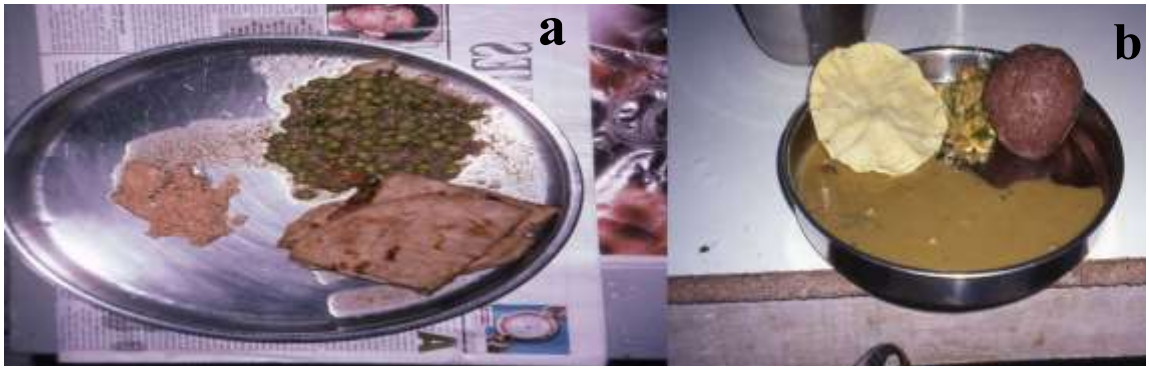


Figure 63. *Chapati* or *mude* on *Thali*

a, *chapati* from wheat; b, *mude* from finger millet, *Eleusine coracana.*

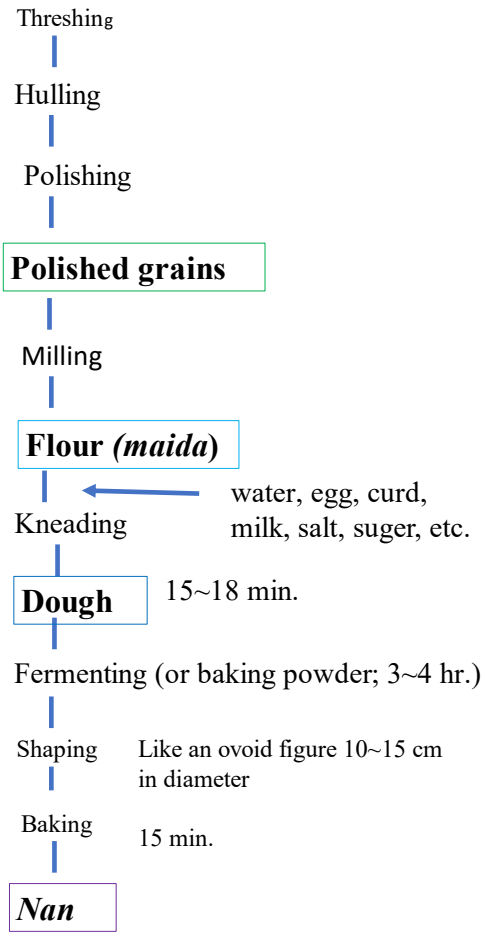


Figure 64. Cooking *nan*

Some other fried foods

Vada (*amavadai*) is a doughnut shaped or round flat cake made from freshly ground *dal* or millet flour, spiced with chilli, ginger, or onion, deep fried to golden brown colour in peanut oil.

Papad is a crispy salted wafer made with *dal* (many kinds of beans), vegetables, and cereals. This food is a deep-fried circular wafer, thin like paper, and golden yellow (Figure 63b). Those beans are *Cajanus cajan*, *Cicer arietinum*, *Lens culinaris*, *Pisum sativum*, *Vigna mungo*, and *Vigna radiata*.

Murukku is a rice (and *dal* or millet) flour snack in the shape of coil, moulded by hand and fried in oil (Skelton and Rao 1975).

Dosa* and *idli

Dosa is a South Indian thin leavened pancake, made from batter, the basic ingredients of which are ground parboiled rice (*cela*) and husked split black bean (*Phaseolus vulgaris* L.) as shown in Figure 59c and Figure 65. This food is also made from wheat, oat, pulse, and so on (Lal 1974). *Dosa* is stuffed with potato curry or dipped in *sambar* and chutney.

Idli is a leavened poundcake made from the same ingredients as *dosa* (Figure 59f and Figure 65). However, *idli* is a steamed food, while *dosa* is fried. The former has been cooked at least for 40 years ago in South India, as rice consumption increased and *idli katoris* (pressure cooker) became

popular. There are two types of the stone griding mortar for preparing *dosa* and *idli* paste, manual or electromotive. *Idli* is eaten with sambar and chutney.

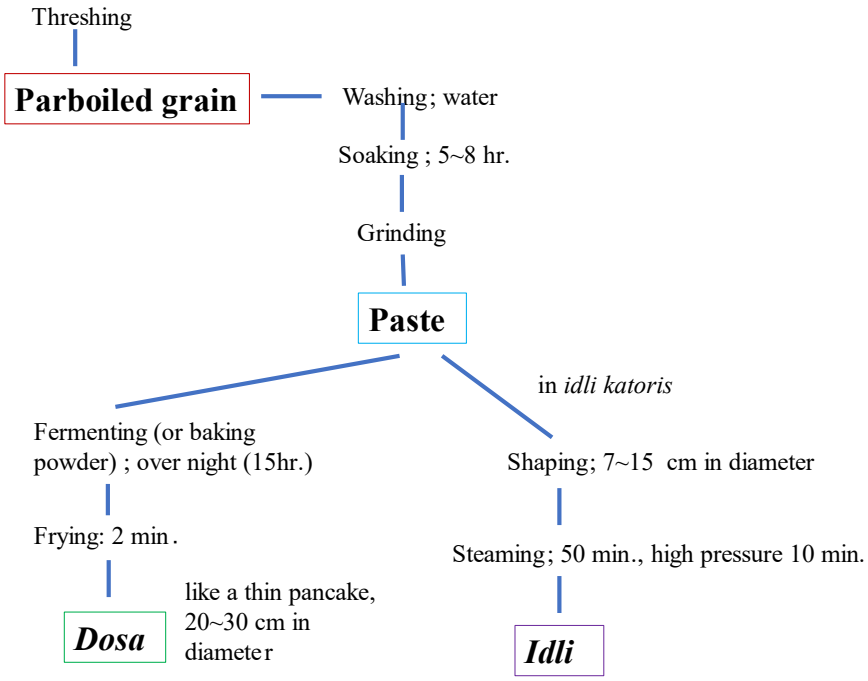


Figure 65. Cooking method of *dosa* and *idli*

Samosa is a deep-fried snack, consisting of a crisp, triangular and layer wheat casing filled with spiced meat or vegetables. In about AD 1300 Amir Khusrau describes, among foods of the Muslim aristocracy in Delhi, the *samosa* prepared from meat, *ghee*, onion, etc (Figure 66a). About fifty years later Ibun Battuta calls it *samusak*, describing it as 'minced meat cooked with almonds, walnuts, pistachios, onions and spices placed inside this envelope of wheat and deep fried in *ghee*' (Achaya 1977).

Figure 66. *Samosa* and Festival foods on banana leaf

There are two main cooking methods of bread, one is unleavened, and another is leavened. *Chapati*, *puri*, *paroatha* and *roti* are unleavened breads, while *nan* and many kinds of breads are leavened breads. These had been originated in Near East, North Africa, India and Europe with the grain crops of Triticeae. Noodles and *baozi* had been made around China via Central Asia to Europe as shown in Figures 67 and 68. There are three cooking methods of noodles, that is, hand-pulled, stretched and extruded.

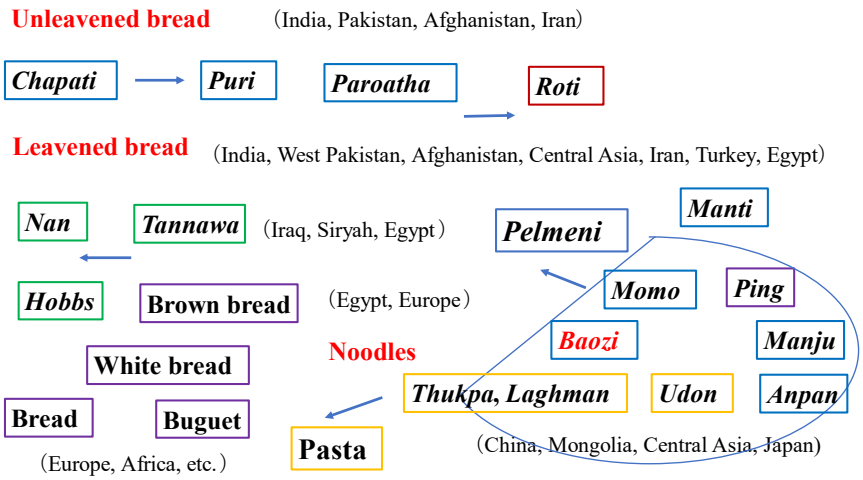


Figure 67. Cooking and Food from wheat flour

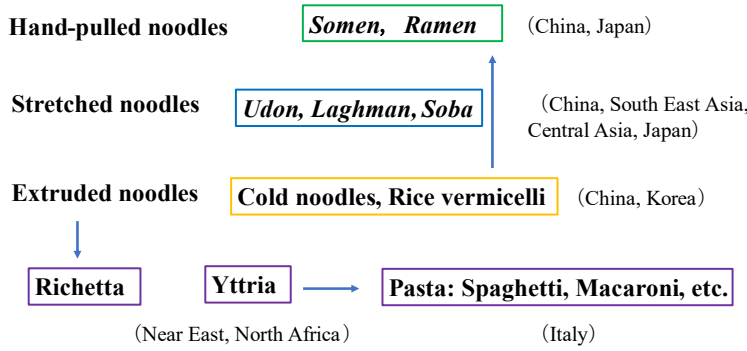


Figure 68. Three cooking methods of Noodles

Mude and *ganji*

Mude (*kali*, *sankati*) is a kind of starch-paste made from millet flour. Mude is homologous to *dhido* in Nepal and *oneri* in Japan. In South India *mude* and *anna* are the most popular ways to cook the staple foods. *Ganji* is a kind of very thin starch-paste made from the same ingredients as *mude* (Figure 69). *Ganji* requires a larger volume of water at boiling than *mude* (Figure 70).

Porridge is made from two millets in South Asia and Europe, and is called *waji* (Halmahhera Islands), *mude* (India), *kochi* (Afghanistan), *mamalyga* (Caucasia), *ugre* (Turkey), *pcheno* (Bulgaria), *māmāliga* (Romania), *polenta* (Italy), *millat* (France), and so on. In some countries dumplings and flour porridge are made from these millets. Dumplings are called *shito* (Ainu people in Hokkaido, Japan), *abai* (Formosa), sweet *ladu* (Pakistan). Flour porridge made from foxtail millet is called *kosayo* (Ainu people), *ganji* (South India), and so on. Bread is mainly made in India and Eastern Europe, and is called *roti* (India), *tathui* (North Pakistan), *kulsik* (Caucasia), *prosenic* (Bulgaria) and so on.

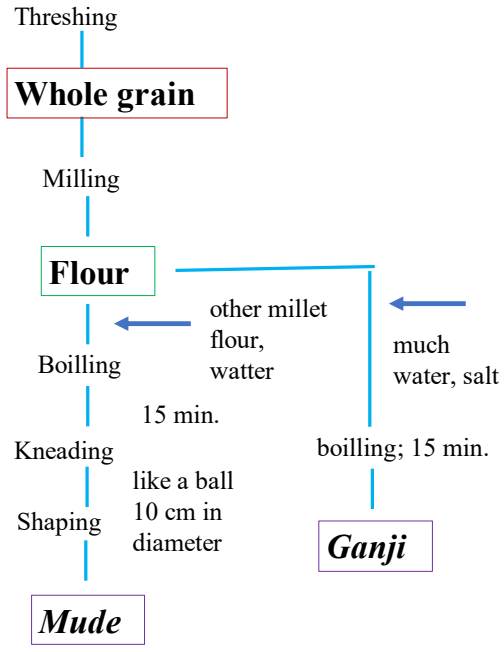


Figure 69. Cooking *mude* and *ganji*

Figure 70. Ganji made from Sorghum and finger millet

Also in Japan, many foods have been made from sorghum as shown in Figure 71. For example, *dango* is made from finger millet in Gunma, *hecchoko-dango/ ukiuki-danngo* are made from sorghum in Iwate, and *mochi* from sorghum in Yamanashi. These millets, finger millet and sorghum had dispersed from Africa, via India and China to Far East Japan together with their same cooking methods. Even now it is an amazing story of the agricultural culture complex.

Figure 71. Many foods made from sorghum in Japan

a, *Dango* made from finger millet in Gunma; b, *Hecchoko-dango* made from sorghum in Iwate; c, *Ukiuki-dango* made from sorghum in Iwate; d, *Mochi* made from sorghum in Yamanashi.

Comparison of cultivation, processing and cooking methods between *korne* and *korati*

The various food preparations made from *korne*, *Brachiaria ramosa* are shown in Figure 72. Nine kinds of food can be classified as grain and flour foods. The grain foods include boiled grain (*anna*) and sweetened gruel (*kheer*). The broken grain is used for preparing semi-solid porridge (*nuchina mudda*). There is no practice of parboiling grains. In the Tumkur district, farmers usually eat *anna* twice a month, but *kheer* only on festivities. Flour foods consist of unleavened bread (*roti*), leavened thin pancake (*dosai*) and a few deep-fried snack foods (*nippattu*, *chakkulli*, *haralu*, *kodubale* and *kadabu*). The grain foods are prepared by boiling with water, while the flour foods are prepared by baking or frying with vegetable oil (Kimata, M., E.G. Ashok and A. Seetharam 2000).

The grain foods of *korne* are prepared as follows: 1) *anna*. The polished grain was first washed in water, then put into a pot with hot water and boiled over a strong fire for about 6 min. with occasional stirrings with a spatula; excess water is drained off; and then that grain is again steamed over a weak fire for 3 min. The cooked *anna* is served with *sambar* (a kind of spicy vegetable stew) or yogurt. 2) *kheer*. Grain is boiled with a larger quantity of water until it becomes tender, and is mixed with sugar or jaggery to make it sweet and bring it to the consistency of gruel. Fried groundnut

is used for dressing the *kheer*. *Kheer* is also a good food for nursing mothers. 3) *nuchina mudda*. The broken grains and finger millet flour are mixed in a 1:4 proportion and added to boiling water and cooked for 3 min.; They are well kneaded using a flat wooden stick. This batter is put on a wooden plat, kneaded with an iron spatula, and hand-shaped into a ball.

The preparation of six flour foods are as follows: 1) *roti*. The flour is kneaded with water and mixed with chopped onion. Chopped green chilies, broken groundnut and salt are added to taste. This thick dough is shaped into a flat round pancake by hand or rolling pin, and then baked with a spoonful of oil in a frying pan (*hanch*) on both sides. 2) *dosai*. Flour is mixed with water to form a thin batter which is spread on a frying pan and baked with a spoonful of vegetable oil for about 4 min. The baking process for *dosai* and *roti* are more or less the same. *Dosai* is normally served with a side dish of chutney (made of grated coconut and spices) and *sambar*. 3) *nippattu*, *kodubale* and *chakulli*. These are deep-fried snack foods prepared by mixing flour of *korne* with black gram flour or maida (specific fraction of wheat flour) in various proportions. Fried Bengal gram and groundnut are mixed while preparing the dough for *nippattu*. 4) *kadabu*. Flour of *korne* is made by mixing with water. A small quantity of this dough is taken and flattened using a rolling pin and then stuffed with sweet ingredients, and deep-fried in groundnut oil until golden brown.

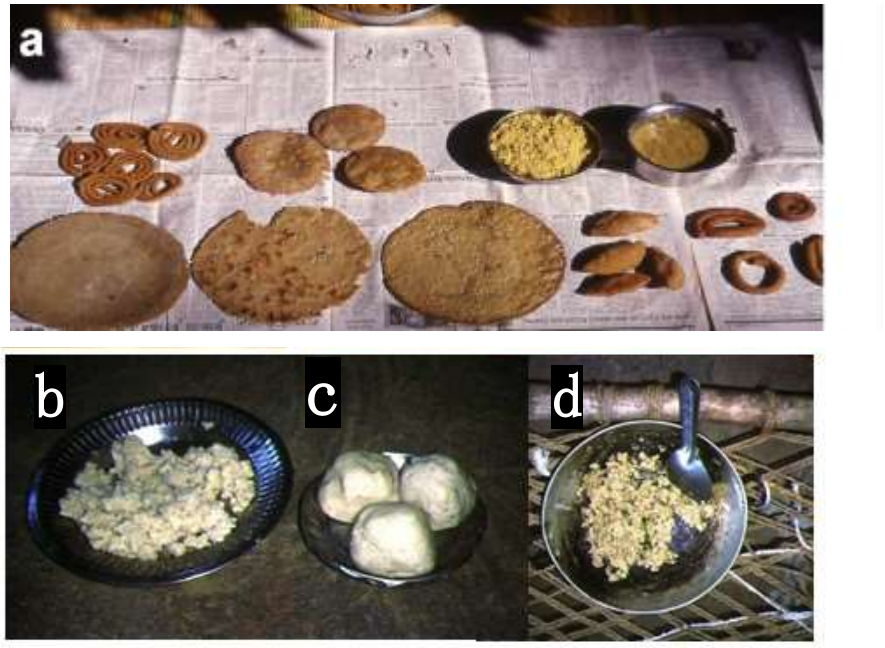


Figure 72. Cooking methods of *korne* and *korati*

a, nine sorts of foods made from *korne*; b, *annam* made from *korati*; c, *sankati* (syn. *mude*); d, *uppitu*.

The grains of *korati*, *Setaria pumila* (syn. *S. glauca*) are used in many food preparations, boiled grain (*anna*), unleavened bread (*roti*), porridge (*sankati*) and thin gruel (*ganji* or *peja*) in South India. *Korati* grains are cooked together with little millet in all these. The parboiled *korati* was observed only once during the survey in Orissa state. At Jalaripalli village, surveyed in 1997, six kinds of food were made.

The grain foods of *korati* were prepared as follows: 1) *annamu*. The process is almost the same as *anna* made from *korne* in Karnataka. 2) *sankati*. Cooked *annamu* is kneaded by wooden

sticks and then shaped into ball. 3) *ganji*. Cooked *annamu* is added to boiling water, a little salt and pepper, and mixed. 4) *uppitu*. The broken grains are first washed in water, vegetables such as chili and onion are fried with coriander, mustard seed, chili powder and salt in vegetable oil; fried vegetables are boiled adding water and the broken grains. 5) *kheer*. Broken grains are boiled with large quantities of water until tender, excess water is drained, and that grain is mixed with sugar.

Roti is the only flour food made from the mixed ingredient. The process is the same as *roti* made from *korune*. Both *sankati* made from *korati*, and *nuchina mudda* made from *korne* are modified grain foods, but the *mude* made from the other cereals are usually made from flour and are thus generally classified as flour foods. Apparently, these grain foods are new variations that have appeared in rather recent times.

History on processing and cooking methods of cereals

The porridge was very simple processing/cooking methods in ancient times. Coarse ground porridge and roasted grains of barley/wheat had been one of the oldest foods as shown in Figure 73. Also, roasted ground porridge had been an ancient cooking method in Near East area. Moreover, many methods of flour porridge methods are shown in Figure 74.

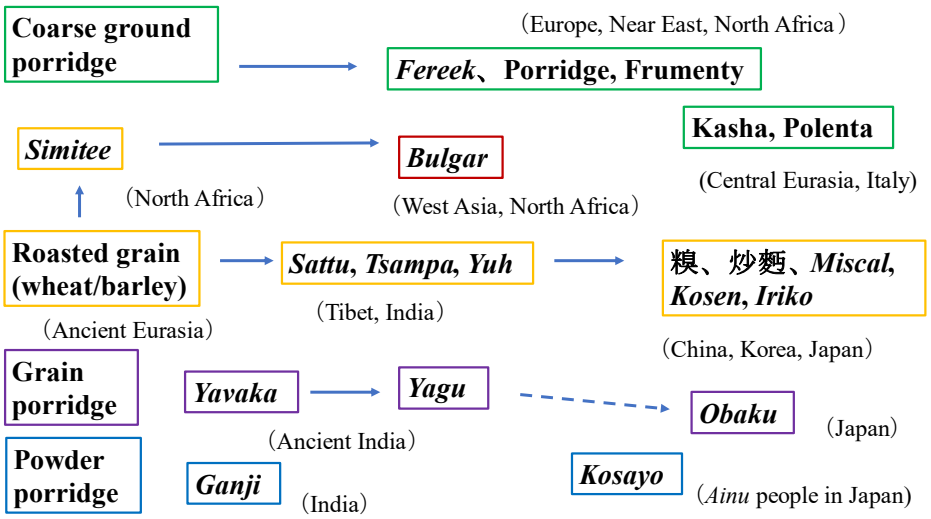


Figure 73. Many kinds of porridge cooking methods

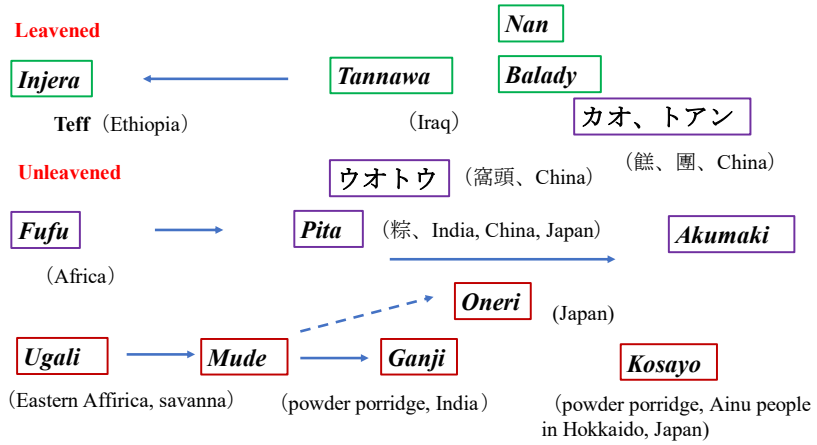


Figure 74. History on flour foods

Fermented drinks and foods

Sherpa people say that *kodo chan* has the best taste of all (finger millet, rice, wheat, barley, and maize) in Nepal. *Kodo* is finger millet in Nepal, but it is not *kodora* (*Paspalum scrobiculatum*). They obtain fermented *chan* (a crude alcoholic drink) or *roksi* (a distilled alcoholic drink) from grain as shown in Figures 75 and 76. Newar people ferment *chan* with the malt of barley, while the Sherpas do so with malted buckwheat. In the traditional manner, Serpas suck *kodo chan*, which has been diluted with boiled water, through a bamboo straw (*chapshing*) from a certain kind of vessel (*tongba*). Similarly,

Non-alcoholic drinks are made in Caucasia and Eastern Europe, and are called *buza* (Caucasia), *boza* (Bulgaria), *mied* (Romania) and so on. Alcoholic drinks are made mostly from waxy grain only in East Asia. Before the process of alcoholic fermentation, the cereal grain (starch) including several millets is saccharised by *koji* (*Aspergillus oryzae*) in East Asia and India, while it is done through malting in Europe and Africa (Nakao 1967). This difference may be related to the following characteristics of grains. The covered grains of Asian millets must be dehusked and then polished before using them, while the naked ones of African millets do not need such processing.

Sorghum bicolor and *Pennisetum glaucum* are mainly used for making *roti*, while *Eleusine coracana* is mostly used for making *mude* and fermented alcoholic drink *chan* (Figure 75 and 76). With respect to fermented foods, a starter is made from *Hordeum vulgare* (Figure 75c, starter; 75d, a jar for fermentation; 75b, alcohol drink, *chan*, made from *Eleusine coracana*; and 75e, yogurt, *dahi*.

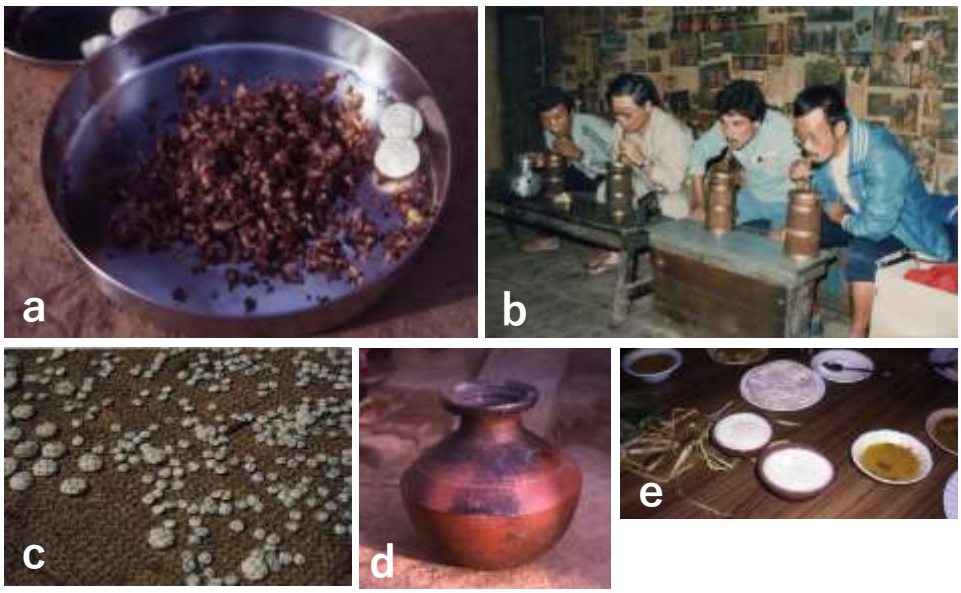


Figure75. Ferment foods

a, yeast made from barley, *Hordeum vulgare*; b, a vessel for fermentation; c, alcoholic drink, *chan* made from finger millet, *Eleusine coracana*; d, yogurt *dahi*.

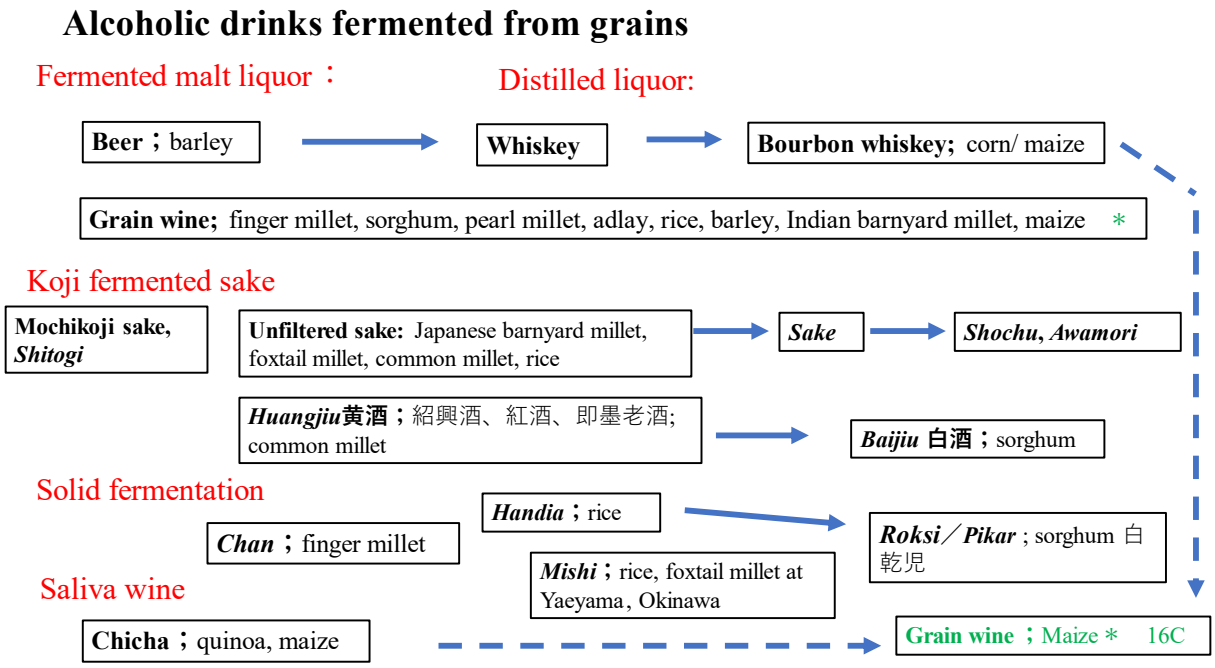


Figure 76. Alcoholic drinks fermented from grains

Food preparation and secondary compounds in grain

The Eurasian foods made from common millet are classified into four processing methods: grain, coarse-ground flour, fine flour, and drinks. Asian people cook boiled grain and porridge from the polished grains of non-glutinous varieties. Especially, East Asians cook steamed grain and *mochi* (a kind of cake) from the polished grains of glutinous varieties and ferment alcoholic drinks from polished grains of both non-glutinous and glutinous varieties. Inner Mongolians drink daily milk tea

with roasted grains. Uzbeks top *non* (a kind of bread) with colored grains and cook milk porridge from non-glutinous varieties for lunch at a nursery school. Europeans cook milk porridge from coarse-ground flour, bread from fine flour, and ferment non-alcoholic drinks from polished grains of only non-glutinous varieties. Based on the endosperm starch in seed grains, the varieties were divided into two glutinous or non-glutinous categories. The distribution of glutinous varieties of common millet and *Setaria italica* were restricted to eastern Asia. On the contrary, the geographical distribution of phenol color reaction to seed coats in *S. italica* was very similar to that of *Oryza sativa*, but the distribution in common millet was different from the trends in *S. italica* and *O. sativa* (Sakamoto 1982, Kawase and Sakamoto 1982, Kimata and Negishi 2002).

The four types of local varieties of common millet were categorized by the composition of the minor fatty acids arachidic, behenic, and eicosapentaenoic acid. If the ancestral prototype was the weedy AE type containing arachidic and eicosapentaenoic acids, the AB type (arachidic and behenic acid) may have been bred both in Europe and Asia, while the ABE (all three fatty acids) and O (no fatty acids) types may have originated around Central Asia and then spread to both Europe and Asia (Kimata et al. 2007).

Cereals with waxy endosperm are used to make staple foods not only in Japan, but also in various other countries of East Asia. Waxy endosperm is found in common millet, foxtail millet, Job's tear (adlay), sorghum, rice, barley and maize. From all the information obtained concerning these seven cereals that have waxy endosperm varieties, the following conclusion can be drawn. The waxy varieties of foxtail millet (Figure 77), sorghum, adlay, rice and maize are distributed over wide areas of East Asia from the mountainous regions of Assam to Japan. The waxy forms of common millet and barley are confined to China, Korea and Japan. On the other hand, they are never found in the western half of Eurasia, the areas ranging from India to Europe, Africa and the New World (Sakamoto 1982).

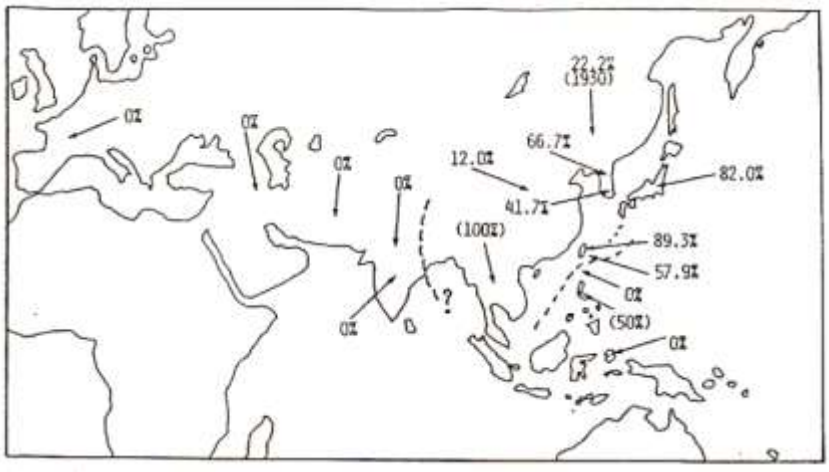


Figure 77. Geographical distribution of the waxy landraces of foxtail millet.
Each rate (%) shows the percentage of waxy landraces in respective region (Sakamoto 1982)

The millets grown in Eurasia have been classified into four groups according to geographical origin. These were dispersed from a certain domesticated region throughout the Eurasian land mass during pre-historic ages. The processing and cooking of millets is the most important parts of basic

agricultural culture complex. Therefore, a comparative study on processing and cooking methods must help to clarify the geographical origin and dispersal of a given millet (Kimata 1987, 1989). The processing and cooking methods used for the following four groups of millets are compared in order to study the relationship between processing and cooking methods and dispersal of millets into South and East Asia.

Common millet and foxtail millet (Group I)

Since ancient times many traditional foods and drinks have been made from common millet and foxtail millet extensively in wide area of Eurasia. The preparation oof boiled grain, gruel, *mochi* and alcoholic drinks is popular in East Asia, while meal porridge, bread and non-alcoholic drinks prevail in Southeast Asia and Europe as shown in Table 43 (Sakamoto 1987a, partly modified). Boiled grain is made from waxy and non-waxy grain, but the former grain is supplementally used for the latter. It is called *meshi* (Japan), *anna* (India), *gharaji* (Pakistan) (Kawase and Sakamoto 1989) and so on. Gruel is made only non-waxy grain in East Asia, while *mochi* is make only from waxy grain.

Table 43. Foods and drinks made from the grains of common millet and foxtail millet in Eurasia

Region	Types of cooking								
	Grain			Meal	Flour			Drink	
	Boiled grain	Gruel	Mochi	Porridge	Dumpling (dango)	Flour porridge	Bread	Non-alcoholic	Alcohlic
Japan									
non-waxy	○	○			△				
waxy	○		○		○	△		○	○
Korea									
non-waxy	○								
waxy	○		○						○
China									
non-waxy	○	○					○		○
waxy			○				○		○
Formosa									
non-waxy	○								
waxy	○		○		○				○
Batan Island				○					
Halmahera Islands				○					
India	○			○		○	○		
Pakistan	○				△		○		
Afghanistan				○			○		
Caucasia				○					○
Turkey				○					
Bulgaria				○			○		○
Romania				○					○
Italy				○					
France				○					

(Sakamoto 1987a modified)

Indian millets (Group IIa)

Indian cookery has enriched over a period of many centuries by different cultures that were super-imposed with each new wave of invaders. These invaders introduced new cooking ingredients and techniques that late spread to different regions of the Indian subcontinent, but mostly enhancing and refining the North, where the new hordes primarily settled because of the similarity of climate and landscape to those that they came from. Furthermore, natural barriers and great distances made

migration to the South slow and infrequent (Sahni 1986).

Many cereals accompanied each cooking method introduced many times from several regions into Deccan Plateau. *Chawal* (boiled grain) made from Asian millets (Group I and IIa) and rice is often made in Eastern India, while *roti* (bread) made from millets (mainly Group IV) and *Chapati* (unleavened bread) made from wheat that are modified from Mediterranean flour food frequently made in Western India as shown in Table 44 (Kimata 1987).

Mude modified from African meal porridge (mainly Group IV) is often cooked from many kinds of cereals restricted to South India and Nepal (also In Japan), but not in North-Western and Central India. Generally speaking, the characteristics of Indian cookery are divided into two main parts, i.e., the North and the South, delineated by a line writing from Bombay (Mumbai) to Hyderabad. *Mude*, *ganji* (flour porridge), *dosa* (thin leavened pancake) and *idli* (leavened poundcake) are also frequently cooked only in South India. The diversity of cooking styles is the most remarkable in Tamil Nadu. Going toward the West, there is a decrease in the variety in the cooking styles and the farmers mainly eat *chapati* and *roti*. However, going toward the East while the same tendency occurred farmers eat mainly *chawal*.

Table 44. Cereal cooking styles and their ingredients in India

Grope	Cooking												Total
Ingredients	*Chawal*	*Upuma*	*Chapati*	*Roti*	*Non*	*Puri*	*Wada*	*Dosa*	*Idli*	*Mude*	*Ganji*	*Mavu*	
I													
Pan. miliaceum	○	△		○			△			○	○		6
Se. italica	○	△		△			○	○		○	○	○	8
II a													
B. ramosa	○		○	○						○			3
Ec. frumentacea	○	△					○			○	○		5
Pan sumatrense	○	○		△			○	○		○	○		7
Pas. scrobiculatum	○			○						○	○		4
Se. pumila	○			△						△	△		4
IV													
El. coracana	△	○		○			○	○	○	○	○		8
Pe. americanum	○	○		○						○	○		5
So. bicolor	○	○		○			○	○	○	○	○		8
O. sative	○	○					○	○	○	○	○	○	8
H. vulgare		○		○				○	○	○	○		6
T. aestivum			○		○	○		○		○	○		6
T. dicoccum		○							△				2
T. duram		△	△			○			△				4
Z. mays	△	○		○			△			△	○		6
Total	12	12	2	11	1	2	8	7	6	14	13	2	90

The grain of adlay (**Group IIb)** is ground into flour and is either used to make bread or a sweet dish is prepared by frying the grain and adding sugar. The whole grain is also eaten raw as a snack, or fermented to produce beer in Assam (de Wet 1989). Adlay is also used to make *prisan* (a non-alcoholic drink) in Korea and Japan, meal porridge in Formosa and Halmahera Islands, and *mochi* in Korea and Formosa.

Japanese barnyard millet (**Group III**) is used to many kinds of foods in Japan i.e., boiled grain (*meshi*), gruel (*kayu*), *hie-mochi* (made from non-waxy grains), meal porridge (*oneri*), dumplings (*dango*), flour porridge, and alcoholic drinks (*doburoku*). In Cheju Island, Korea, this millet may be used to make boiled grain.

African millets (Group IV)

In Afro-Eurasia various foods and drinks have been made from the grains of African millets as shown in Table 45 (Esele 1989; Jiaju 1989: Kimata 1983, 1987, 1989; Malleshi 1989; Rao *et al*. 1985; Sakamoto and Fukui 1972; Sakamoto *et al.* 1980; Shigeta 1987; Takei 1984). Boiled grain is mostly made from sorghum in South-East Asia, and is called *meshi* (Japan), *chawal*, *anna*, *bhat*, *sadam* etc. (Indian subcontinent). It is traditionally made by the "drying up" method in East Asia, while it is done by "draining off," hot water removal method in Indian subcontinent. Gruel (grain) is not made from any African millet. *Mochi* (a kind oof cake made from grains with waxy endosperm) is made from sorghum in Japan and Korea, and is called *mochi* and *docok*, respectively. Meal porridge is made from finger millet, sorghum and pearl millet in East Asia, India, and Africa, and is called *oneri* (Japan), *dhido* (Nepal), *mude*, *kali*, *sankati*, *onda*, etc. (India), *ugari* (Uganda), *kwon* (Sudan), *tō* (Ghana) and so on. This meal porridge has been a very important staple food in Africa and India. The dumpling (*dango*) is only made from finger millet and sorghum in Japan. Flour porridge is made from all three African millets, and is called *ganji*, *kulu* (India), *nyoka* (Sudan), *koko* (Ghana). Bread (*roti*) is made from African millets only in the Indian subcontinent. Non-alcoholic drinks are made from only finger millet in India and Uganda. Alcoholic drinks are fermented from all three millets mostly in the Indian subcontinent and Africa, and is called *chan* and its distilled *roksi* (Nepal), *handia* (Bihar, India), *talla* and its distilled *araki* (Ethiopia), *kongo* (Sudan), *pito* (Ghana) and so on.

Table 45. Foods and drinks made from the grains of finger millet, sorghum and pearl millet in Afro-Eurasia

Crops/Region	Type of cooking								
	Grain			Meal	Flour			Drink	
	Boiled grain	Gruel	*Mochi*	Porridge	Dumpling (dango)	Flour Porridge	Bread	Non-alcoholic	Alcoholic
El. coracana									
Japan			△	○	○	△	○		
Nepal				○			○	○	○
India	△			○		○			○
Sudan				○					○
Ethiopia								○	○
Uganda				○		○			○
Burkina Faso				○					
So. bicolor									
Japan	△		○		○				
Korea	○		○						○
China									○
Halmahera	○								
India	○			○		○	○		
Sudan				○		○	△		○
Ethiopia									○
Burkina Faso				○					○
Pe. americanum									
India	○			○		○	○		
Sudan				○					△
Ghana				○		○			○
Burkina Faso				○					

Cooking method and foods made of millets

The Indian subcontinent is a wonderland for studying the domestication process of grain crops. Several species of millet are domesticated in this region. Cooking of cereals forms an important part of the basic agricultural culture complex. This culture complex is composed of their vernacular names, religious function, archaeological evidence, etc. In the next chapter 7, I will explicate those data. I had participated six times in expeditions for millet research and collected numerous accessions of millets and their relative species, with information on their agricultural complex, from hundreds of farmers in their villages and fields.

Ancient farmers had originally domesticated six species of millet from the relative weed species in India. Indian millet species were domesticated in the process of diffusion from humid paddy fields in Eastern India to dry upland rice fields in the Deccan Plateau, Southern India.

Indian food culture has been a reflection of the people's heritage. It represents India's historical development, religious beliefs, cultural practices, and above all, geographical attributes (Sahni 1986). In the Indian subcontinent, staple foods made using grain crops are served with various types of spicy curries and legume *dal* stews (*dhal*). Many unique cooking styles can be found for each cereal in any part of the subcontinent (Aziz 1983, Sahni 1986). Cooking of cereals forms an important part of the agricultural complex (Maeshwari 1987, Sakamoto 1988). Indian cooking consists of a unique combination of special cooking styles developed for each grain crop (Kimata et al. 2000). Moreover, the agricultural complex is composed of their vernacular names, religious function, archaeological evidence, etc.

It is very interesting to look for some basic elements of the Indian cooking of those cereals which might be found in Japanese methods for cooking grains. Therefore, a comparative study of the methodology of cooking is one of the scientific approaches which can help clarify the geographical origin and dispersal of given grain crops.

People have cooked many types of food using millets and cereals. Mainly *bhat* (*meshi* in Japanese), *roti* (*pan*), and *mude* (*oneri*) are cooked because they are frequently made using most of the cereals listed in Table 3 (Kimata 1987). *Bhat* is the most popular food, a boiled grain food made using all the ingredients shown in Fig. 4a, 4d right, and 5a (2nd from upper right). *Bhat* originated in ancient China and was brought to the Indian subcontinent via Eastern India. *Roti* is also a popular food made from cereal flour and originated from the cooking of wheat bread in the Fertile Crescent and was brought to the subcontinent via Western India.

People have cooked many types of food using millets and cereals. Mainly *bhat* (*meshi* in Japanese), *roti, mude* (*oneri*) are cooked because they are frequently made using most of the cereals listed in Table 46 (Kimata 1987). *Bhat* is the most popular food, a boiled grain food made using all the ingredients previously mentioned. *Bhat* originated in ancient China and brought to the Indian subcontinent via Eastern India. *Roti* is also a popular food made from cereal flour and originated from the cooking of wheat bread in Fertile Crescent and was brought to the subcontinent via Western India. *Mude* is a popular food made from cereal flour and originated from the cooking of *ugari* brought from Eastern Africa via the Arabian Peninsula. Figures 78 and 79 show cooking methods for cereals in Indian subcontinent: (a) a traditional boiled rice with *papad*. *Papad* is crispy salted wafer made from *dal*, vegetables, and cereals. (b) *upma* and *kesari bhat*. (c) *dosa*. (d) *mude* and boiled grain made using *Brachiaria ramosa*. (e) *puri* and (f) *idli*.

Sorghum bicolor and *Pennisetum glaucum* are mainly used for making *roti*, while *Eleusine coracana* is mostly used for making *mude* and fermented alcoholic drink *chan*. Other millet species are mainly used for *bhat*. A special food *mavu*, is made from the raw flour of *Setaria italica* and *Oriza sativa* as offering for gods and goddesses during festivals. Nine foods are made using *Brachiaria ramosa*, *mude* is made using *Eleusine coracana*, and *chapati* is made using wheat, *Triticum aestivum*. With respect to fermented foods, a starrer is made from *Hordeum vulgare*.

Our cookeries are shown in Tables 46 and 47. *Upma* is a coarse-grain food. *Dosa* is a thin leavened pancake, and moreover, *masara dosa* is stuffed with potato curry. Idli is a leavened pound cake made using the same ingredients as *dosa*. *Vada* is a cake made from freshly dal or millet flour. *Ganji* is a very thin starch-paste made from the same ingredients as *mude*.

Table 46. Millets and their food in the Indian subcontinent

Species name	Food								
	Indian name	bhat	upuma	roti	vada	dosa	idoli	mudde	ganji	mave
	Japanese name	meshi		pan	age pan		mushipan	oneri	konagayu	shitogi
Sorghum bicolor		○	○	◎	○	△	○	○	○	
Pennisetum americanum		○	○	◎				○	○	
Eleusine coracana		△	○	○	○	○	○	◎	○	
Setaria italica		◎	△	△	○	○		○	○	○
Panicum miliaceum		◎	△	○	△			○	○	
Panicum sumatrense		◎	○	△	○	○		○	○	
Paspalum scrobiculatum		◎		○				○	○	
Echinochloa flumentacea		◎	△		○			○	○	
Brachiaria ramosa		◎		○	○			○	○	
Setaria pumila		◎		△				△	△	
Digitaria crusiata		◎		○						

◎, main ingradient used; ○, generally; △, rarely or suppliment mixed.

The number of ingredients on each cooking styles in South -East India

The number of ingredients made main 12 foods are shown in Table 47. *Chawal* (*bhat*,48) and *roti* (42) are made frequently by the most ingredients. *Ganji* (36) is cooked by many ingredients in Tamil Nadu and Mahdia Pradesh, *Mude* (*Mudde*, 27) is cooked by many ingredients in South India. *Upma* (26) is many in Karnataka and Tamil Nadu. *Chapati*, *nan* and *puri* made from wheat flour are cooked around West India. *Vada* is cooked mainly in Tamil Nadu, *dosa* is cooked in South India, and *idli* is cooked in Karnataka. *Mavu* is made only in Tamil Nadu. Decreasing with the distance from Tamil Nadu to the north, the number of ingredients is clearly decreased, namely the diversity of cooking styles in millets is declined.

Table 47. The number of ingredients on each cooking styles in South -East India

Cooking style	Number of ingredients							Total
	Maharashtra	Mdhya Pradesh	Karnataka	Tamil Nadu	Andhra Pradesh	Orissa	Bihar	
Chawal	3	8	6	9	8	7	7	48
upma	0	0	9	11	2	3	1	26
chapati	1	1	1	2	1	1	1	8
roti	4	10	7	4	6	2	9	42
nan	1	0	1	0	0	0	0	2
puri	1	0	1	1	1	1	0	5
vada	1	0	1	8	0	0	0	10
dosa	0	0	4	7	5	1	1	18
idli	1	0	4	1	1	1	1	9
mude	0	0	7	12	7	1	0	27
ganji	2	10	3	11	5	5	0	36
mavu	0	0	0	2	0	0	0	2
Total	14	29	44	68	36	22	20	233

On the other hand, cereals and the number of their ingredients cooked in the Deccan Plateau are shown in Table 48. For cooking main 12 foods of cereals, rice (34) is used most frequently, and followed by *samai* (25), foxtail millet (25) and *ragi* (finger millet, 23). The other cereals are used for cooking foods around Indian subcontinent. However, barley, emma and durum wheat are only grown at mountainous villages. *Korati* (8) and *korne* (4) are grown only at the confined area in Eastern Decan. The methods of processing/cooking are summarized in Figures 78 and 79.

Table 48. Cereals and the number of their ingredients cooked in the Deccan Plateau

Ingredients	Number of ingredients							Total
	Maharashtra	Mdhya Pradesh	Karnataka	Tamil Nadu	Andhra Pradesh	Orissa	Bihar	
El. coracana	1	1	6	7	4	3	1	23
Pe. americanum	1	1	2	4	2	1	2	13
So. bicolor	0	2	4	7	3	0	1	17
H. vulgare	0	2	0	5	0	0	0	7
T. aestivum	3	3	3	4	2	2	1	18
T. dicocum	0	0	0	1	0	0	0	1
T. durum	0	0	2	3	3	0	0	8
P. miliaceum	0	0	4	5	1	0	2	12
S. italica	1	2	5	7	5	3	2	25
O. sativa	5	3	6	7	5	4	4	34
B. ramosa	0	0	3	0	0	1	0	4
Ech. frumentacea	0	3	0	5	2	2	1	13
P. sumatrense	3	3	5	6	4	2	2	25
Pas. scrobiculatum	0	3	2	3	1	2	2	13
S. pumila	0	3	0	0	4	1	0	8
Z. mays	0	3	2	4	0	1	2	12
Total	14	29	44	68	36	22	20	233

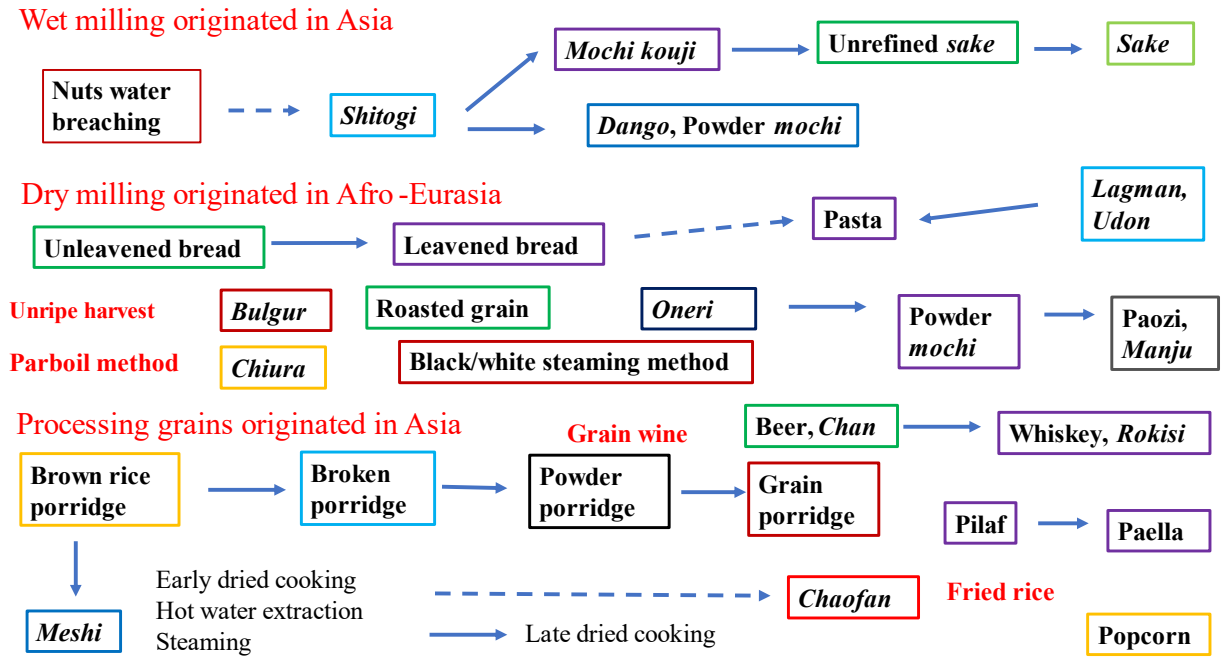


Figure 78. Milling, processing, and then cooking cereal grains

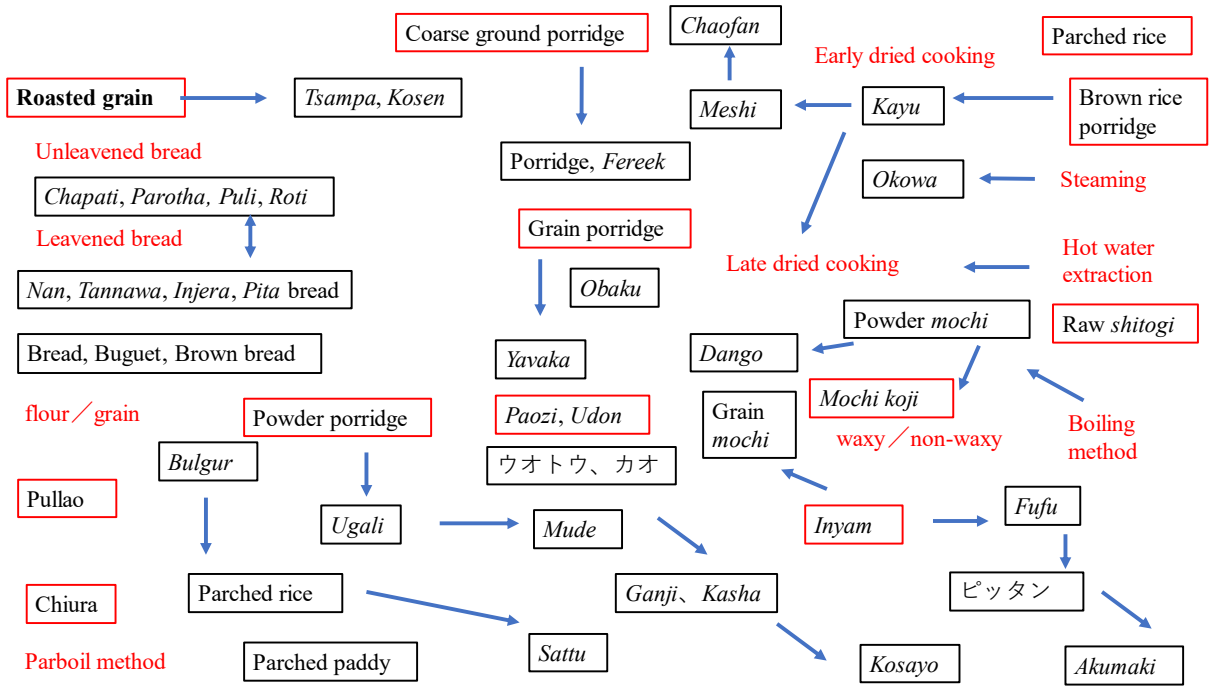


Figure 79. Historical relationship diagram of processing and cooking grain

Cereal seed grains are not easy to process for cooking, but these grains are able to storage for a long time. Therefore, they had been used to stable foods, and also a national tax. Many cereals accompanied each cooking method introduced many times from several regions into the Decan Plateau. The biocultural diversity of cereals, especially of millets, has guaranteed our security of daily life, because it has become rich historically by the acceptance into and transformation in Indian

subcontinent.

Chawal (syn. *bhat*, boiled grain) made from Asian millets and rice is often made in Eastern India, while *roti* (bread) made from millets and *chapati* (unleavened bread) made from wheat that are modified from Mediterranean flour food are frequently made in Western India (Kimata 1987). Mude modified from African flour porridge is often cooked from many kinds of cereals restricted to South India and Nepal (also in Japan), but not in North-Western and Central India. Generally speaking, the characteristics of Indian cookery are divided into two main parts, i.e., the North and the South, delineated by aa line writing from Mumbai (Bombay) to Hyderabad. *Mude*, *ganji* (flour porridge), *dosa* (thin leavened pancake) and *idli* (leavened poundcake) are also frequently cooked only in South India. The diversity of cooking styles is the most remarkable in Tamil Nadu. Cooking toward the West, there is a decrease in the variety of cooking styles and the farmers mainly eat *chapati* and *roti*. However, going toward the East while the same tendency occurs farmers eat mainly *chawal*.

The integrating hypothesis for the dispersal route of Indian millets is illustrated in Figure 80 on the basis of the results. *Echinochloa furumentacea*, *Panicum sumatrense* and *Paspalum scurobiculatum* were secondary crops to upland rice. First, their ancestral plants were companion weed derived from the relative weeds that invaded paddy fields in humid regions of Eastern India. Second, the companion weeds became insurance crops in upland rice fields, and they spread to a dry region in Deccan Plateau (Kobayashi 1987, 1989). *Brachiaria ramose* and *Setaria pumila* were so called tertiary crops to the other millet species domesticated from their relative weeds in upland fields. On the other hand, *Digitaria cruciata* has been recently derived from the relative weed grown in maize or vegetable fields, Kashi Hill, Megaraya, and is limited to the same area (Singh and Arora 1972).

Tentatively, Indian millet species were domesticated in the process of diffusion from humid paddy fields in Eastern India to dry upland rice fields in the Deccan Plateau, Southern India. The domesticated place of rice was Pearl River, rice had been dispersed from South China, via Zomia to East India.

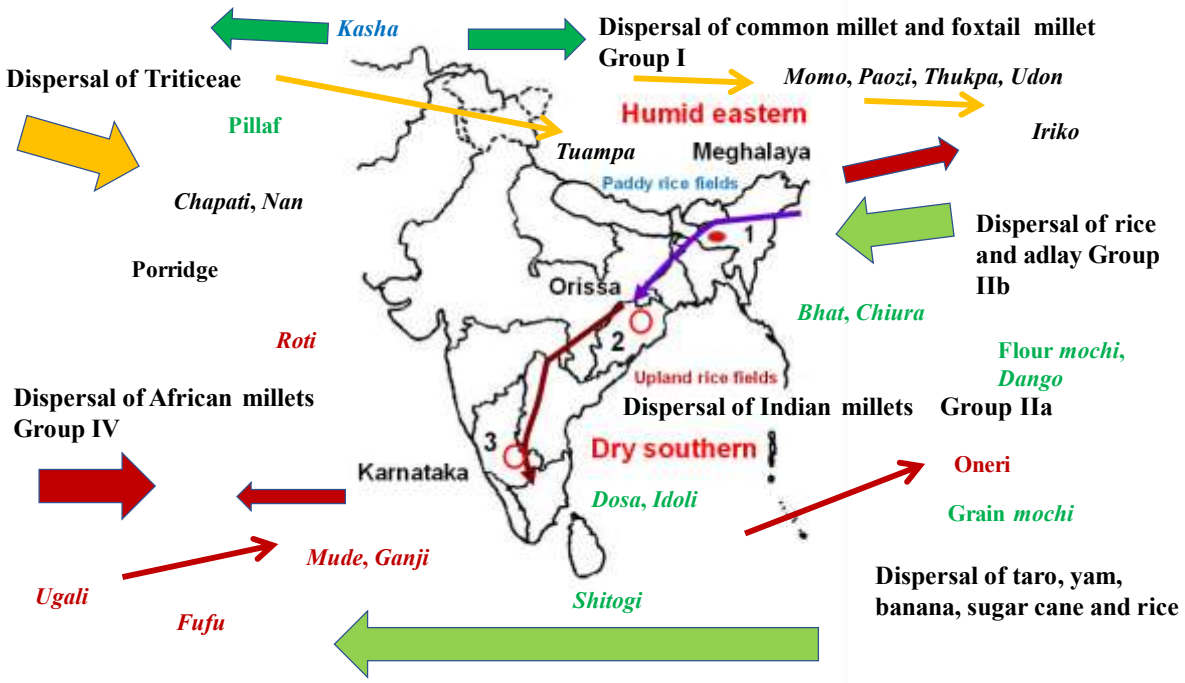


Figure 80. Dispersal of crops in the Indian subcontinent

Up-to-date utilization of millet in Japan

In the Far East (Japan), the following six millets have traditionally been grown and used; common millet, foxtail millet, adlay, Japanese barnyard millet, finger millet and sorghum. Japanese cooking has developed under the influence of Africa, India, and Chinese agricultural complexes. It is very interesting to look for some of the basic traditional elements of such cooking of millets that might be found in Japanese methods for cooking grains. For example, as mentioned above, Indian *mude* is mainly made from African millets, and is homologous to Africa *ugari*. A similar food is called *dhido* in Nepal and *oneri* in Japan. That is to say that the cooking of ugari has spread from Africa to the Far East using various millets, including Asian millets, maize and buckwheat (*Fagopyrum esculentum* Moench.).

Today, Japanese staple foods are mainly a boiled grain made from rice or a bread made from wheat flour. The above-mentioned six millets are now rarely cultivated except in a few mountain villages. Recently, however, Asian millets, common millet, foxtail millet and Japanese barnyard millet have been used to prepare efficacious foods against atopic dermatitis, an allergic disease, for the many Japanese children who are very sensitive to other staple foods such as rice and wheat. Many kinds of foods (for example, breads, cookies and noodles) are attempted to be prepared using several kinds of millet. Millet derived foods are also efficacious for arterial sclerosis, colon cancer, and anemia because millet has more dietary fibre and iron ions than rice. Dietary fibre reduces the cholesterin content in blood and sustains good conditions for bacterial flora in the colon. The iron ion promotes erythropoiesis.

Millets are very important crops in semi-arid and mountainous regions, and must therefore be maintained, in association with traditional cooking, religious celebrations, as important materials for future utilization. Millet should attain more important position as food grain and fodder in the near future, because of desertification and population increase. No doubt most important utilization

of small millets is for food; but these crops are used for various other purposes. Their leaves and culms are nutritious fodder for cattle. The millet cultivation maintains the sustainable agriculture together with the livestock farming. The small grains of millets also form feed for pet birds. This utility cannot be ignored because of the large demand in European countries and Japan.

While the traditional foods need to be handed down, the modern foods must be developed, the modern foods must be developed. A perspective plan for millets utilization should be drawn through interdisciplinary, institutional industry collaboration and as well as international cooperation.