Cabbage *(Brassica oleracea capitata)*

CHAPTER NINE

Fermented Leaf Vegetables

The food we eat also becomes food, and a home, for a huge variety of anaerobic microorganisms. The physical and chemical changes brought about by these organisms are called fermentation. Uncontrolled fermentation is often responsible for the spoilage of our food and can even cause food poisoning. Controlled fermentation, on the other hand, encourages the growth of particular microorganisms to achieve a desired physical or chemical change in a food or other material.

In traditional food fermentation processes, control is far from absolute. Long experience with trial and error has shown us how to get enough control to exclude most of the destructive or toxin-producing microbes. Normally several, even hundreds, of species are involved in fermentation, sometimes working in combination with each other and sometimes working in sequence. Isolating a single species of bacteria to use for fermenting foods is usually only possible in a laboratory or factory setting. It is closely analogous to the practice of raising crop monocultures in farming. More complex ecosystems with a greater variety of species tend to be more stable and require less intervention than monocultures, though the output may be somewhat more variable.

Partially controlled fermentation has been an important process in preparing and in preserving foods for many centuries. It is still the basis of several food industries. Bread, beer, wine, yogurt, cheese, chocolate, pickles, olives, soy sauce, vinegar, and vanilla are examples of familiar foods processed by fermentation. Techniques for modifying leaf vegetables through fermentation have also been used for thousands of years. The best known fermented leaf products are sauerkraut and kimchi. Fermenting green leaves serves three primary purposes: preserving the leafy vegetables for later use, improving digestibility, and enhancing flavor.

Often the process of fermentation involves a succession of microbes, each altering the environment to favor the next in the sequence. So for example, sauerkraut will typically begin with coliform bacteria dominating, then leuconostoc, and finally lactobacilli. Each increases the acidity of the cabbage until they are replaced with the next more acid tolerant species. Lactobacilli are especially important because they efficiently convert carbohydrates to lactic acid. Eventually the cabbage reaches a pH of about 4.0. This protects the cabbage, now sauerkraut, from further bacterial spoilage because most bacteria prefer a pH of about 7.0 and can't reproduce in a medium below 4.6. The sauerkraut can be kept for up to several months in a refrigerator. It is sometimes canned to extend its shelf life even further, though this eliminates the benefits associated with consuming live bacteria.

Having a relatively simple means of preserving green leaves has been very useful in situations where fresh food is not available for long periods, such as temperate zone winters or tropical dry seasons. Greens preserved by fermentation were often the difference between life and death on long sea voyages, where they

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provided enough vitamin C to protect those on board from dreaded scurvy. The slang term "kraut" was given to German sailors because of their custom of packing plenty of sauerkraut for ocean voyages.

Fermenting greens alters their nutritional value in several ways. In a sense, fermentation moves green leaves up the trophic pyramid in much the same way that feeding leaves to meat or milk animals does. After the bacteria have had their fill, there is less energy, or calories, remaining in the leaves but many of the nutrients are pre-digested and easier to absorb in our intestinal tract. Fibrous cell walls are softened, making their contents more readily available to our digestive enzymes. While some vitamin C and beta-carotene is lost, the levels of B-vitamins, especially vitamin B-1 and B-2, are often increased. Protein quality is also enhanced as the bacterial enzymes alter the vegetable's amino acid profile.

Fermentation also can break down some of the compounds that inhibit nutrient absorption, including phytates, tannins, oxalic acid and nitrates. Carcinogenic aflatoxins from molds can be broken down into harmless molecules by bacterial fermentation. Hydrocyanic acid yielding compounds, such as linamarin in cassava, can also be neutralized through fermentation.

A taste for fermented leaf vegetables is an acquired thing. In many cultures that rely heavily on bland starchy staples, such as, rice, maize, potatoes, and cassava, the strong tangy flavors of fermented leafy vegetables play an important role in keeping the diet interesting.

Some of the most interesting and important fermented greens are sauerkraut, kimchi, gundruk, and kawal. Sauerkraut probably arrived in Europe with the Mongols and other nomads of central Asia. To many Westerners, sauerkraut, or choucroute as it is called in French, is the only familiar fermented green vegetable. Traditionally served with hot dogs or other meats, it is often available canned in grocery stores and sometimes available unpasteurized in health food stores. Sauerkraut has traditionally been used to alleviate symptoms of ulcers. Recent studies in Europe suggest that sauerkraut may be even more effective at reducing cancer risk than unfermented cabbage.

Kimchi is the national food of Korea. It usually is made from some type of cabbage, flavored with garlic, chili, and ginger. While many North and South Americans find kimchi to be overly strong flavored, Koreans eat it at nearly every meal and miss it when they travel. Hundreds of varieties of kimchi are made, reflecting regional preferences and seasonal availability of ingredients.

Gundruk is a national dish of Nepal and is popular throughout the Himalayan region. It is made by fermenting the

partially wilted leaves of vegetables, mainly from the cabbage family. It is an important source of vitamins and minerals over the long Himalayan winter when fresh food is scarce.

One of the more unusual fermented foods is called kawal[1]. It is made solely from the fermented leaves of the sickle pod tree *(Cassia obtusifolia)* in the Sudan. It has a strong flavor and is used as a meat substitute in soups and sauces by the resourceful people of this arid region. Once it is fully dried, kawal is a compact, high protein food that provides a measure of food security.

The sickle pod leaves are picked toward the end of the rainy season. Stems, flowers, and insects are carefully removed but the leaves are not washed, so that the beneficial bacteria and fungi on their surface are not removed. The leaves are then pounded to a pulp that is packed tightly in buried clay jars. It is allowed to ferment for about two weeks, then rolled into small balls and sun dried.

While fermented greens play a significant part in the global diet, that role could be enlarged[2]. The first step would be to begin systematic experimentation with the fermentation of more leaf crops. The cabbage (mustard) family, especially common cabbage and Chinese cabbage, currently make up the bulk of the world's fermented leaf crops. These are nutritious foods but they prefer cooler growing weather than what is common in many areas where malnutrition is prevalent. Leafy varieties of the cabbage family, such as kale, collards, mustard, and turnip greens, are denser sources of most nutrients than their head forming relatives, and so would make more nutritious fermented greens. Dozens of other high nutrition leaf crops could be tested for how well they ferment.

Since minerals are usually not lost in fermentation, and often made more bioavailable, it makes sense to try fermenting leaf crops that contain the highest levels of minerals. Given that iron deficiency anemia is the most common nutritional problem in the world, we should look to iron rich leaf crops. Chinese boxthorn, moringa, parsley, chaya, winged bean, dandelion, spinach, amaranth, taro, pumpkin, purslane, cowpea, Swiss chard, cilantro, vine spinach, lambsquarters, sweet potato leaves and many other leaf crops contain far more iron than the commonly fermented cabbages.

Productive research could be done to determine if cassava leaves could be fermented to make a product that was acceptable in flavor. If the fermentation process sufficiently lowered the hydrocyanic acid content, fermented cassava leaves could become an important dietary source of micronutrients. Cassava leaves are available and cheap in many areas with the highest rates of malnutrition.

The high sodium content in many fermented foods is a concern to some nutritionists. Half a cup of typical sauerkraut has about 470 mg of sodium, nearly a third of what is recommended for daily intake. There are some lower-sodium fermented leaf products available in big markets, and much of the sodium can be removed simply by draining and rinsing. If fermented greens are used in small amounts as a garnish it is irrelevant, but if they play an important role in the diet, as kimchi does in Korea, it is worth looking at ways to reduce the sodium in the diet.

1 http://practicalactionpublishing.org/sudan/docs/technical_information_service/kawal.pdf
2 The Benefits of Fermenting Fruits and Vegetables. http://www.fao.org/docrep/x0560e