

Fermented Foods: Sauerkraut¹

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Introduction

This publication is intended for individuals seeking an extensive understanding of sauerkraut, including its production process and associated health benefits and risks. Aimed at culinary professionals, health enthusiasts, and nutrition researchers, this publication provides a comprehensive overview of sauerkraut, from its ancient origins to its contemporary dietary relevance. The objective is to provide an analysis of the fermentation process, the nutritional benefits, and the possible health implications of sauerkraut consumption, thereby enabling informed decisions regarding its inclusion in the diet.

What is sauerkraut?

Sauerkraut, the German word for “sour cabbage,” is raw, chopped cabbage that undergoes spontaneous lactic acid fermentation (Peñas et al. 2017). Its origins can be traced back over 2,000 years to ancient China, where laborers building the Great Wall preserved cabbage during cold winters using rice wine fermentation—a process in which the alcohol and natural microbes in rice wine help inhibit spoilage and encourage fermentation. Over time, this technique traveled westward to Europe, where rice wine was replaced with salt (Peñas et al. 2017). Salting the cabbage promotes the growth of beneficial lactic acid bacteria, which produce natural acids that preserve the cabbage and give it its distinctive sour taste. Today, sauerkraut remains a staple in many central and eastern European diets and is also enjoyed in various parts of Asia and the United States.

How is sauerkraut made?

To prepare sauerkraut, white cabbage is first thoroughly washed, trimmed, and shredded into fine strips (Touret et al. 2018). The shredded cabbage is then mixed with salt, as well as any other desired herbs and spices, and massaged by hand to release its natural juices (Touret et al. 2018). Subsequently, the cabbage and its released juices are transferred to a sterile jar. If the natural juices do not completely submerge the cabbage, a cooled brine solution is added, and the jar is closed tightly (Touret et al. 2018; Zepp et al. 2023; Özer and Yıldırım 2019). Finally, the sauerkraut is stored at room temperature, ideally between 70°F and 75°F (21°C and 24°C), and away from direct

sunlight for three to six weeks to allow fermentation to fully develop (Touret et al. 2018; Zepp et al. 2023). In humid environments, such as Florida, the actual room temperature can be warmer, which may accelerate the process. Therefore, maintaining a stable environment within the recommended temperature range and monitoring the fermentation closely are important. Once the sauerkraut reaches the desired level of fermentation, it can be transferred to the refrigerator to slow further fermentation, preserving its flavor and texture (Zepp et al. 2023).

Similar to kimchi and sourdough bread, sauerkraut is fermented by lactic acid bacteria under anaerobic conditions (Özer and Yıldırım 2019). These bacteria are naturally present on the surface of raw cabbage leaves. Under the right conditions—when salt is added and oxygen is excluded—these lactic acid bacteria transform the cabbage’s natural sugars into lactic acid (Özer and Yıldırım 2019). This process not only preserves the cabbage but also suppresses the growth of spoilage microbes by quickly lowering the pH (making the environment more acidic), ensuring the safety and longevity of the fermented product (Özer and Yıldırım 2019; National Research Council 1992).

What are the potential health benefits of sauerkraut consumption?

Sauerkraut consumption has been linked to several health benefits, such as reducing inflammation, fighting free radicals, and even helping prevent certain diseases, thanks to its rich content of natural plant compounds (phytochemicals). It is rich in vitamin C, which acts as an antioxidant to protect the body from damage caused by oxidative stress. For example, vitamin C can help lower levels of C-reactive protein, a marker of inflammation in the blood. Sauerkraut is also a source of vitamin K1, vitamin B6, and folate, which support blood clotting, metabolism, and cell health, respectively. Additionally, sauerkraut has been shown to suppress the production of nitric oxide, a compound that can contribute to inflammation (Peñas et al. 2017). In fact, lactic acid

fermentation bolsters many of the inherent health-promoting properties found in raw cabbage.

Fermentation enhances sauerkraut's health benefits by increasing the bioavailability of certain nutrients and transforming natural compounds like glucosinolates into their more biologically active forms (Peñas et al. 2017). Additionally, sauerkraut contains live, beneficial bacteria such as *Lactobacillus* species that support gut health. These microorganisms can help ease digestive issues like diarrhea and constipation. Moreover, *Lactobacillus* may support immune function by stimulating the activity of immune cells in the gut, which plays a key role in the body's defense system.

What are the possible risks of sauerkraut consumption?

Despite its numerous health benefits, sauerkraut poses certain risks that should be taken into consideration. Fermentation transforms naturally occurring compounds in cabbage, leading to elevated levels of histamine and tyramine compared to raw or traditionally cooked cabbage. Histamine, a compound that can trigger or worsen digestive issues and allergy-like symptoms in sensitive individuals, increases in response to bacterial activity during fermentation (Raak et al. 2014). Similarly, tyramine is formed in higher amounts during the fermentation process; this amino acid can interact dangerously with monoamine oxidase inhibitors (MAOIs)—medications commonly used to treat depression, anxiety disorders, and Parkinson's disease (Raak et al. 2014).

Another concern is sauerkraut's high sodium content—1 cup provides nearly 1,000 milligrams of sodium (USDA-ARS, n.d.). Persistent excessive sodium intake can elevate blood pressure, increasing the risk of serious heart-related issues (NASEM 2019). For individuals with or at risk of hypertension, consuming sauerkraut in moderation or avoiding it altogether may be advisable (NASEM 2019).

Lastly, improper preparation of sauerkraut can lead to food safety risks. If food safety practices are not followed, harmful pathogens, such as *Clostridium botulinum*, can grow and produce toxins that cause botulism, a severe foodborne illness (Nielson-Stowell, n.d.). Fortunately, the high acidity produced during fermentation prevents the growth of harmful bacteria, making it crucial to maintain proper acidity levels for a safe product (Nielson-Stowell, n.d.). Certain groups of people, such as those with compromised immune systems, should be particularly cautious. They should either ensure homemade sauerkraut is prepared safely or choose a reputable store-bought product to minimize the risk of foodborne illness (Nielson-Stowell, n.d.).

Summary

Sauerkraut is a cabbage product that originated in ancient China and is now consumed worldwide. Sauerkraut is made through lactic acid fermentation, and it has been associated with a variety of health benefits, including antioxidant, anti-inflammatory, and anticarcinogenic properties (Peñas et al. 2017; Özer and Yildirim 2019; National Research Council 1992). Individuals with high blood pressure or histamine sensitivities, those prescribed MAOIs, or those who are immunocompromised should consider avoiding sauerkraut due to its high sodium and histamine content, possible food safety risks, and potential interaction with MAOIs (Peñas et al. 2017; Raak et al. 2014; Nielson-Stowell, n.d.).

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¹ This document is FSHN26-3, one of a series of the Department of Food Science and Human Nutrition, UF/IFAS Extension. Original publication date March 2026. Visit the Ask IFAS website at <https://ask.ifas.ufl.edu> for the currently supported version of this publication. © 2026 UF/IFAS. This publication is licensed under [CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/).

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