Fermented Flavors: From Pickles to Kimchi and Beyond……

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Introduction

Vegetables can be preserved for longer period with the aid of some of the naturally occurring bacterial species that break down the sugars present in vegetables into lactic acid. This process is called lactic acid fermentation. The product this formed has a sour flavor and a range of advantages. The acidity caused due to lactic acid fermentation. It inhibits the growth of other harmful bacteria and in turn, increases the shelf life of the product. In addition to the above-mentioned features taste and nutritional value is also enhanced thus increasing its market value.

Fermentation Process of Pickled Vegetables

A series of biochemical reactions occurs during the process of fermentation during which bacteria species such as *Lactobacillus planetarium and Leuconostoc mesenteroides* begin to multiply in number. The sugars present in the vegetables are utilized for the nutrition of these microbes during which they produce acids like lactic acid which acts as the preservative agent.

A wide range of other chemicals are also produced by the bacteria which includes aldehydes, ketones, esters and other volatile compounds imparting a characteristic flavor to the product.

The curing process typically lasts several weeks, during which time the pickles undergo the following changes

1. *Initial fermentation* (1-3 days): The bacterial population starts multiplying in number producing carbon dioxide gas which results in the floating of the pickles.

2. *Acidification* (3-7 days): As the bacteria increases in number the acid production also increases hence lowering the pH which allows the growth of only beneficial microorganisms.

3. *Flavour development* (7-14 days): The bacteria continue to grow producing more and more flavour compounds enhancing the flavour of the product.

4. *Maturation* (2-4 weeks): This is the final stage where the pickle reaches a stage of the optimal flavour of balanced taste.

Procedure

Acidity should be controlled and the right ingredients must be used to ensure safe and flavorful fermented pickles. Vegetables used for pickling should be firm and fresh and vegetables with mold or signs of any spillage should be avoided. Herbs like dill which are insect-free and canning salt that doesn't contain iodine should be used. Less salt and more water usage must be avoided as this can inhibit the growth of useful bacteria.

For getting the best flavor fresh spices should be used and should be stored in air-tight containers. Soft water should be used because hard water can interfere with acid formation. Alum or food-grade lime can be used as a firming agent and excess lime should be washed out to maintain acidity. Finally, vinegar with 5% acidity can be used to ensure the right level of acidity.

Factors affecting fermentation

pH Levels

pH of around 7 is the optimal range for most bacteria but some species especially those involved in acid fermentation which are acid tolerant can survive in environments with lower pH also

Oxygen Availability

Most of the bacteria involved in the acid fermentation are microaerophilic -they can grow best in an environment with reduced oxygen levels. This adaptability is very crucial in fermentation where oxygen levels can fluctuate

Nutrient Requirements

For sustaining a good metabolism, a good source of nutrients is required by all bacteria. In the process of fermentation, bacteria depend on carbohydrates from vegetables which range from simple sugars like glucose and fructose to complex ones like cellulose and starch. The substrate concentration can also affect the fermentation rates.

Other Fermentation Factors

In addition to the above-mentioned factors several other factors like temperature, salt concentration, pressure, Microbial concentration, relative humidity and presence of inhibitory compounds affect the growth and activities of the microbes.

Fermented Vegetable products in India

Fermented vegetable products are mostly seen in the eastern Himalayan regions of India which has abundant greenery. The natives preserve and consume the perishable vegetable products by fermenting them. Gundurak, Khalpi and Sinki are some of the examples. Mostly Lactic acid fermentation is used for preparing these delicacies. The most predominant lactic acid bacteria involved are *Lactobacillus* spp., *Leuconostoc* spp., and *Pediococcus* spp. These strains are also seen in other fermented products using bamboo shoots like Soidon and Mesu.

Gundruk

Gundruk is a fermented vegetable product seen in Nepal and the Himalayas. Fresh leaves of locally available vegetables are used for preparing this dish. Leaves of cabbage, Cauliflower, Mustard etc. are used. The process of making this is rather simple, for 2 days the leaves are wilted and they are tightly pressed in an airtight earthen pot and kept for 2-3 weeks. After this period, it is sundried and stored for further use. It is typically used in soups and as a pickle. *Lactobacillus* spp. and *Pediococcus* spp. are the bacteria involved in this fermentation.

Goyang

Goyan is a fermented leaf product using the leaves of *Cardamine macrophylla Willd*. It is a traditional food product in Sikkim and Nepal. They are collected, washed and chopped into pieces. The chopped leaves are squeezed to get rid of moisture content. They are then tightly packed in bamboo baskets lined with leaves. They are fermented at room temperature for a month. Yeast, *Lactobacillus* spp. and *Pediococcus* spp. are used for fermentation

Soidon

Soidon is made from the bamboo shoot tips typically seen in Manipur. The shoots are submerged in water with a starter from a previous batch and are allowed to ferment for a week. Sometimes, *Garcinia pedunculata* leaves are added for extra flavor. After fermenting, it can be stored for up to a year. The bacteria involved are of the genera *Leuconostoc* spp., *Lactobacillus* spp. and *Lactococcus* spp. etc.

Khalpi

It is a unique fermented cucumber dish enjoyed in Sikkim and Nepal. It is the only available fermented cucumber product. To make it, ripe cucumbers are cut and they are sun-dried for one or two days, and then placed in a bamboo basket. They are then sealed with dried leaves. The cucumbers are allowed to ferment for 3-5 days, becoming sour if left longer. Khalpi is typically prepared and eaten as a pickle. The fermentation involves bacterial genera like *Lactobacillus* spp., and *Leuconostoc* spp.

Inziangsang

Inziangsang is another fermented leafy vegetable dish from mustard leaves, called hangam locally. It is native to Nagaland and Manipur. The process of preparing Inziangsang involves crushing the leaves, blanching them in warm water, squeezing out the excess and packing them in air-tight container to ferment for a week. After that, it is sun-dried for approximately 5 days and can be stored for up to a year. It is fermented by beneficial bacteria like *Lactobacillus* spp. and *Pediococcus* spp.

Fig 1. Various fermented vegetable products: a) Gundruk, b) Soidon, c) Khalpi, d) Kimchi, e) Shalgam Juice, f) Paocai, g) Sauerkraut, h) Sayur Asin, i) Nozawana-Zuke

Fermented Vegetable products in other Asian countries

Fermented vegetable products from different Asian countries provide diverse flavors and historical significance. Each dish highlights local ingredients and unique fermentation methods from China's tangy Paocai to Malaysia's exotic Tempoyak, showcasing centuries of culinary tradition.

Kimchi

Kimchi is a popular fermented Korean side dish that involves fermenting vegetables like Chinese cabbage. It typically includes salt and the principal ingredients, mixed with various seasonings. It is fermented under cold conditions The kimchi flavor begins to develop into a combination of sour, sweet,

and low carbonation as the pH text drops down to around 4.0 LAB involved are *Leuconostoc* spp. and *Lactobacillus* spp. Kimchi is rich in β-carotene and vitamin C. They also have antioxidant properties and dietary fiber making them a suitable candidate in our diet.

Sauerkraut

Sauerkraut or "sour cabbage," is just shredded cabbage mixed with salt. It is left in a lidded jar to ferment. Both homo and heterofermentative Lactic acid bacteria are involved in this process. It starts with *Leuconostoc spp*. and then *Lactobacillus spp*. and *Pediococcus spp*. Sauerkraut will have a final pH of 3.5–3.8. Sauerkraut brine could be used for industrial purposes making carotenoids and β-glucosidase.

Sayur Asin

It is an Indonesian fermented mustard greens, involves rubbing the leaves with salt and adding rice liquid for fermentation. LAB such as *Leuconostoc* spp. and *Lactobacillus* spp. dominate the process, with yeasts like *Candida*.

Paocai

Paocai is a traditional Chinese lactic acid fermented vegetable with various seasonings, it can be made up of cabbage, celery, cucumber and radish. Through anaerobic fermentation, it produces a crunchy cucumber and tart flavor. They are responsible for the proper fermentation due to their enzymatic activities as, phytase and proteases among others that help are *Leuconostoc* spp. and *Lactobacillus* spp. to control this process.

Yan-Dong-Gua

Yan-dong-gua is a type of fermented food created from wax gourd. The process includes drying the gourd, combining it with other ingredients like salt, sugar etc. and fermenting for up to two months. It is employed as a flavoring in different dishes in Taiwan. The chief bacteria involved are *Weissella* spp.

Shalgam Juice

Shalgam juice (Turnip juice), popular in Turkey, is made from turnips, black carrots, bulgur flour, salt, and water. It undergoes a two-stage fermentation process involving LAB such as *Lactobacillus* spp. and *Pediococcus* spp., resulting in a tangy, flavorful drink. It is a non-alcoholic fermented beverage generally preferred with Turnip patties (Kebab), and also aids in digestion

Nozawana-Zuke

Low-salt pickle made from Nozawana (field mustard) with inorganic salts and red pepper. Fermented with *Lactobacillus* and *Leuconostoc,* mainly *Lactobacillus curvatus*.

Pobuzihi

Traditional food is made with cummingcordia, either caked or granular. Boiled cummingcordia is mixed with salt, and cooled in containers for caked pobuzihi. Contains *Lactobacillus* spp.*,Weissella* spp. and *Pediococcus* spp.

Jiang-Gua

Fermented cucumber, mixed with salt, sugar, vinegar, and optionally soy sauce. Fermented for at least 1 day at 6-10°C, containing *Weissella* spp., *Lactobacillus* spp., *Leuconostoc* spp., and *Enterococcus* spp.

Conclusion

Fermented vegetables are valuable food sources, that offer numerous health benefits and many culinary uses. But still, their production, storage and consumption also come with potential safety risks, such as contamination and the formation of harmful compounds and substances. To fully extract the benefits of fermented vegetables by minimizing their risks, further research and processes are to be developed. This includes elucidating the relationship and interactions between the core microbiota, product substrates, and flavour compounds, by developing more efficient technologies to ensure quality and safety and creating novel, interesting, attractive and healthy fermented vegetables with desired functions that meet consumer acceptance. By understanding the advancements, trends and capabilities in fermented vegetable production, we can reveal their full potential and produce new, safe, and healthy food products that benefit consumers and support the growth of the industry.

References

Swain, M. R., Anandharaj, M., Ray, R. C., & Rani, R. P. (2014). Fermented Fruits and Vegetables of Asia: A Potential Source of Probiotics. Biotechnology Research International, 2014.

Dimidi, E., Cox, S. R., Rossi, M., & Whelan, K. (2019). Fermented Foods: Definitions and Characteristics, Impact on the Gut Microbiota and Effects on Gastrointestinal Health and Disease. *Nutrients*, *11*(8).

Terefe, N. S. (2021). Recent developments in fermentation technology: Toward the next revolution in food production. *Food Engineering Innovations Across the Food Supply Chain*, 89-106.

Yuan, X., Wang, T., Sun, L., Qiao, Z., Pan, H., Zhong, Y., & Zhuang, Y. (2024). Recent advances of fermented fruits: A review on strains, fermentation strategies, and functional activities. *Food Chemistry: X*, *22*, 101482.

Thounaojam, Premlata & Sharma, Vivek & Bisht, Madho & Chongtham, Nirmala. (2020). Edible bamboo resources of Manipur: consumption pattern of young shoots, processing techniques and their commercial status in the local market. Indian journal of traditional knowledge. 19. 73-82.

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