**Daikon Radish Characteristics and Fermentation Properties**

Rémy Benjamin Daitch

The Culinary Institute of America

CUSC – Microbial Ecology of Food Systems

Professor Marisa Monaghan and Chef JJ Lui

May 18th, 2024

**Annotated Bibliography**

Chae, S., Lee, O. N., Park, H. Y., & Ku, K. (2022). Seasonal Effects of Glucosinolate and Sugar Content Determine the Pungency of Small-Type (Altari) Radishes (Raphanus sativus L.). *Plants*, *11*(3), 312. https://doi.org/10.3390/plants11030312

This study examines the pungency compounds as they relate to the metabolite glucoraphasatin and other polar metabolites within radishes. This chemical affects the pungency of Daikon. The study took place in Incheon, Korea under typical spring and autumn growing seasons. It was found that radishes grown and harvested during the autumn, that these radishes were preferred by the customer/consumer base. The spring crop of radishes had higher levels of raphasatin, a bitterant in the radishes. The study found a relation between raphasatin concentration levels and the total sweetness values of the sugars within the radishes. The researchers analyzed polar metabolites, they found seven amino acids, sugars, and glucoraphasatin in three different radish cultivars were statistically significantly different between the two growing seasons compared. It was found that higher levels of amylase were found in the autumn grow radishes. The study kept track of environmental factors, temperatures, rainfall measurements, and relative soil moisture levels were kept and compared. This relates to culinary knowledge in knowing the best seasonality of produce that has more than one growing season. The understanding of the nutritional content and flavor tastants and aroma of Daikon season-to-season. This research paper had an ample amount of citations and cross references.

Ippoushi, K., Fukuoka, N., Ishida, M., Takeuchi, A., & Azuma, K. (2016). Easy Method for the Approximate Quantitation of 4-Methylthio-3-Butenyl Isothiocyanate of Daikon (Raphanus sativus L.). *International Journal of Food Properties*, *19*(5), 993–999. https://doi.org/10.1080/10942912.2015.1052146

The Japanese researchers from the Ishikawa Prefectural University used a new more cost-effective alternative method of spectrophotometric analysis they found suitable for evaluation of numerous Daikon samples without the need for human sensory evaluation. This substitute method is much cheaper than gas chromatography or high-performance liquid chromatography. When used in combination with sensory evaluation the researchers suggested that this would make analytical evaluation easier for assessors. This agricultural study was conducted by the Ministry of Agriculture, Forestry, and Fisheries of Japan. This was part of a greater research project of “Breeding and Integrated Research toward Enhancing Consumption of Domestic Farm Products in the Food Service Industry”. This study singles out 4-methylthio-3-butenyl isothiocyanate as the characteristic reason for the Daikon’s pungent aroma, odor, and taste. This was a small narrowly focused study evaluating the aroma and flavor characteristic of the Daikon. The citations list was on the shorter side (13).

Kato, S., Kitamura, E., Yamamoto, S., & Ohshima, S. (1991). Effects of Sodium Chloride, Ethanol, Glucose Content and pH on the Growth of Lactic Acid Bacteria Isolated from Salted “Daikon” (Raphanus sativus). *Nippon Shokuhin Kōgyō Gakkaishi*, *38*(10), 962–966. https://doi.org/10.3136/nskkk1962.38.962

This study examined the impact of salt (sodium chloride) levels increased from 6.3% to 8.3% and the ethanol percentage to 2.0% from zero, and increasing glucose from 0.3% to 2.3% and increasing acidity to 5.0 pH to 4.0 pH. The researcher studied the growth of six types of lactic acid bacteria (LAB): *Lactobacillus plantarum*, *Lactobacillus brevis*, *Lactobacillus bavaricus*, *Lactobacillus coryniformis subspecies torquens*, *Lactobacillus coryniformis subspecies coryniformis*, and *Lactobacillus subspecies 1* in GAM broth (cultivation medium). It was found that the growth of the six species were subdued completely by the circumstances consisting of amalgamations of several factors: with 6.3% salt and pH≦4.0; with 7.3 % salt, pH≦4.5 and ethanol≧2.0%; with 8.3 % salt, pH≦5.0 and ethanol≧2.0%. It is important to note that fermentation of Daikon is advised at being maintained at an ambient temperature under 20℃, otherwise putrefaction may occur due to acidification from over fermentation. This happens because of accumulation of excess amounts of lactic acid owing to growth of LAB. Drawbacks to this study although it has valid applications to experimental design is that only three references are cited, the titling of the sections were inconsistent, a conclusion section was totally omitted from the publication, and the study was conducted 33 years ago.

Kobayashi, W., Kobayashi, T., Takahashi, A., Kumakura, K., & Matsuoka, H. (2021). Metabolism of glutamic acid to alanine, proline, and γ‐aminobutyric acid during takuan‐zuke processing of radish root. *Journal of Food Science*, *86*(2), 563–570. https://doi.org/10.1111/1750-3841.15567

This investigation looks at the Japanese style of Daikon fermentation, preservation, and pickling called Takuan-zuke. This technique either involves salt form pressing or sun drying followed by salt aging. Extensive chemical analysis was conducted to evaluate alanine, proline, and γ -aminobutyric acid (GABA) during Daikon processing. It was found that sun drying, and salt aging had a higher accumulation of amino acids that were more effective at bringing out the rich aroma, odor, and taste of Takuan-zuke. That the cold-dry dehydration was prefer for commercial production because of repeatable consistency between batches, but was less nutritious and less flavorful than homemade small batch sun drying and salt aging methods. It is know that free amino acids enrich the aroma, odor, and taste of the food by infusing umami/savory, bitter, and some sweet taste into the food systems they exist in. A beneficial aspect of the paper is that it is a recent publication and has an ample number of citations. They found that the secondary metabolism of Daikon in the initial step of Takuan-zuke production stimulates a temporary stress response in the Daikon ending in higher GABA accumulation. This was the first study of its kind to analyze gene, protein, and metabolite changes during the processing of Takuan-zuke.

Li, J., Chaytor, J. L., Findlay, B., McMullen, L. M., Smith, D. C., & Vederas, J. C. (2015). Identification of Didecyldimethylammonium Salts and Salicylic Acid as Antimicrobial Compounds in Commercial Fermented Radish Kimchi. *Journal of Agricultural and Food Chemistry*, *63*(11), 3053–3058. https://doi.org/10.1021/jf5063588

The purpose of this article published by the Journal of Agricultural and Food Chemistry was to identify the antimicrobial compounds and bacteria that are present in commercially fermented Kimchi. The authors did point out they had a competing financial interest in Griffith Laboratories. This company produces and markets food ingredient systems for augmentation of food flavor and safety. This study made use of high-performance modern technology to undergo a highly accurate chemical analysis of Kimchi samples. It was found that didecyldimethylammonium chloride is known to inhibit the growth of several gram-positive bacteria, notably *Staphylococcus aureus*. The antimicrobial activity of commercial Leuconostoc, the Kimchi filtrates (LRRFF) are ascribed to salicylic acid and didecyldimethylammonium salts, it was found that there was not enough Carbon 14 to be the catalyst product of the Kimchi production to have these salts produced, the likely source was as a result of petroleum feed. More studies need to be done. The experiments validated that salicylic acid and didecyldimethylammonium chloride are often times natural products produced by plants and LAB are present in Kimchi brine and aid in the destruction of pathogens in pickling and fermentation to allow for safe human consumption. This shows the scientific evidence of safe food practices during commercial Kimchi production.

Li, X., & Liu, D. (2022). Nutritional Content Dynamics and Correlation of Bacterial Communities and Metabolites in Fermented Pickled Radishes Supplemented With Wheat Bran. *Frontiers in Nutrition*, *9*. https://doi.org/10.3389/fnut.2022.840641

This study was conducted by the Food Science Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou, China. The Chinese version of the FDA Food Code was cited as their guardrails for safety, sanitation, and manufacturing practices of fermented radishes. The research found that the addition of wheat bran to the fermentation of radishes aided in the aroma, odor, and flavor of the final product. It was found that an increase in free amino acids and other functional ingredients such as: GABA, a-linoleate, thiamine, and riboflavin were present with bran fermentation. Increased levels of alcohol, ester, acid, and ketones were present suggesting better microbial nutritional content in the wheat bran. Conversely, this fermentation reduced the number of dimethyl disulfide and dimethyl trisulfide. This improved the aroma, odor, and taste, plus reduced the undesirable aromas, negatively associated odors, and off flavors. Lots of high technology and scientific tools and mathematical statistical analysis were performed to verify and validate the study. An ample quantity of cross references were employed in the publishing of the research. This aligns with previously mentioned references of the chemical, nutritional, and flavor make up of radish fermentation. A short coming I found with this study was that that the control group was dosed using aspartame. This was never explained as to their reasoning why they were using an artificial sweetener to induce fermentation of radishes.

Pappa, S., Papadelli, M., Paramithiotis, S., Daferera, D., Polissiou, M., & Drosinos, E. (2018). Effect of herb addition on spontaneous fermentation of radish (Raphanus sativus L.) roots in brine and the fate of L. monocytogenes and E. coli O157:H7. *Journal of Medicinal Studies*, *6*(2), 32–39. https://www.plantsjournal.com/archives/2018/vol6issue2/PartA/5-6-34-905.pdf

This research was conducted by a Polish group of scientists researching the addition of thyme, garlic, and mint to the spontaneous fermentation of radishes. The research is well cited and referenced. The study is a little dubious in that in all cases the LAB prevailed out competing microbials studied, *Listeria monocytogenes* and *Escherichia coli* *(O157:H7)* inoculated at four or six log CFU/mL, this begs the query did the herbs have any effect? They were scientifically proven to have no negative net effect, but did not disprove the null hypothesis to satisfaction. The beneficial aspects of this study are a better understanding of the fermentation process. Fermentation in the study was considered done when both total titratable acidity (TTA) and pH estimates showed no statistically significant change between two consecutive samplings. LAB are generally only a small portion of the initial microecosystem population, but out compete competition because of their metabolic capacity in the fermentation process. The recommendation of the study was to prolong the fermentation process to eradicate *Listeria monocytogenes* and *Escherichia coli* *(O157:H7)*.

Pardali, E., Paramithiotis, S., Papadelli, M., Mataragas, M., & Drosinos, E. H. (2017). Lactic acid bacteria population dynamics during spontaneous fermentation of radish (Raphanus sativus L.) roots in brine. *World Journal of Microbiology & Biotechnology*, *33*(6). https://doi.org/10.1007/s11274-017-2276-8

This experiment was aimed at assessing the development of LAB population dynamic during spontaneous fermentation of *Raphanus sativus L.* in brine between 20℃ and 30℃. In both cases the LAB out competed in the other microbial organism, resulting in a 3.6 pH and TTA increased 0.4%. This is one of many other studies previously to mention the nutritional value of radishes and the corresponding popularity of fermented foods as pre and probiotic nutritional value to human well-being. The study is credible in that it is well referenced and cited, but a source of bias is that the E. Economides & Co GP for provided the raw materials and “helpful discussions”. They used 1.5 cm radius samples for the tests, this helped ensure consistency in the results obtained. The pathogens *Staphylococcus aureus, Clostridia (sulfur-reducing), Escherichia coli, Listeria monocytogenes* and *Salmonella sp.* remained below the study’s parameters throughout fermentation. Nonexistence of *Escherichia coli, Listeria monocytogenes,* and *Salmonella sp.* foodborne pathogens were verified. The use of fructose and glucose were the carbohydrates found while fermenting the results of their catabolism were LAB, ethanol, acetic acid.

Park, C. H., Ki, W., Kim, N. S., Park, S., Kim, J. K., & Park, S. U. (2022). Metabolic Profiling of White and Green Radish Cultivars (Raphanus sativus). *Horticulturae*, *8*(4), 310. https://doi.org/10.3390/horticulturae8040310

This research has the requisite number of references required. The study looks at the metabolic profile of green and white radishes. They profiled and studied 55 different metabolites, sugar alcohols, organic acids, carbohydrates, and amino acids. It was found that green radishes had significantly statistically higher amounts of these amino acids: alanine, valine, leucine, isoleucine, proline, serine, alanine, 4-aminobutyric acid, cysteine, arginine, glutamic acid, phenylalanine, asparagine, glutamine, lysine, and tryptophan. They found the green cultivars contained higher levels of the sugars, sucrose, and raffinose. Higher levels of sugar alcohols were also found in green radishes in the form of mannitol, inositol, and glycerol. Increased amounts of organic acids were observed threonic acid (TCA) and shikimic acid, and TCA intermediates of fumaric acid, malic acid, and citric acid. In contrast, the white cultivar had higher contents of organic acids such as: pyruvic acid, lactic acid, nicotinic acid, glyceric acid, and succinic acid. It was found that green radishes are preferable from a nutritional health and well-being standpoint, the research outlines the nutritional content of the two cultivars of radish.

Vatansever, S., Vegi, A., Garden-Robinson, J., & Hall, C. A., III. (2017). The Effect of Fermentation on the Physicochemical Characteristics of Dry-Salted Vegetables. *Journal of Food Research*, *6*(5), 32. https://doi.org/10.5539/jfr.v6n5p32

This research paper from the North Dakota State University in Fargo, North Dakota studied dry-salted vegetables such as Kimchi, sauerkraut, carrots, and Daikon. They were test fermented in a 50-50 mixture of Daikon-Carrots (mix I) and Daikon-Red Cabbage (mix II). The research stated Leuconostoc strains have been reported as the prevalent microorganisms throughout the opening days of fermentation, as fermentation persisted, LAB dominated for the remainder of the process. Samples were taken on days 0, 3, 7, 10, and 14 to perform chemical and physical analyses. Fermented Daikon had higher pH values than other vegetables. This might be due to less available sugar for the fermentation than other vegetables, and seasonal influences on the radishes available. Fermented Carrot-Daikon had a Brix value increased significantly up to day seven and ten, respectively. The combination of Red Cabbage-Daikon increased phenolic compounds and polyphenol oxidase (PPO) levels; this mixture was good medium for PPO activity and the formation of enzymatic browning compounds. Water activity and hardness of the Daikon were measured. The results of the study, proved that the natural fermentation of vegetables can be completed in either 7 days or 10 days

Wieczorek, M. N., & Drabińska, N. (2022). Flavour Generation during Lactic Acid Fermentation of Brassica Vegetables—Literature Review. *Applied Sciences*, *12*(11), 5598. https://doi.org/10.3390/app12115598

This literature review is the most scholarly work with 116 references cited, and gives a good broad to narrow view of LAB fermentation, and how it relates to Kimchi production. The work gives a brief background on the history of fermentation and the subject of the review is the flavor generation of LAB whist fermenting. The work says that there is an “infinite” number of chemical stimuli can be perceived through orthonasal olfaction “Olfaction, providing information regarding the environment with particular interest in aspects related to food, danger, or social interactions and integration.” (Spors & Grinvald, 2002). Upon further research the publisher of the literature review plagiarized Spors & Grinvald, 2002 by citing them through a secondary source. The review found that in Brassica vegetables, an important group of compounds generated during fermentation were derivatives of glucosinolates and sulfur compounds, that were in large part responsible for the distinctive aroma, odor, and taste of LAB fermented vegetables. The review found in one report that in the early phases of fermentation, the content of citric acid, malic acid, and succinic acid increased, later decreased with a concurrent rise in LAB and acetic acid. The degradation of carbohydrates in Kimchi consequently aids in the formation of multiple organic acids, that are accountable for the exceptional sour taste of Kimchi. The most desired pH associated with aroma, odor, and taste was between 4.0 pH to 4.5 pH. The review states that the sensory profile of Kimchi is slow heat burn (trigeminal sensations), fermented, and the seasoning being fishy, garlic, and Gochugaru (Korean red peppers). The most intense odorants in Kimchi are sulfur compounds: diallyl disulfide, diallyl trisulfide, dimethyl trisulfide, and methallyl disulphide.