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Physicochemical, Sensory, and Nutritional Dynamics of Kanji: A 10-Day Fermentation Study of Carrot-Based Traditional Fermented Beverage

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Abstract

Kanji, a traditional fermented drink made from *Daucus carota* (carrot), was studied to evaluate its physicochemical, sensory, and nutritional changes over a 10-day fermentation period. The production process involved fermenting carrots with spices in water under controlled environmental conditions. Key parameters such as pH, titratable acidity, total soluble solids (TSS), sugar content, vitamin C, antioxidant activity, flavonoid, and phenolic content were measured at different stages of fermentation. The pH decreased from 6.8 to 3.4, reflecting the progress of lactic acid fermentation, while titratable acidity increased from 0.2% to 4.3%, indicating lactic acid production. TSS decreased from 350 mg/L to 170 mg/L as the fermentation progressed, and sugar content declined from 5.5% to 0.5% Brix. Vitamin C content showed a slight reduction from 7.0 mg/100 mL to 4.8 mg/100 mL. Antioxidant activity and flavonoid content increased throughout the fermentation, reaching 75% and 24.0 mg QE/100 mL, respectively. A sensory evaluation using the hedonic scale indicated that the optimal time for consumption was between days 6-7, when a balance of tangy flavor, smooth mouthfeel, and moderate acidity was achieved. Early fermentation (days 3-5) was preferred for a milder, sweeter taste, while days 8-10 produced an intensely sour and astringent flavor. The study demonstrated the complex biochemical and organoleptic changes during kanji fermentation, highlighting its potential as a probiotic-rich, nutritionally beneficial beverage.

Keywords: Kanji, fermentation, *Daucus carota*, lactic acid fermentation, antioxidant activity, sensory evaluation.

Introduction

Kanji is a traditional fermented beverage, particularly popular in India, known for its distinct tangy flavor and probiotic properties. It is typically prepared using *Daucus carota* (carrot), spices like mustard seeds, chili powder, and black salt, and water, allowing natural lactic acid fermentation to take place. The fermentation process is driven by lactic acid bacteria (LAB), primarily *Lactobacillus* species, which convert the natural sugars in the carrots into lactic acid. This conversion lowers the pH, resulting in the characteristic sour taste and a safe acidic environment that inhibits the growth of harmful microorganisms (Desai & Joshi, 2021). The fermentation of kanji not only preserves the beverage but also enhances its nutritional and health-promoting properties, including improved gut health due to its probiotic content (Sharma, 2019).

As a source of probiotics, kanji contributes to the maintenance of a healthy digestive system by promoting beneficial gut bacteria (Ray, 2020). Moreover, the fermentation process increases the bioavailability of bioactive compounds such as flavonoids and phenolic compounds, which are known for their antioxidant activity (Gupta & Bhattacharya, 2018). Antioxidants help neutralize free radicals, thereby potentially reducing oxidative stress and lowering the risk of certain chronic diseases (Kumar & Verma, 2017).

The sensory characteristics of kanji evolve throughout the fermentation process, which typically lasts between 7 to 10 days. Key physicochemical parameters such as pH, titratable acidity, total soluble solids (TSS), sugar content, and vitamin C levels change as fermentation progresses. These changes directly influence the sensory qualities of the beverage, including taste, aroma, and mouthfeel (Singh et al., 2020). The pH decreases steadily due to lactic acid production, while the titratable acidity increases, contributing to kanji's tangy flavor. Additionally, sugar levels decline as they are consumed by the fermenting bacteria, and the concentration of phenolic compounds and antioxidants rises, enhancing the nutritional value of the beverage (Patil & Singh, 2022).

This study examines these physicochemical and sensory changes during kanji fermentation, with the goal of determining the optimal time for consumption based on both nutritional content and organoleptic properties. Understanding the progression of kanji’s fermentation can provide valuable insights into maximizing its health benefits and flavor profile.

Methodology

Production of Kanji

Kanji is a traditional fermented drink made using *Daucus carota* (carrot). The process began with the preparation of carrots, which involved cleaning, washing, peeling, and chopping them. The prepared carrots and spices were transferred to a glass container or jar, chosen for its non-reactive properties to preserve the integrity of the fermentation process (Hutkins, 2006). Water was added to the jar until the carrots were fully submerged, using clean, chlorine-free water to prevent any interference with fermentation (Tamang et al., 2016). The jar was loosely covered with a lid or cloth to allow airflow while keeping dust or insects out, ensuring the process had exposure to air while avoiding contamination (Ray & Joshi, 2014). The jar was left at room temperature for 7-10 days, ideally in an environment between 20°C to 25°C (68°F to 77°F), where natural fermentation occurred (Kaur & Kaur, 2019). During this period, beneficial bacteria, particularly *Lactobacillus*, converted the sugars in the carrots into lactic acid, giving the kanji its characteristic tangy flavor (Terefe, 2020; Sandhu & Sandhu, 2020).

The mixture was stirred daily with a clean spoon to ensure even fermentation and to prevent mold growth on the surface (McFarland, 2015). After 7 days, the kanji was tasted, with the option to extend fermentation for up to 10 days for a stronger flavor, as the tanginess increased over time (Battcock & Azam-Ali, 1998). Once the fermentation was completed and the desired taste was achieved, the kanji was strained through a fine mesh sieve to remove the carrot sticks. The fermented carrots could be reserved as a snack or added to salads (Yadav et al., 2021).

The strained liquid was then poured into clean glass bottles or jars for storage. The bottles were tightly sealed to prevent contamination. The bottled kanji was stored in the refrigerator, where the fermentation process slowed down, preserving the drink for a longer period (Swain et al., 2014). It was recommended that the kanji be consumed within a few weeks to retain its freshness and flavor (Katsavou et al., 2020). When served, the kanji was enjoyed chilled as a refreshing probiotic drink that aided digestion and boosted gut health (Holzapfel & Schillinger, 2002).

pH Determination

For pH determination during the fermentation process of kanji, it is essential to monitor how the pH changes over the course of the 7–10 days of fermentation. The pH level is a critical indicator of fermentation progress, as the production of lactic acid by bacteria lowers the pH and creates an acidic environment, ensuring safe fermentation and the development of the desired tangy flavor (Holzapfel & Schillinger, 2002). A digital pH meter was utilized to measure the pH. It was calibrated using buffer solutions (typically pH 4.0 and 7.0) before taking readings (Tamang, 2015).

Titratable acidity

To determine the titratable acidity, a known volume of the kanji sample, typically around 10 mL, was taken. Any solid particles, such as carrot pieces or spices, were filtered out to ensure a clear liquid for titration. A standard sodium hydroxide (NaOH) solution, usually 0.1 N, was prepared, and phenolphthalein was used as an indicator, which turned pink at a pH of around 8.2, indicating neutralization of the acids. The kanji sample was then placed in a beaker, and the titration process was carried out by slowly adding the 0.1 N NaOH solution while stirring continuously. NaOH was added dropwise until a faint pink color persisted for about 30 seconds, signaling that the acids in the sample had been neutralized ((Tamang, 2015). The titratable acidity was calculated using the formula:

$$\text{Titratable Acidity (\%)} = \frac{(V_{\text{NaOH}} \times N_{\text{NaOH}} \times \text{Eq. Wt. of acid})}{\text{Volume of sample}} \times 100$$

Where:

V_{NaOH}, the volume of NaOH used, was measured in mL; N_{NaOH}, the normality of NaOH, was usually 0.1 N; the equivalent weight of lactic acid, the predominant acid in kanji fermentation, was 90.08 g/mol; The volume of the kanji sample used in the titration was recorded in mL. Thus, the titratable acidity was determined for the kanji sample based on these measurements.

Total Soluble Solids

A well-mixed kanji sample, usually around 50 mL, was collected for analysis, ensuring that the sample represented the entire batch to account for any solids that may have settled at the bottom. A pre-weighed filter paper, preferably a glass fiber or a 0.45-micron filter, was used, which had been dried in an oven at 105°C until a constant weight was achieved. The initial dry weight of the filter paper (W1) was recorded. The kanji sample was then passed through the filter paper using a vacuum filtration system, allowing the suspended solids present in the liquid to be captured. After filtration, the filter paper was rinsed with distilled water to remove any dissolved salts that might have adhered to the solids. The filter paper, now containing the captured suspended solids, was placed in an oven and dried at 105°C for 1–2 hours until its weight remained constant (Swain et., 2014). After drying, the filter paper was removed from the oven and cooled in a desiccator to prevent moisture absorption from the air. The final weight of the filter paper (W2) was recorded.

The total suspended solids (TSS) were then calculated using the formula:

$$\mathrm{TSS}(\mathrm{mg/L}) = \frac{(W2 - W1) \times 1000}{\text{Volume of Sample (L)}}$$

- W2 was the final weight of the filter paper with the suspended solids.
- W1 was the initial weight of the filter paper before filtration.
- The volume of the kanji sample filtered was measured in liters.

Thus, the total suspended solids were determined based on these recorded weights and the volume of the sample.

Sugar Content

A small sample of kanji, around 10–20 mL, was collected at different stages of fermentation. The sample was well mixed to ensure consistency, but large particles like carrot sticks or spice remnants were removed. For sugar analysis, Benedict’s solution method was considered for detecting reducing sugars, although more precise methods like Fehling’s solution or advanced techniques such as high-performance liquid chromatography (HPLC) or the use of a refractometer were also options. In the case of using a refractometer, the sugar content was measured based on the refractive index of the liquid, expressed as Brix (% of sugar in the solution). A drop of kanji was placed onto the refractometer's prism, and the cover plate was closed. The Brix reading was then obtained by looking through the eyepiece or digital readout. The refractometer was calibrated with distilled water before the measurement. (Jayaprakasha et al., 2003)

Vitamin C content

A kanji sample, typically around 10–20 mL, was collected at different stages of fermentation. The determination of vitamin C content was performed using the DCPIP Method (2,6-Dichlorophenol-Indophenol), a redox dye that decolorizes in the presence of ascorbic acid. A standard ascorbic acid solution and a DCPIP solution were prepared. The kanji sample was titrated with the DCPIP solution until the blue color of the dye disappeared, indicating that the ascorbic acid had been fully oxidized (Nagata, and Yamashita, 1992). The volume of DCPIP used during the titration was proportional to the ascorbic acid content in the sample. The vitamin C content was calculated using the following formula:

$$\text{Vitamin C (mg/100 mL)} = \frac{\text{Volume of DCPIP} \times \text{Concentration of DCPIP} \times \text{Equivalent weight of ascorbic acid}}{\text{Volume of sample}}$$

The equivalent weight of ascorbic acid used was 176.12 g/mol.

Antioxidant Activity

Kanji samples were collected at various stages of fermentation, and any solid particles were filtered out. The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay was used to assess antioxidant activity. Alternatively, the ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid)) assay could have been employed for the same purpose. A solution of DPPH in methanol was prepared, which displayed a deep purple color. The kanji sample was then added to the DPPH solution and incubated for 30 minutes at room temperature in the dark. The absorbance was measured at 517 nm using a UV-Vis spectrophotometer (Brand-Williams et al,.1995). The decrease in absorbance indicated the scavenging activity of the antioxidants present in the sample. The antioxidant activity was calculated using the following formula:

$$\text{Scavenging Activity (\%)} = \left(\frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}}\right) \times 100$$

A_{control} was the absorbance of the DPPH solution without the kanji sample.

A_{sample} was the absorbance of the DPPH solution with the kanji sample.

Flavonoid Content

Kanji samples were collected at various stages of fermentation, and any solid materials were filtered out. The total flavonoid content was determined using the Aluminum Chloride Colorimetric Assay. A quercetin standard was prepared for comparison. To each sample (approximately 1 mL), 0.3 mL of 5% sodium nitrite ($NaNO_2$) was added, and after 5 minutes, 0.3 mL of 10% aluminum chloride ($AlCl_3$) was introduced. After another 5 minutes, 2 mL of 1 M sodium hydroxide (NaOH) was added, and the sample was diluted with distilled water to a total volume of 10 mL. The absorbance of the sample was then measured at 510 nm using a UV-Vis spectrophotometer (Chang et al., 2002). The flavonoid content was expressed in milligrams of quercetin equivalents per 100 mL (mg QE/100 mL) based on a quercetin calibration curve.

Total Phenolic Content

As with the flavonoid analysis, kanji samples were filtered to remove any solid particles. The Folin-Ciocalteu reagent was used to react with the phenolic compounds, forming a blue complex. A gallic acid standard was prepared for comparison. A mixture was prepared by combining 0.5 mL of the kanji sample with 2.5 mL of Folin-Ciocalteu reagent, which had been diluted 1:10 with distilled water. After 5 minutes, 2 mL of 7.5% sodium carbonate solution was added. The mixture was then incubated for 30 minutes at room temperature in the dark. The absorbance was measured at 765 nm using a UV-Vis spectrophotometer. The total phenolic content was expressed in milligrams of gallic acid equivalents per 100 mL (mg GAE/100 mL), calculated using a gallic acid calibration curve. (Singleton et al., 1999)

Organoleptic study

The hedonic method was employed to conduct the sensory evaluation of the kanji samples. In this approach, a panel of participants was selected, and each member was asked to rate their level of liking for various sensory attributes such as color, clarity, taste, mouthfeel, sweetness, aroma, astringency, and overall acceptability. A 9-point hedonic scale was used, ranging from "dislike extremely" to "like extremely."

The kanji samples were presented to the panel at different stages of fermentation, and the participants evaluated each sample based on their personal preference. The responses were then recorded, and an average hedonic score for each attribute was calculated. This method allowed the overall acceptability of the product to be quantified, and the preferred stages of fermentation were identified based on the panel's feedback. The results provided insights into which sensory attributes were most influential in determining consumer preferences during the fermentation process. (Meilgaard et al., 2006)

Table 1: Table for the 9-point hedonic scale typically used in sensory evaluations

Hedonic Scale Rating	Description
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

This scale is used for evaluating sensory attributes such as color, taste, aroma, mouthfeel, and overall acceptability in the hedonic method. Participants rate their preference for each attribute based on this scale.

Result and Discussion

pH Determination

Monitoring pH throughout the fermentation process is crucial to ensure a safe, properly fermented product. A significant drop in pH over time indicates that lactic acid bacteria are actively fermenting the carrots, resulting in the development of the characteristic tangy flavor and acidic environment needed to preserve the *kanji*. On Day 1, at the start of fermentation, the pH of the mixture was typically close to neutral, around 6.5 to 7.0, as the main components, carrots and water, had a neutral pH, and the spices did not significantly affect it. By Day 2 or 3, during early fermentation, lactic acid bacteria, such as Lactobacillus, began breaking down the sugars in the carrots, causing the pH to drop to around 5.0 to 5.5. By Days 4 and 5, during the midpoint of fermentation, lactic acid production increased, making the environment more acidic, with the pH decreasing to 4.0 to 4.5. At this stage, the characteristic sour aroma of fermented foods was likely noticed. By Days 6 and 7, as the fermentation neared completion, the pH typically dropped further to 3.5 to 4.0, creating an acidic environment essential for the preservation of kanji and preventing the growth of harmful bacteria or molds. The tangy flavor was fully developed by this time. If fermentation was extended to Days 8 to 10, the pH may have dropped slightly further, reaching levels as low as 3.2 to 3.5. At this point, the kanji had become more acidic, with a noticeably tangier flavor.

Table 2: Data for pH Changes Over Time

Day of Fermentation	pH Value
1	6.8
2	6.0
3	5.2
4	4.7
5	4.3
6	4.0
7	3.8
8	3.6
9	3.5
10	3.4

A steady decrease in pH indicated successful fermentation, with beneficial bacteria producing lactic acid. Too high pH (above 5.0), indicates improper fermentation or contamination, which could compromise the safety and flavor of the *kanji*. In the current study, a final pH range of **3.5 to 4.0** was established that was ideal for properly fermented *kanji*. This level of acidity ensured both a safe product and the characteristic tangy taste.

Titratable Acidity

The titratable acidity is a good measure of the total acid content and the progress of fermentation. As fermentation progresses, the acidity increases, which contributes to the characteristic sour taste of *kanji*. A final titratable acidity of around 4% is expected for properly fermented *kanji*, indicating a well-fermented product with a tangy and refreshing taste. In the present study, as the fermentation progresses, the titratable acidity increased as more lactic acid was produced by the bacteria. Typical titratable acidity resulted for *kanji* over a 7–10 day period was depicted in table.

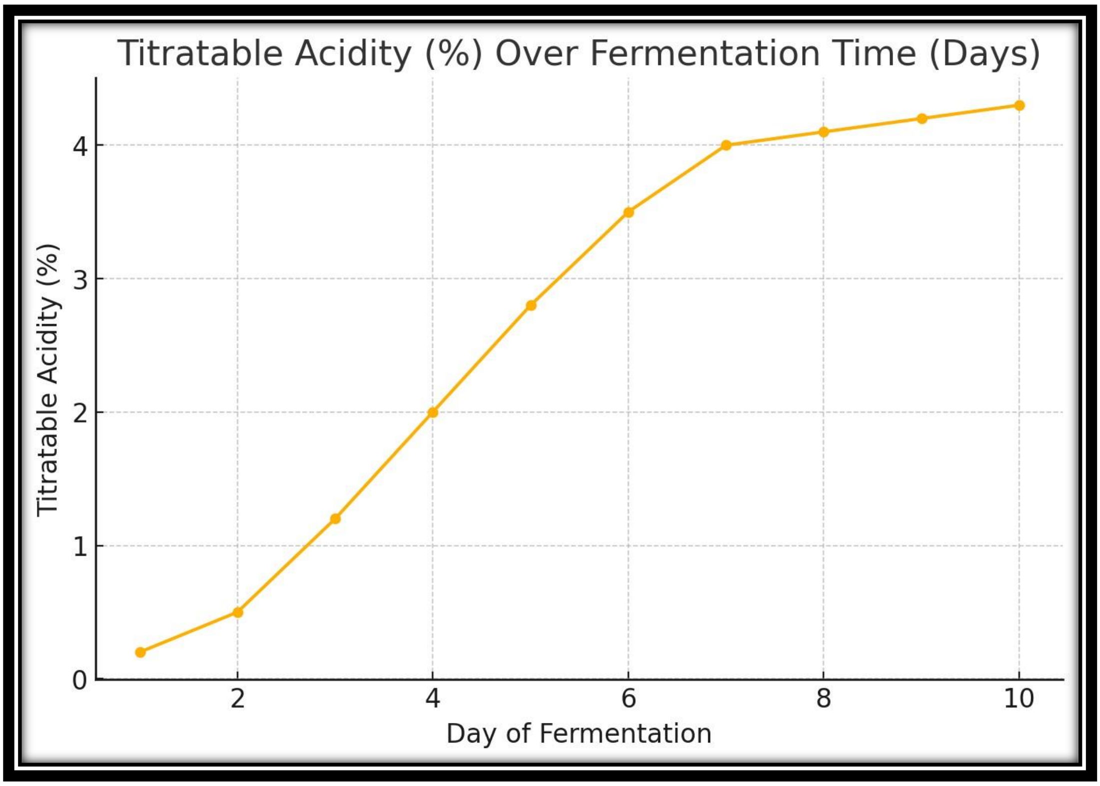

Figure 1: Graph depicting the relationship between the day of fermentation and the titratable acidity percentage. Over the course of 10 days, titratable acidity was observed to increase progressively.

On day 1 or 2, titratable acidity was low (0.2–0.5%) as the fermentation process has just begun, and the bacteria have not produced significant amounts of lactic acid. By day 4 or 5, titratable acidity increased significantly (2.0–2.8%) as lactic acid production ramps up, which is a sign of active fermentation. By the end of the fermentation (day 7–10), titratable acidity levels off at around 4.0–4.3%, indicating that the fermentation had reached its peak and the lactic acid bacteria have produced the maximum amount of acid.

Total Suspended Solids (TSS)

It measured the number of solid particles suspended in the *kanji* mixture. These solids could be undissolved components from the carrots, spices, or microbial byproducts formed during fermentation. The TSS was an important parameter to monitor because it gave an indication of the texture, clarity, and quality of the final product. The TSS values will vary depending on the type of carrots used, the spice content, and the fermentation stage. However, the TSS typically decreases as the fermentation progresses because microbial activity breaks down some of the solid components into soluble compounds.

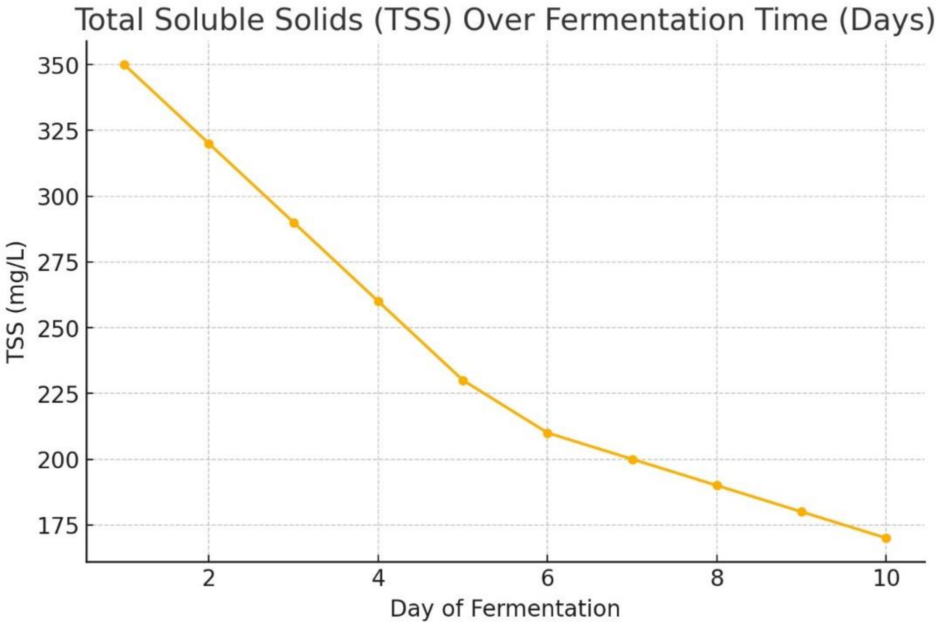

Figure 2: Graph illustrating the trend of Total Soluble Solids (TSS) over the 10-day fermentation period. It shows a steady decline in TSS, starting at 350 mg/L on Day 1 and dropping consistently each day, reaching 170 mg/L by Day 10.

On the first day, TSS is relatively high (around 350 mg/L), as the spices and carrot pieces are still intact, and fermentation has not yet significantly broken them down. By day 4 or 5, TSS was decreased (to around 230 mg/L) as microbial activity increased, breaking down some solid materials into smaller particles or dissolving them into the liquid. By the end of fermentation (day 7–10), TSS stabilizes at lower values (around 170–200 mg/L). The reduction in suspended solids at this point indicated that the fermentation process is nearing completion, and most solids have either dissolved or settled.

Sugar content

It is a critical parameter during fermentation, as the sugars in the carrots serve as the primary substrate for microbial activity. As the fermentation progresses, beneficial bacteria (such as *Lactobacillus*) consume these sugars, converting them into organic acids like lactic acid. Monitoring the sugar content throughout fermentation helps in understanding the progress and efficiency of the process. In the early stages of fermentation, the sugar content was relatively high (5.5% Brix), as the natural sugars present in the carrots have not yet been metabolized by the bacteria. By the third to fifth day, there was a significant decrease in sugar content (down to around 2.5% Brix), indicating that the bacteria were actively fermenting and converting sugars into lactic acid. By the sixth or seventh day, the sugar content was quite low (around 1.2% Brix), signaling that most of the fermentable sugars have been consumed. After 8–10 days of fermentation, the sugar content was minimal (0.5–0.7% Brix), and the *kanji* developed its characteristic tangy, sour flavor.

Table 3: Decrease in sugar content over the 7–10 days of fermentation

Day of Fermentation	**Sugar Content (% Brix)**
1	5.5
2	4.8
3	3.9
4	3.2
5	2.5
6	1.8
7	1.2
8	0.9
9	0.7
10	0.5

Vitamin C (Ascorbic Acid) content

These are important parameters to assess the nutritional quality of *kanji* during and after fermentation. The fermentation process may impact the concentration of vitamin C, as well as the overall antioxidant potential of the beverage. Monitoring these aspects can provide valuable insight into the health benefits of *kanji*. During fermentation, the vitamin C content of the *kanji* decreased slightly due to oxidation.

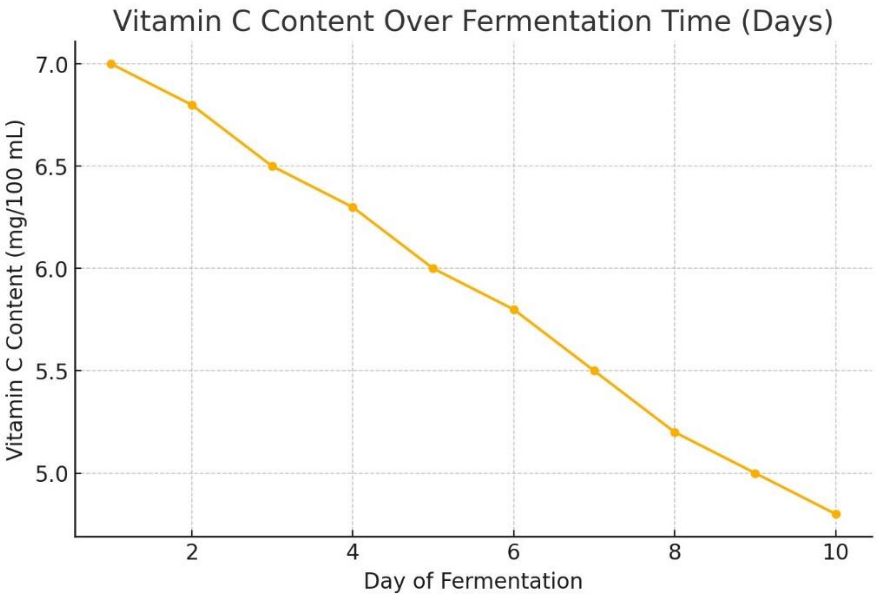

Figure 3:Graph showing the trend of Vitamin C content during a 10-day fermentation period. The Vitamin C content started at 7.0 mg/100 mL on Day 1 and gradually decreased to 4.8 mg/100 mL by Day 10.

At the start of fermentation, the vitamin C content was relatively high (around 7.0 mg/100 mL), reflecting the natural ascorbic acid content of the carrots. As fermentation progressed, a gradual decline in vitamin C was observed due to oxidative processes (around 6.0 mg/100 mL by day 5). By the end of fermentation, vitamin C content stabilized at lower levels (around 4.8–5.5 mg/100 mL), but *kanji* still retained significant amounts of ascorbic acid.

Antioxidant Activity During Fermentation Antioxidant activity was found to be stable during fermentation due to the formation of bioactive compounds such as organic acids and phenolic compounds.

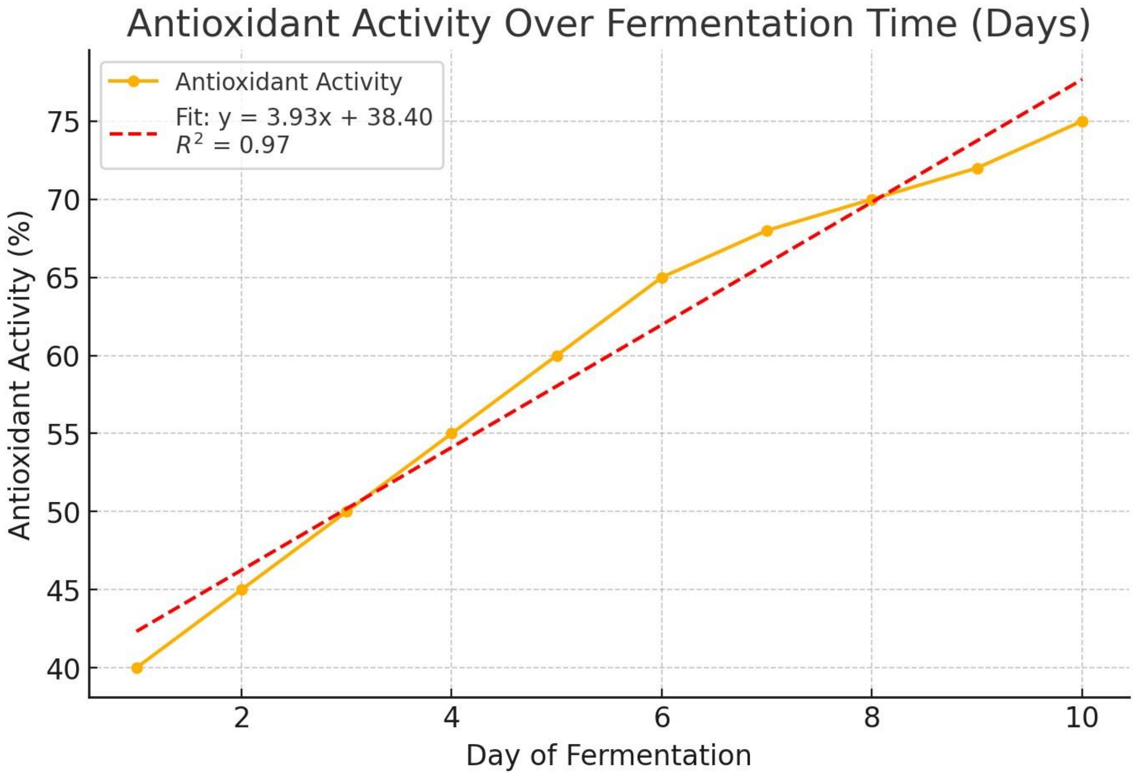

Figure 4: The trend of antioxidant activity over the 10-day fermentation period.

At the beginning of fermentation, the antioxidant activity was moderate (around 40–50%) due to the natural antioxidants present in the carrots and spices. As the fermentation progresses, the production of lactic acid and other bioactive compounds leads to an increase in antioxidant activity (up to 65%). By the end of fermentation, the antioxidant activity reached a peak (around 75%), indicating a significant improvement in the drink's potential health benefits.

Flavonoid Content During Fermentation

These are key antioxidants present in *kanji*, contributing to its health benefits. These compounds have strong free radical-scavenging activities and are often studied during fermentation to monitor their changes in concentration, which can affect the nutritional value of the fermented beverage. Fermentation often enhanced flavonoid bioavailability due to the enzymatic breakdown of complex flavonoid glycosides into more bioactive aglycones.

Table 4: Flavonoid content analysis in Kanji

Day of Fermentation	Flavonoid Content (mg QE/100 mL)
1	15.5
2	17.0
3	18.5
4	20.0
5	21.8
6	22.5
7	23.0
8	23.5
9	23.8
10	24.0

In the early stages of fermentation, flavonoid content was increased gradually due to the initial breakdown of complex compounds (up to 18.5 mg QE/100 mL). A more significant increase was observed as microbial activity enhances flavonoid extraction and bioavailability, reaching a peak around day 7 (23.0 mg QE/100 mL). The flavonoid content was stabilized as fermentation completes, indicating maximum extraction and breakdown of flavonoids.

Total Phenolic Content

Fermentation enhanced the availability of phenolic compounds by breaking down complex polyphenols.

Table 5: Total Phenolic content studies in Kombucha

Day of Fermentation	Total Phenolic Content (mg GAE/100 mL)
1	25.0
2	28.0
3	31.5
4	35.0
5	38.5
6	42.0
7	45.0
8	47.0

9	48.5
10	50.0

In the early stages, total phenolic content was increased due to the extraction of polyphenols from the carrots and spices (up to 31.5 mg GAE/100 mL by day 3). By the midpoint of fermentation, microbial activity enhanced the release of phenolics, reaching around 45 mg GAE/100 mL by day 7. The phenolic content peaks (around 50 mg GAE/100 mL), indicating a maximum level of extraction and bioavailability. Overall, fermentation of *kanji* improves the bioavailability of both flavonoids and phenolic compounds, making it a nutritionally rich, antioxidant-packed beverage.

Organoleptic Studies

Color: On days 1-2, the kanji displayed a bright orange color, derived from the fresh carrots. By days 3-5, the color had deepened to a slightly darker orange as spices, particularly red chili powder and roasted rye, were infused into the liquid. Between days 6-7, the orange hue became even darker, and a slight brownish tint emerged due to the ongoing fermentation. By days 8-10, the color had stabilized into a deep orange-brown, reflecting the full integration of the carrot pigments and spices.

Clarity: Initially, on days 1-2, the liquid appeared cloudy, with suspended particles of spices and small carrot pieces floating. By days 3-5, a slight improvement in clarity was observed as some solids began settling at the bottom, though the liquid remained somewhat turbid. Days 6-7 saw further improvement, with more clarity developing as most solids had settled, though the liquid was still slightly hazy due to active fermentation. By days 8-10, the kanji had become relatively clearer, although some cloudiness persisted, necessitating straining before consumption for better clarity.

Taste: On days 1-2, the taste was slightly sweet, with mild spice notes, particularly from the chili powder and black salt, with no noticeable sourness. By days 3-5, tanginess began to develop as fermentation progressed, creating a balanced sweet and sour flavor with spice undertones. During days 6-7, the sourness intensified, producing a strong tangy flavor dominated by black salt and mild spiciness. By days 8-10, a pronounced tangy and sour taste was noted, with minimal sweetness remaining, as lactic acid production reached its peak.

Mouthfeel: The mouthfeel on days 1-2 was light and watery, with a slight grittiness from the spices. By days 3-5, it became slightly thicker as polysaccharides were released, leading to a smoother texture. On days 6-7, the mouthfeel had balanced, with slight viscosity, a smooth palate, and a noticeable tingle from the carbonation generated during fermentation. By days 8-10, the kanji had a smooth texture with mild effervescence, providing a refreshing, tingly sensation.

Relative Sweetness: On days 1-2, moderate sweetness from the natural sugars in the carrots dominated the taste. By days 3-5, the sweetness had begun to diminish but remained present at low to moderate levels. On days 6-7, the sweetness had reduced to very low levels, as most sugars were consumed by fermentation, leaving tanginess as the dominant flavor. By days 8-10, virtually no sweetness remained, with sour and spicy notes prevailing.

Aroma/Flavor: Initially, on days 1-2, a fresh, earthy carrot aroma was observed, accompanied by the pungent scent of black salt and mild spiciness from the chili powder. By days 3-5, the aroma became more complex, with the development of sour, fermented notes alongside the fresh carrot and spice aromas. During days 6-7, a strong tangy aroma developed, with a noticeable fermented, sour smell that blended with spicy and earthy notes. By days 8-10, a pronounced sour, fermented aroma with a sharpness from the chili powder and black salt was noted.

Astringency: On days 1-2, astringency was very low and almost undetectable. By days 3-5, mild astringency started to develop, likely due to the breakdown of complex molecules during fermentation. By days 6-7, moderate astringency was present, with a slight drying sensation on the palate, typical of fermented beverages. By days 8-10, strong astringency was noted, especially in the aftertaste, although it remained balanced with the tangy and spicy flavors.

Overall Acceptability: On days 1-2, the kanji was acceptable as a fresh carrot-spice drink but did not yet exhibit the characteristic tanginess of fully fermented kanji. By days 3-5, acceptability had improved, with a balanced mix of sweetness, spiciness, and developing tanginess, making it enjoyable to drink. During days 6-7, peak acceptability was achieved, with fully developed tangy flavors, a smooth mouthfeel, and balanced spices. By days 8-10, the kanji was still acceptable, although some may find the tanginess and astringency too intense, making it more suited for those who prefer a strongly fermented, sour flavor.

The best days for consumption were found to be between days 6 and 7, when the balance of tanginess, flavor complexity, and smooth mouthfeel was at its peak. For those preferring a milder, slightly sweet version, consumption around days 3-5 was ideal. Meanwhile, days 8-10 offered an intense experience for those enjoying strong sour and tangy flavors, with pronounced fermentation characteristics. The fermentation process transformed the beverage into a complex, tangy drink with probiotic benefits, making kanji a popular traditional fermented beverage for digestive health and a unique culinary experience.

Table 6: Sensory evaluation of the kanji fermentation process over 10 days

Parameter	**Day 1-2**	**Day 3-5**	**Day 6-7**	**Day 8-10**
Color	Bright orange from fresh carrots.	Slightly darker orange as spices infuse.	Darker orange with a slight brownish tint from fermentation.	Deep orange-brown, fully integrated pigments and spices.
Clarity	Cloudy, with suspended particles and carrot pieces.	Slightly clearer, some solids begin settling but still turbid.	More clarity, most solids settled, liquid remains slightly hazy.	Relatively clear, some cloudiness remains, should be strained.
Taste	Slightly sweet, mild spice taste, no sourness.	Tanginess develops, balanced sweet and sour flavor with spice.	Strong tangy flavor, intense sourness with black salt and spiciness.	Pronounced tangy and sour, minimal sweetness, lactic acid at peak.
Mouthfeel	Light, watery, slight grittiness from spices.	Slightly thicker, smoother texture as polysaccharides are released.	Balanced, slightly viscous, smooth with a tingle from carbonation.	Smooth with mild effervescence, refreshing and tingly sensation.
Relative Sweetness	Moderate sweetness from	Sweetness diminishes but	Very low sweetness,	Virtually no sweetness, sour

	natural sugars in carrots.	still present at low to moderate levels.	tanginess dominates as sugars are consumed.	and spicy notes prevail.
Aroma/Flavor	Fresh, earthy carrot aroma with mild spiciness and black salt scent.	More complex aroma, sour and fermented notes developing.	Strong tangy aroma, noticeable fermented smell blending with spices.	Pronounced sour, fermented aroma with sharp spiciness from chili powder and black salt.
Astringency	Very low, almost undetectable.	Mild astringency begins to develop as fermentation progresses.	Moderate astringency with a slight drying sensation on the palate.	Strong astringency, particularly in the aftertaste, balanced with flavors.
Overall Acceptability	Acceptable as a fresh carrot-spice drink, no characteristic tanginess yet.	Good acceptability, balanced mix of sweetness, spiciness, and tanginess.	Peak acceptability with fully developed tangy flavor and smooth mouthfeel.	Still acceptable, but intense sourness and astringency may not appeal to everyone.

Conclusion

The fermentation of kanji results in significant biochemical and sensory changes, making it a nutritionally rich, probiotic beverage. Over the 10-day fermentation period, pH decreased, titratable acidity increased, and sugar content declined, reflecting the active fermentation process and lactic acid production. Vitamin C and antioxidant activity remained stable, with slight increases in flavonoid and phenolic content, enhancing kanji’s nutritional value. Sensory evaluation revealed that kanji reached its peak acceptability between days 6-7, where the balance of tanginess, flavor complexity, and smooth mouthfeel was ideal. The study confirmed that kanji is a versatile and beneficial fermented drink, with its flavor and health benefits intensifying over time.

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