EFFECT OF MICROWAVE AND CONVENTIONAL HEAT TREATMENT ON DIFFERENT QUALITY PARAMETERS OF SPONTANEOUSLY FERMENTED KOHLRABI PICKLE DURING STORAGE

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Abstract
Many perishable vegetables are fermented in Himalayan region of India, and Kohlrabi, one of the most prominent cruciferous vegetables, is no exception.However, spontaneous fermentation causes a slew of issues in the marketing and storage of this fermented pickle. Continuous fermentation causes over-acidification, texture softening, unpleasant aroma and appearance. The purpose of the study was to examine at the influence of conventional heat and microwave treatment on desired quality parameters including pH, acidity, texture, microbial load, and sensory characteristics of fermented kohlrabi pickle over a 25-day storage period. Microwave-treated samples T1(2min), T2(2.5min), T3(3min), T4(3.5 min), and T5(4mins), as well as conventional heat-treated samples T6, T7, and T8(90 C for 5,10, and 15 min, respectively) and T9, T10, and T11(100 C for 5,10, and 15 min, respectively) were analyzed for various quality attributes over 25 days at regular intervals in comparison with controls (T0). The results indicated a significant difference among control and treated samples in terms of pH, acidity, texture, microbial load,and sensory score, The pH and acidity of all the samples showed significant differences when compared to control (pH-3.64; TA-1.41) at the end of storage period.Although both treatments considerably reduced LAB count as compared to control (8.21 log CFU/g), microwave treated samples, particularly T5, had a better control than conventional heat-treated samples. Texture study indicates that pickle hardness decreased over time, but microwave treated samples in general, and T5 in particular, showed a significant decrease in hardness value as compared to control and conventional heat-treated samples. The overall acceptability of samples T4, T5, and T11 were 6.37, 6.18, and 6.40 respectively, which varied significantly from other treated samples and control. From the present findings, it can be concluded that both the treatments could arrest/slowdown the growth of LAB in a fermented pickle. However proper process parameters need to be selected as excessive exposure to microwaves or conventional heataffects the sensory and textural attributes of the product.

Keywords: Fermentation, Kohlrabi, Lactic acid bacteria, Microwave heating, Quality attributes

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1. INTRODUCTION

Vegetables are an essential part of the human diet. Because of their high nutritional and phytochemical content, they are essential for human nutrition and health. Vegetables are high in nutritive components such as dietary fiber, carbohydrates, proteins, vitamins, and minerals, as well as non-nutritive components like phenolic compounds, flavonoids, anthocyanins, and bioactive peptides, and so on[1]. Significantly reduced risk of some chronic, non-communicable ailments such as cancer and cardiovascular disease has been associated with the consumption of sufficient amount of vegetables and this has been substantiated by numerous in-vitro, pre-clinical, and clinical trials [2,3]. Genus *Brassica* forms an important part of the *Brassicaceae* family which comprise cruciferous vegetables such as kale, kohlrabi, cabbage, collards, Brussel sprouts, cauliflower, and broccoli which hold a notable place in the human diet universally [4].Because of being continuously associated with numerous health benefits and prevention of diseases such as cancer, cardiovascular disease, and diabetes, the intake of cruciferous vegetables has increased over the years. The various health-promoting properties of cruciferous vegetables such as antioxidant potential, antiinflammatory, anti-diabetic and anti-cancer activity, are attributed to the presence of a rich amount of nutritional and non-nutritional components which include carbohydrates, proteins, organic acids, vitamins, minerals, sulphur containing glucosinolates, flavonoids, antioxidant enzymes, anthocyanins, terpenes and other minor components [5]. Kohlrabi (*Brassica oleracea var Gongylodes L*), is one of the dietary cruciferous vegetablescultivated globally. It is one of the popular vegetable crops in Europe, Asia, the United States, and Canada. Known by vernacular names like Olkabi, Ganth Gobi, Knol-kohl, Nookal, and Monji Haak, Kohlrabi forms the prime cruciferous vegetable crop grown in the Himalayan region of Jammu and Kashmir, India. It is also a conventional crop in West Bengal and some parts of South India [6,7].Kohlrabi, like other Cole vegetables, is low in fat, and rich in vitamins, minerals, fiber as well as phytochemical compounds [8]. As per the United States Department of Agriculture National Nutrient Database, the raw kohlrabi stem contains 91% moisture, 3.6% dietary fiber,1.7% protein,0.01% lipids,1% ash,6.2% carbohydrates, 2.6% total sugars, and 27 kcal per 100 g. It has also been reported to contain a significant amount of essential minerals and vitamins including calcium, magnesium, phosphorus, sodium, vitamin C, β- carotene, vitamin E, Vitamin K, Vitamin A, and B complex vitamins. Phytochemicals found in kohlrabi include phenolics, luteolin, kaempferol, quercetin, glucoraphanin, glucobrassicin, glucoerucin, and glucoiberin. [9,10].

Vegetables are perishable and hence prone to spoilage after being harvested. To enhance the shelf life of these nutritious perishable commodities it is essential to preserve them from being spoiled. For the same, various processing have been evaluated and used to preserve and enhance the shelf life of vegetables.Fermentation, which involves the breakdown of fermentable carbohydrates into simpler compounds by the action of microorganisms is considered to be one of the simplest and most economical methods to preserve perishable food materials. Vegetables contain an appreciable amount of fermentable sugars, amino acids, and organic acids that support the growth and proliferation of Lactic acid bacteria (LAB). LAB which form a modest part of the autochthonous (indigenous) microflora of vegetables ranging between 2.0 to 4.0 log cfu/g are capable of carrying out spontaneous lactic acid fermentation of vegetables under favorable conditions. This process is widely utilized to boost the safety, sensory, and nutritional properties of vegetables along with increasing the period of their practical usage [11,12]. The fermented foods form an integral part of the local culture and tradition of people in the developing countries and these foods are widely consumed as a part of their diet [13]. Many perishable vegetables are subjected to preservation by fermentation in the Himalayan region [14]. Kohlrabi, which is preferred for its soft, tender leaves and enlarged, plump, above-ground stem known as knob[7], is subjected to spontaneous fermentation in the Himalayan region of Jammu and Kashmir. However, lactic acid fermentation is a spontaneous process that results in over-acidification, undesirable flavor, and aroma owing to the uncontrolled growth of LAB. There is a need to adopt different suitable techniques to control the lactic acid fermentation to minimize the variability in the spontaneously fermented product.

Therefore the main aim of the present study was to evaluate the efficiency of microwave and conventional heat treatment in controlling or slowing-down LAB growth in the fermented product after attaining the desired value of pH and acidity, to enhance its shelf life, with minimal impact on organoleptic qualities, as well as consumer acceptability.

2. MATERIALS AND METHOD

2.1. Procurement of raw material

Fresh kohlrabi was procured from the local market of Hazratbal, Srinagar, and brought to the Food processing pilot plant of the Department of Food Science and Technology. The vegetablesfree from physical damage and other defects were properly cleaned and used for further processing and product formulation.

2.2. Chemicalsand reagents

The chemicals and reagents that were used for Physico-chemical and microbial analysis were purchased from HIMEDIA, India, and Sigma-Aldrich, Chemie (Buchs, Switzerland). All the chemicals used were of analytical grade.

2.3. Preparation of fermented kohlrabi pickle

Kohlrabi (leaves, stem, and stalk) was thoroughly cleaned under running water, shredded into pieces, and accurately weighed. For two days, the kohlrabi was shade-dried, with occasional turnings to eliminate surface moisture. The dried vegetable was then pickled by combining it with oil and spices.The mustard oil was heated on low flame and then cooled, followed by the addition of spices which comprised of cumin, partially ground mustard seeds, head-less cloves, fennel powder, coriander powder, red chili powder, turmeric powder, carom seeds,and ginger-garlic paste. The dried vegetable was mixed with theoil-spice mixture. This was followed by the addition of 3% common salt. The product was filled in a sterilized plastic container. The filled container was stored under ambient conditions and the product was allowed to ferment spontaneously.The product (P) was monitored at regular intervals during the fermentation process until desired acidity and pH were attained. On day 15 of fermentation, the fermented product was subjected to conventional heat and microwave treatment after achieving the desired pH and acidity. Five samples were subjected to microwave treatment for 2, 2.5, 3, 3.5, and 4 minutes, filled into sterilized plastic containers, and labeled as T1, T2, T3, T4, and T5 respectively. Similarly, sixother samples were subjected to a conventional heat treatment of 90°C and 100°C for 5, 10, and 15 minutes respectively. The treated samples were then filled into sterilized plastic containerslabeled as T6, T7, T8, T9, T10, and T11 respectively. One lot was kept as control (untreated) and labeled as T0.From the day of treatment, the samples were analyzedat an interval of 5 days for 25 days to evaluate the impact of thetreatments on various quality attributes.

2.4. Physicochemical analysis

2.4.1. pH

The pH of the product (P) and samples wasdetermined by using a pH meter (Digital microprocessor pH meter, LT-501, Labtronics, India) calibrated using standard buffer solutions.

2.4.2. Titratable acidity

The titratable acidity (TA) ofthe product (P)and samples was determined by the titrimetric method. 10 g of sample was homogenized with 100 ml of distilled water. 10 ml of aliquot was titrated against 0.1N NaOH using 2-3 drops of phenolphthalein as an indicator. The acidity was expressed as percent lactic acid and calculated as follows:

% Titratable acidity = (N of NaOH x Eq. Wt of acid x Vol made up / Wt of sample x aliquot x 1000) x 100

2.5. Microbiological analysis

The LAB count of the product (P) and samples was done by serial dilution followed by spread plating on MRS[15] agar plates under aseptic conditions. The plates were incubated under anaerobic conditions at 37 °C for 48 hours. The well-grown, discrete bacterial colonies were enumerated for total colony forming units(CFU)[16]. The LAB count was expressed as $\log_{10}$ CFU/g.

2.6. Texture analysis

The texture analysis of the samples was done by a cutting probe using a texture analyzer (Stable Microsystem, Model TA.XT plus, England). Texture profile analysis (TPA) was performed on each sample at room temperature. The conditions of texture analysis were as follows: test speed 2.00mm/sec, post-test speed 10.00mm/sec, maximum load 50kg, distance 15 mm, and trigger type "force". Before analysis, the height of the probe was calibrated. The texture profile analysis of each sample was obtained as a curve plotted between force (g) and time (seconds). A value of maximum force (Hardness) was determined for each sample.

2.7. Sensory analysis

The sensory analysis of the product (P) and samples was done usinga 9- point hedonic scale for attributes like flavor, texture, aroma, and color. Sensory analyses were carried out byten non- trained panelists (21 to 34 years of age) and four trained panelists (30 to 45 years of age) in the Department of Food Science and Technology. Samples were coded and served to panelists at room temperature. Samples were given to panelists separately for unbiased evaluation of sensory attributes. The overall acceptability of the product was evaluated and calculated as the sum of all the sensory attributes taken into consideration during the analysis.

2.8. Statistical analysis

The data was statistically analyzed using IMB SPSS statistics 28. The difference among treatments and the duration of storage was evaluated by two-way analysis of variance (ANOVA) and Tukey HSD post hoc test at a significance level of 5%. All the data are reported as means ± standard deviations (SDs).

3. RESULTS AND DISCUSSION

3.1. pH value

The pH of the raw material was 6.48 at the commencement of fermentation and steadily reduced to 4.31 on the day of treatment (Figure 1). After treatment on day 15 of fermentation, the pH values of all samples declined comparably throughout storage (Table 1). pH values in the control sample (T0) dropped significantly from 4.14 on day 5 of storage to 3.64 at the end of the storage period. The pH of microwave-treated samples T1, T2, T3, T4, and T5 decreased during storage from 4.21 to 3.38, 4.17 to 3.98, 4.13 to 4.01, and 4.14 to 4.00 respectively. Similarly, conventionally heat-treated samples T6, T7, T8, T9, T10, and T11 also showed a decrease in pH during storage from 4.13 to 3.78, 4.15 to 3.87, 4.15 to 3.98, 4.15 to 4.00, 4.16 to 4.01 and 4.16 to 4.00 respectively. The pH levels of the treatments did not differ significantly. They did, however, differ considerably from the control sample. As anticipated, the pH decreases during lactic acid fermentation due to the growth of LAB that convert fermentable carbohydrates to lactic acid[17].Several research reports have also reported a decline in pH in fermented products [18–21].

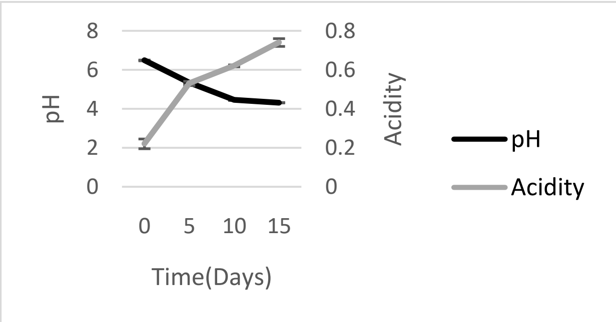

Figure 1: pH and Acidity values of product (P) during fermentation before treatment

3.2. Titratable acidity

The titratable acidity of raw material, measured as a percentage of lactic acid, was found to be 0.22 % at the beginning of fermentation and steadily escalated to 0.74 % on the day of treatment (Figure 1). Following treatment on day 15 of fermentation, the acidity levels of all samples increased similarly during storage.(Table 2).In the control sample (T0), acidity values showed a significant increase during storage from 1.02 to 1.41 %. The acidity (%) was measured to be 0.98, 0.99, 1.02, 1.02, and 1.05 for microwave treated samples T1, T2, T3, T4, and T5 respectively on day 5 of storage. These values increased during storage to 1.24, 1.19, 1.19, 1.18, and 1.16 respectively. Similarly, conventionally heat-treated samples T6, T7, T8, T9, T10, and T11 also showed an increase in acidity (%) during storage from 1.05, 1.05, 1.02, 1.06, 1.02, and 1.02 to 1.22, 1.22, 1.19, 1.19, 1.19, and 1.19 respectively. The acidity levels did not vary significantly across treatments. They did, however, differ considerably from the control sample at the end of the storage period.As expected, the acidity value increases during lactic acid fermentation as the concentration of lactic acid increase owing to the conversion of fermentable sugars by LAB[22].

Table 1: pH of fermented kohlrabi pickle samples during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	4.14 ± 0.015^{aq}	4.04 ± 0.023^{bq}	3.96 ± 0.020^{cs}	3.75 ± 0.020^{ds}	3.64 ± 0.030^{es}
T1	4.21 ± 0.015^{ap}	4.15 ± 0.025^{ap}	4.11 ± 0.015^{bp}	3.95 ± 0.035^{br}	3.83 ± 0.030^{br}
T2	4.21 ± 0.015^{ap}	4.14 ± 0.025^{abcp}	4.12 ± 0.020^{bp}	4.11 ± 0.020^{bcp}	4.04 ± 0.040^{cdp}
T3	4.17 ± 0.026^{aq}	4.13 ± 0.020^{abp}	4.06 ± 0.030^{bq}	4.02 ± 0.026^{bcq}	3.98 ± 0.025^{cdpq}
T4	4.13 ± 0.015^{aq}	4.11 ± 0.015^{ap}	4.04 ± 0.020^{br}	4.01 ± 0.015^{bqr}	4.01 ± 0.015^{bp}
T5	4.14 ± 0.020^{aq}	4.11 ± 0.020^{abp}	4.04 ± 0.052^{br}	4.02 ± 0.020^{bqr}	4.00 ± 0.015^{bp}
T6	4.13 ± 0.015^{aq}	4.07 ± 0.015^{abq}	4.02 ± 0.025^{brs}	3.94 ± 0.041^{cqr}	3.78 ± 0.030^{dr}
T7	4.15 ± 0.020^{aq}	4.13 ± 0.020^{ap}	4.04 ± 0.040^{br}	3.99 ± 0.015^{bcpq}	3.87 ± 0.025^{dqr}
T8	4.15 ± 0.025^{aq}	4.12 ± 0.020^{abp}	4.06 ± 0.036^{bq}	4.05 ± 0.030^{bcpq}	3.93 ± 0.094^{cdq}
T9	4.15 ± 0.015^{aq}	4.13 ± 0.020^{ap}	4.07 ± 0.015^{bcp}	4.07 ± 0.020^{cpq}	4.00 ± 0.015^{dpq}
T10	4.16 ± 0.020^{aq}	4.13 ± 0.025^{abp}	4.09 ± 0.010^{bp}	4.05 ± 0.045^{bdpq}	4.01 ± 0.015^{dep}
T11	4.16 ± 0.015^{aq}	4.14 ± 0.020^{ap}	4.08 ± 0.020^{abcp}	4.04 ± 0.050^{bpq}	4.00 ± 0.040$^{bc\ p}$

Values are represented as mean± SD
Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$)

Table 2: Acidity (% lactic acid) of fermented kohlrabi pickle samples during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	1.02 ± 0.049^{dp}	1.11 ± 0.051^{cdp}	1.18 ± 0.023^{cbp}	1.24 ± 0.028^{bp}	1.41 ± 0.051^{ap}
T1	0.96 ± 0.055^{cp}	1.05 ± 0.051^{bcp}	1.12 ± 0.045^{abp}	1.20 ± 0.051^{ap}	1.24 ± 0.028^{aq}
T2	0.99 ± 0.005^{cdp}	1.02 ± 0.049^{bcp}	1.10 ± 0.023^{bp}	1.12 ± 0.045^{abq}	1.19 ± 0.023^{aq}
T3	1.02 ± 0.051^{bp}	1.09 ± 0.023^{abp}	1.12 ± 0.045^{abp}	1.13 ± 0.028^{abq}	1.19 ± 0.070^{aq}
T4	1.02 ± 0.046^{bp}	1.09 ± 0.023^{abp}	1.12 ± 0.045^{abp}	1.16 ± 0.045ap	1.18 ± 0.023^{aq}
T5	1.05 ± 0.051^{bp}	1.10 ± 0.023^{abp}	1.13 ± 0.028^{abp}	1.15 ± 0.028^{ap}	1.16 ± 0.040^{aq}
T6	1.05 ± 0.051^{ap}	1.09 ± 0.087^{ap}	1.11 ± 0.098^{ap}	1.20 ± 0.051^{ap}	1.22 ± 0.032^{aq}
T7	1.05 ± 0.058^{bcp}	1.09 ± 0.023^{bp}	1.15 ± 0.028^{abp}	1.19 ± 0.023^{ap}	1.22 ± 0.028^{aq}
T8	1.02 ± 0.046^{bcp}	1.09 ± 0.023^{bp}	1.13 ± 0.028^{abp}	1.18 ± 0.017^{ap}	1.19 ± 0.023^{aq}
T9	1.06 ± 0.061^{cp}	1.05 ± 0.046^{bcp}	1.12 ± 0.045^{abcp}	1.18 ± 0.023^{ap}	1.19 ± 0.020^{aq}
T10	1.02 ± 0.046^{cdp}	1.09 ± 0.023^{cp}	1.10 ± 0.023^{bcp}	1.19 ± 0.020^{ap}	1.19 ± 0.023^{aq}
T11	1.02 ± 0.049^{cdp}	1.09 ± 0.023^{cp}	1.10 ± 0.023^{bcp}	1.19 ± 0.020^{ap}	1.19 ± 0.020^{aq}

Values are represented as mean± SD
Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$)

3.3. Microbial load

The initial microbial load of raw material in terms of LAB was found to be 4.23 log CFU/g which increased to 7.46 log CFU/g on the day of treatment (Figure 2). It is well known that raw- vegetablesharbor LAB as a small part (2-4 log CFU/g) of their autochthonous microflora which under favorable conditions proliferate and carry out the fermentation process[11]. On day 5 of storage, the LAB count of all treated samples decreased significantly as compared to the control (T0) (Table 3). The LAB count of the control was 7.97 log CFU/g on day 5 of storage, and it rose markedly during storage to 8.21 log CFU/g. The lactic count (log CFU/g) of microwave treated samples T1, T2, T3, T4, and T5 on day 5 of storage was 7.20, 7.17, 6.97, 6.83, and 6.65 which increased significantly throughoutthe storage period to 7.45, 7.40, 7.22, 7.15 and 7.16 respectively. In the case of conventional heat-treated samples T6, T7, T8, T9, T10, and T11, the LAB count (log CFU/g) on day 5 of storage was 7.22, 7.18, 7.12, 7.10,7.02 and 6.8, which showed a significant increase to 7.45,7.43,7.40,7.38,7.31 and 7.28 respectively during storage.Due to the inherent difference in heating mechanism, it is difficult to compare the effectiveness of microwave and conventional heat treatment. Many studies have demonstrated the effectiveness of microwave heating in controlling microbial growth owing to various thermal and non-thermal effects on microorganisms[23–25]. Although the conventional treatment has been reported to decrease the microbial load in foods [26], there are numerous factors such as heat resistance of the target microorganisms, physical properties of the food such as specific heat, conductivity, porosity, etc and rate of heat exchange between heating medium and food that have a profound effect on its effectiveness. [23]. The data indicate that both treatments slow down the lactic growth as compared to control.However, a better control was observed in microwave treated samples, particularly T5 as compared to conventional heat-treated samples

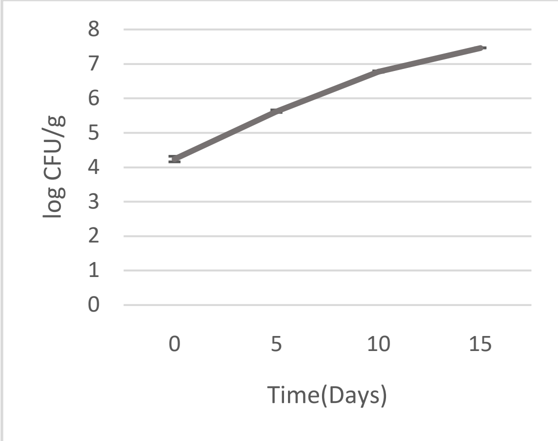

Figure 2: LAB count of product (P) during fermentation before treatment

3.4. Texture

Texture plays a prime role in the consumer acceptability of fermented vegetables. Therefore the control and fermented samples were analyzed to determine the texture through measurement of hardness value (H). The texture of control and treated samples showed a decline during storage as presented in figure 3.A similar trend has been observed in cauliflower pickles[20].The hardness (H) value of control (T0) decreased to 1004 from 1287. For microwave-treated samples T1, T2, T3, T4, and T5, the hardness decreased from 1272,1277,1281,1280 and 1284 to 797,604,564,495 and 467 respectively during storage. Conventional heat-treated samples T6, T7, T8, T9, T10, and T11 also exhibited a decline in hardness over time. The values decreased from 1285, 1272,1275,1288,1284 and 1284 to 979,815,775,705,672 and 632 respectively. The highest decline was observed in microwave treated sample T5 where the hardness value reached 467 at the end of the storage period.

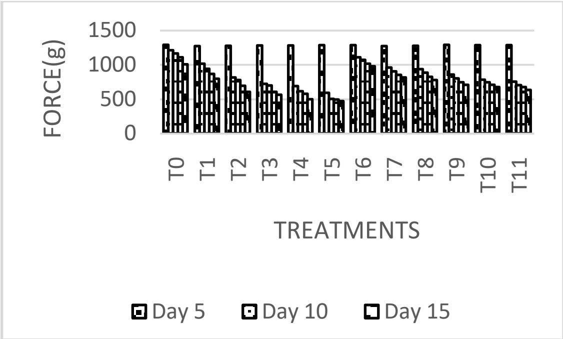

Figure 3: Hardness (H) values of kohlrabi pickle during storage

3.5. Sensory score

The overall acceptability score of control and treated samples are presented in Table 4. The results indicated that the sensory quality of control (T0) was rated best by the panelists. On the fifth day of storage, the overall acceptability of T0 was 7.78, which decreased to 6.90 after 25 days of storage. The sensory score for microwave-treated samples T1, T2, T3, T4, and T5 was 7.58, 7.57, 7.52, 7.47, and 7.40, which declined to 6.67, 6.75, 6.70, 6.37 and 6.18 respectively during storage. The sensory score for conventional heat-treated samples T6, T7, T8, T9, T10, and T11 was 7.64, 7.50, 7.42, 7.40, 7.38, and 7.30, which decreased to 6.95, 6.82, 6.81, 6.74, 6.62 and 6.40 respectively through the storage time. Results indicate that microwave treated samples T4 and T5 received the lowest scores possibly because of the textural degradation, cooked appearance, and slight color change caused due to the microwave treatment. These results are in agreement with previous research studies[27,28].

Table 3: LAB count (log CFU /g) of fermented kohlrabi pickle during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	7.97 ± 0.016^{ap}	8.01 ± 0.010^{bp}	8.12 ± 0.010^{cp}	8.17 ± 0.006^{dp}	8.21 ± 0.010^{ep}
T1	7.20 ± 0.005^{aq}	7.27 ± 0.004^{br}	7.38 ± 0.006^{cq}	7.42 ± 0.007^{dq}	7.45 ± 0.004^{eq}
T2	7.17 ± 0.008^{aq}	7.20 ± 0.006^{bs}	7.29 ± 0.002^{cs}	7.33 ± 0.007^{dr}	7.40 ± 0.004^{er}
T3	6.97 ± 0.014^{at}	7.01 ± 0.018^{bv}	7.08 ± 0.010^{cw}	7.13 ± 0.008^{dv}	7.22 ± 0.009^{et}
T4	6.83 ± 0.028^{au}	6.92 ± 0.008^{bw}	7.01 ± 0.010^{cx}	7.10 ± 0.010^{dw}	7.15 ± 0.012^{eu}
T5	6.65 ± 0.024^{av}	6.81 ± 0.013^{bx}	7.00 ± 0.013^{cx}	7.08 ± 0.013^{dw}	7.16 ± 0.007^{eu}
T6	7.22 ± 0.014^{aq}	7.31 ± 0.005^{bq}	7.37 ± 0.004^{cq}	7.41 ± 0.005^{dq}	7.45 ± 0.006^{eq}
T7	7.18 ± 0.009^{aq}	7.25 ± 0.007^{br}	7.33 ± 0.005^{cr}	7.40 ± 0.007^{dq}	7.43 ± 0.006^{eqr}
T8	$7.12 \pm 0.008^{a\,r}$	7.19 ± 0.004^{bs}	7.26 ± 0.005^{ct}	7.33 ± 0.005^{dr}	7.40 ± 0.006^{er}
T9	7.10 ± 0.007^{ar}	7.15 ± 0.007^{bt}	7.21 ± 0.008^{cu}	7.30 ± 0.009^{ds}	7.38 ± 0.031^{er}
T10	7.02 ± 0.012^{as}	7.12 ± 0.014^{bt}	7.19 ± 0.014^{cu}	7.25 ± 0.005^{dt}	7.31 ± 0.023^{es}
T11	6.8 ± 0.024^{au}	7.05 ± 0.013^{bu}	7.13 ± 0.006^{cv}	7.19 ± 0.007^{du}	7.28 ± 0.005^{es}

Values are represented as mean± SD
Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

Table 4: Overall acceptability of fermented kohlrabi pickle during storage

	Day 5	Day 10	Day 15	Day 20	Day 25
T0	7.78 ± 0.298^{ap}	7.51 ± 0.310^{bp}	7.07 ± 0.230^{cpq}	6.97 ± 0.172^{cp}	6.90 ± 0.170^{cpq}
T1	7.58 ± 0.276^{ap}	7.24 ± 0.262^{bcp}	6.97 ± 0.172^{cpq}	6.74 ± 0.297^{cdpq}	6.67 ± 0.267^{deq}
T2	7.57 ± 0.302^{ap}	7.32 ± 0.289^{bpr}	6.94 ± 0.145^{cpq}	6.92 ± 0.099^{cp}	6.75 ± 0.178^{cpq}
T3	7.52 ± 0.216^{ap}	7.07 ± 0.267^{br}	6.91 ± 0.187^{bcq}	6.84 ± 0.194^{cdpq}	6.70 ± 0.103^{deq}
T4	7.47 ± 0.278^{ap}	6.78 ± 0.183^{bs}	6.58 ± 0.146^{bcr}	6.41 ± 0.253^{cdrq}	6.37 ± 0.132^{cdes}
T5	7.40 ± 0.350^{aq}	6.78 ± 0.214^{bs}	6.58 ± 0.228^{bcr}	6.27 ± 0.201^{drq}	6.18 ± 0.228^{des}
T6	7.64 ± 0.377^{ap}	7.50 ± 0.311^{abp}	7.17 ± 0.281^{bp}	6.98 ± 0.308^{bcp}	6.95 ± 0.262^{bcdp}
T7	7.50 ± 0.268^{ap}	7.38 ± 0.253^{apq}	7.05 ± 0.227^{bpq}	6.94 ± 0.165^{bcp}	6.82 ± 0.154^{bcdp}
T8	7.42 ± 0.302^{ap}	7.18 ± 0.276^{bqr}	6.97 ± 0.189^{bcpq}	6.91 ± 0.151^{cdp}	6.81 ± 0.146^{cdep}
T9	7.40 ± 0.248^{aq}	7.14 ± 0.213^{bqr}	6.92 ± 0.201^{bcq}	6.85 ± 0.198^{cdp}	6.74 ± 0.182^{cdepq}
T10	7.38 ± 0.318^{aq}	7.08 ± 0.187^{bqr}	6.94 ± 0.165^{bcpq}	6.72 ± 0.168^{cdp}	6.62 ± 0.205^{deqr}
T11	7.30 ± 0.257^{aq}	7.02 ± 0.132^{br}	6.82 ± 0.205^{bcqr}	6.64 ± 0.210^{dq}	6.40 ± 0.175^{ers}

Values are represented as mean± SD
Mean values ± SD within a row and column with different superscript letters are significantly different ($P \leq 0.05$).

4. CONCLUSION

The current research examined how microwave and conventional heat treatments affected key quality metrics of spontaneously fermented kohlrabi pickle during storage. In terms of controlling/slowing down the proliferation of lactic acid bacteria, both microwave and conventional heat treatments demonstrated effectiveness. T5, the microwave-treated sample, had somewhat better control. On day 5 of storage after treatment, microwave-treated sample T5 exhibited a considerable decrease in LAB count (6.65 log CFU/g), which steadily increased over storage. Longer microwave treatment, on the other hand, had a detrimental influence on the pickle's textural and sensory properties. Furthermore, no significant effect on final pH and acidity values was observed among the treatments, although the values varied from the control. This work will serve as the foundation for future process improvements and technological interventions aiming to enhance the shelf life, quality characteristics, and customer acceptance of spontaneously fermented products by effectively controlling the fermentation process.

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Conflict of Interest
The authors have no conflict of interest

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