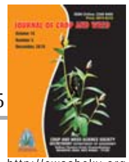
Journal of Crop and Weed, 16(2): 204-209 (2020)

ISSN- O : 2349 9400 ; P : 0974 6315



http://cwssbckv.org
www.cropandweed.com

Studies on shelf life of sauerkraut

P. K. THAKUR, P. PANJA, J. KABIR AND R. S. DHUA

Department of Post Harvest Technology of Horticultural Crops
Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya
Mohanpur-741252, Nadia, West Bengal

Received : 01.11.2019 ; Revised : 15.07.2020 ; Accepted : 20.07.2020

DOI : https://doi.org/10.22271/09746315.2020.v16.i2.1338

ABSTRACT

One of the most important fermented products prepared from cabbage known as Sauerkraut. After completion of fermentation, i.e., 21 days it was subjected to potassium metabisulphite and pasteurization and stored in ambient (25-30^{0}C) and low temperature (6-8^{0}C) with different treatments. In sauerkraut compared to fresh cabbage, pH decreased while TSS, acidity, lactic acid and ascorbic acid increased. Subsequently on 14th day, pH of T_1, T_2 and T_4 increased and thereafter on 21st day decreased marginally. TSS of fresh sauerkraut (7.8^{0}Brix) increased upto 14th day in T_1 (8.8^{0}Brix). Acidity (0.87%) of fresh sauerkraut was higher than fresh cabbage but in storage on 7th day it decreased in all treatments except in T_4, which increased upto 14th day (1.28%) than decreased on 21st day (0.41%). The pattern changes of lactic acid were similar to acidity. Ascorbic acid of KMS treatment remained higher compared to pasteurization. The scoring of T_2 and T_4 indicated that colour and texture on 21st day was good and also on 63rd day (4.00 and 5.95 respectively). Thus at low temperature irrespective of pasteurization and KMS treatments sauerkraut quality and shelf life could be increased. Among the low temperature treatments, T_4 was comparatively better than T_2 as revealed from chemical quality and sensory score.

Keywords: Cabbage, fermentation, preservation, sauerkraut and shelf life

One of the most important fermented products prepared from cabbage known as Sauerkraut (Pederson and Albury, 1969). Sauerkraut is German word literally translated, means acid (sour/sauce) cabbage (kraut). Sauerkraut is a low calorie food can be preserved for long period of time with the nutrients and desirable sensory properties (Mennes, 1994; Trail *et al*., 1996). The indigenous bacteria naturally fermented the cabbage in the presence of salt known as acidic cabbage or Sauerkraut. It is highly popular in some western countries. In India sauerkraut is not known as a food among the masses. Although sauerkraut is manufactured occasionally in small quantity by a few canners in India, they have conducted no research (Doyle *et al.*, 2001). In sauerkraut, fermentation of cabbage yield lactic acid as the major product. This lactic acid along with other minor products of fermentation, gives sauerkraut its characteristic flavour and texture (Keith, 1996). Lactic acid fermentation preserves vegetables mainly by lowering the pH due to lactic acid production, which occurs when lactic acid bacteria convert fermentable sugars (Daeschel and Fleming, 1987). Sauerkraut, if properly prepared, can be quite a rich source of vitamin C (Srivastava, 2008). The extent of microbial growth and the sensory properties of the final product depend on the addition of salt, which is the most critical point in Sauerkraut production (Holzapfel *et al.*, 2003). During the fermentation process, acidic metabolites are formed and the pH decrease, thus altering the microbial flora composition in the medium. Gram-negative bacteria and sporulating bacteria are inhibited when the medium starts acidifying. In these conditions only lactic acid bacteria are able to multiply, followed by a series of other species. Lactic acid bacteria generally isolated from fermented sauerkraut are *Lactobacillus plantarum*, L. *brevis*, *Pediococcus cerevisiae*, *Leuconostoc mesenteroides* and *Lactococcus lactis* (Daeschel and Fleming, 1987; De-Valdez *et al*., 1990; Roberts, 2002; Pandir and Jain, 2010). Sauerkraut stimulates the peptic glands and has mild laxative property which is due to the esters acetycholine and lactylcholine formed during fermentation by lactic acid bacteria (Srivastava and Kumar, 1998). During cooking essential nutrients of cabbage are destroyed. Glass jar, cans and plastic pouches are mostly used for packaging of Sauerkraut (Fleming *et al.*, 1995). The unpasteurized sauerkraut with sodium benzoate (0.1% w/w) and potassium metabisulphite are added as preservatives can be store in refrigerated (Wood, 1998). The pasteurization of Sauerkraut at 74 to 82^{o}C for approximately 3 minutes, with hot sauerkraut is filled into enamel-lined cans or glass jars, sealed and rapidly cooled to create a vacuum (Wood, 1998; Adams and Moss, 1996). Pandir and Jain (2010) prepared and stored sauerkraut at room temperature *i.e.*, 21^{0}C to 24^{0}C in jars for 120 days and found that lactic acid bacteria count increased up to 7th day of fermentation and started declining from 7th day to 120th day of storage.

Email: pranbckv@gmail.com

MATERIALS AND METHODS

The crop was raised in the C-Block Research Farm of BCKV, Naida, West Bengal and post havest study was conducted under laboratory condition at the department of Post Harvest Technology of Horticultural Crops, BCKV, West Bengal. Sauerkraut was prepared according to method of Wiander *et al*. (2005) and Penas *et al*. (2010). The fresh mature cabbage heads were taken after removing the outer green leaves, broken or dirty leaves. Cabbage heads were cut into four pieces and the core of the head was removed. Then they were sliced by knives into shreds as fine as 2 mm and non-iodized salt was added to slice cabbage as requirement. After thoroughly mixing cabbage with salt, it was allowed to stand for several minutes to wilt. It helped to draw juices from the cabbage. The salted cabbage slices were filled inside the beaker and pressed down firmly until juices ran out the cabbage and covered it completely. The cabbage shreds were covered with clean plastic inside the container. Plastic cover was filled smoothly against the side of the container so that the cabbage was not exposed to the air. A weight was put on the top of the cover (filled with water, makes a good weight). Container of cabbage was placed in a well ventilated place with a relatively constant temperature.

Sauerkraut of variety Shaan was prepared according to method described earlier. Sauerkraut after completion of fermentation, *i.e.*, 21 days was subjected to potassium metabisulphite (KMS) and pasteurization treatment and stored at ambient temperature (25-30^{0}C) and low temperature (6-8^{0}C) condition with different treatments as mentioned below.

Treatments

T_1 Pasteurization + Ambient temperature

T_2 Pasteurization + Low temperature

T_3 KMS + Ambient temperature

T_4 KMS + Low temperature

The pH of sample was recorded with the help of digital pH meter (Model: Systronics 1 pH system 361) after standardization with buffer solutions of 7.0 and 4.0 pH. Total soluble solids in ^{0}Brix were determined by taking a direct reading of a drop of the homogenized sample in a digital refractometer (ATAGO PR-1, Japan) with a range of 0 to 32°Brix and resolutions of 0.2°Brix. Titratable acidity and ascorbic acid were estimated according to AOAC (2000). Total acidity expressed as percent (%) lactic acid, were determined following the method given by Cappuccino *et al.* (1996). Sensory score for appearance, colour, texture, flavour and overall acceptability were recorded following 10 point hedonic scale. Where 1 to 4.5 refers as poor quality, 4.5 to 6.5 as fair, 6.5 to 8 as good and 8 to 10 as excellent taste quality was used in the evaluation (Tuorila and Hellemann, 1993) (Lakshmana and Rajanna, 2002). The taste panel of the 10 persons used in this study was trained by a professional specialist in sensory evaluation for carrying out different sensory evaluation tasks. The analysis of data obtained in experiment was analyzed by Completely Randomized Design with 4 replications, by adopting the statistical procedures of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The chemical composition of fresh and fermented cabbage has been presented in table 1. Fresh cabbage possess pH of 5.65, TSS of 5.20 ºBrix, acidity of 0.23%, lactic acid 0.32%, ascorbic acid 30.92 mg 100^{-1} g and total sugar of 2.06%. Composition of fresh fermented sauerkraut (after 21st days *i.e.*, completion of fermentation) were as follows: pH 3.16, TSS 7.8ºBrix, acidity 0.87%, lactic acid 1.22% and ascorbic acid 41.85mg 100^{-1} g (Table 1). Thus in fermented sauerkraut compared to fresh cabbage pH decreases while TSS, acidity, lactic acid and ascorbic acid increases appreciably.

The treatment on sauerkraut to increase shelf life (T_1 to T_4) was significantly different for pH, on 7th, 14th and 21st days of storage. On 7th day of storage pH of T_1 (Pasteurization + Ambient temperature), T_2 (Pasteurization + Low temperature) and T_4 (KMS + Low temperature) decreased to 3.05, 3.15 and 3.10 from pH of fresh sauerkraut of 3.16. Subsequently on 14th day pH of T_1, T_2 and T_4 increased to 4.25, 4.20 and 4.10 respectively and thereafter on 21st day pH decreased marginally. On the other hand pH of T_3 (KMS + Ambient temperature) increased from 3.35 on 7th day to 4.52 on 21st day of storage.

Observation of pH value of T_1 (Pasteurization + Ambient temperature) and T_3 (KMS + Ambient temperature) was not possible after 21st days since sauerkraut of these two treatments (T_1 and T_3) deteriorated and not available due to fungal growth and darkening of product indicating that ambient condition was not suitable for storage irrespective of KMS or pasteurization treatments. T_2 and T_4 *i.e.*, pasteurization and KMS treatments at low temperature was available for storage up to 63rd days. pH slightly decreased on 28th day (T_2= 3.97, T_4= 3.90), then again increased to 4.07 in T_2 and 4.13 in T_4.

Significant difference (5%) among the treatments for TSS content was observed on 7th day, 14th and 21st day of storage (Table 2). TSS of fresh sauerkraut (7.8ºBrix) increased appreciably in storage up to 14th day in T_1 (8.8 º Brix) and 7th day in T_2 (8.6 ºBrix), T_3 (8.6 ºBrix) and T_4 (8.6 ºBrix). T_1 and T_2 *i.e.*, in ambient condition

Table1: Chemical composition of fresh cabbage and sauerkraut after fermentation

Chemical composition	Fresh cabbage	Fresh sauerkraut
pH	5.65	3.16
TSS (^{0}Brix)	5.20	7.8
Acidity (%)	0.23	0.87
Lactic acid (%)	0.32	1.22
Ascorbic acid (mg 100^{-1}g)	30.92	41.85
Total sugar (%)	2.06	-

Table 2: Effect of pasteurization, KMS and storage condition on pH of sauerkraut

Treatments	Storage days				
	7	**14**	**21**	**42**	**63**
T_1= Pasteurization + Ambient temperature	3.05	4.25	4.10		
T_2= Pasteurization + Low temperature	3.15	4.20	4.14	4.36	4.07
T_3= KMS + Ambient temperature	3.35	4.40	4.52		
T_4= KMS + Low temperature	3.10	4.10	4.08	4.13	4.13
SEm (±)	**0.04**	**0.04**	**0.04**		
LSD (0.05)	**0.13**	**0.13**	**0.12**		

Note: KMS= Potassium metabisulphite

Table 3: Effect of pasteurization, KMS and storage condition on TSS of sauerkraut

Treatments	Storage days				
	7	**14**	**21**	**42**	**63**
T_1= Pasteurization + Ambient temperature	8.8	9.0	8.0		
T_2= Pasteurization +Low temperature	8.6	8.2	7.8	6.0	8.2
T_3= KMS + Ambient temperature	8.6	8.0	7.4		
T_4= KMS + Low temperature	8.6	8.4	7.8	6.5	8.4
SEm (±)	**0.07**	**0.10**	**0.13**		
LSD (0.05)	**0.22**	**0.31**	**0.40**		

Table 4: Effect of pasteurization, KMS and storage condition on acidity of sauerkraut

Treatments	Storage days				
	7	**14**	**21**	**42**	**63**
T_1= Pasteurization + Ambient temperature	0.76	1.32	0.66		
T_2= Pasteurization +Low temperature	0.57	0.97	0.76	0.99	0.76
T_3= KMS + Ambient temperature	0.78	0.75	0.76		
T_4= KMS + Low temperature	0.99	1.28	0.41	0.92	1.16
SEm (±)	**0.04**	**0.03**	**0.05**		
LSD (0.05)	**0.13**	**0.103**	**0.14**		

irrespective of treatments sauerkraut were not storable after 21st days. At low temperature (*i.e.*, T_2 and T_4) sauerkraut was available up to 63rd days and TSS of T_2 and T_4 was 8.2 ºBrix and 8.4 ºBrix respectively.

The effect of different treatments on acidity was significant on 7th, 14th and 21st day of storage (Table 4). Acidity of fresh sauerkraut (0.87%) was higher than fresh cabbage but in storage on 7th day it decreased in all the

Table 5: Effect of pasteurization, KMS and storage condition on lactic acid of sauerkraut

Treatments	Storage days				
	7	14	21	42	63
T_1= Pasteurization + Ambient temperature	1.08	1.85	0.94		
T_2= Pasteurization +Low temperature	0.81	1.37	1.08	1.40	1.08
T_3= KMS + Ambient temperature	1.10	1.06	1.26		
T_4= KMS + Low temperature	1.40	1.80	0.68	1.30	1.64
SEm (±)	**0.06**	**0.05**	**0.07**		
LSD (0.05)	**0.18**	**0.15**	**0.22**		

Table 6: Effect of pasteurization, KMS and storage condition on ascorbic acid of sauerkraut

Treatments	Storage days				
	7	14	21	42	63
T_1= Pasteurization + Ambient temperature	29.20	32.76	32.80		
T_2= Pasteurization +Low temperature	48.00	34.80	29.60	34.00	44.10
T_3= KMS + Ambient temperature	63.00	44.10	41.80		
T_4= KMS + Low temperature	76.00	45.50	32.12	42.28	52.00
SEm (±)	**1.37**	**0.25**	**1.33**		
LSD (0.05)	**4.12**	**0.74**	**3.97**		

Table 7: Effect of pasteurization, KMS and storage condition on colour and texture of sauerkraut

Treatments	Storage in days									
	7		14		21		42		63	
	Colour	Texture	Colour	Texture	Colour	Texture	Colour	Texture	Colour	Texture
T1	8.00	7.00	6.00	6.00	4.00	4.00				
T2	8.00	8.00	6.00	6.00	6.40	6.00	5.10	5.00	4.00	5.00
T3	8.00	8.00	6.00	6.00	4.10	4.00				
T4	8.00	8.00	7.10	8.00	7.00	7.00	6.00	7.00	5.95	7.00
SEm (±)	**0.34**	**0.44**	**0.36**	**0.47**	**0.42**	**0.43**				
LSD (0.05)	**NS**	**NS**	**NS**	**1.40**	**1.25**	**1.30**				

treatments except in T_4. Acidity of T_4 increased up to 14th day of storage (1.28%) than decreased on 21st day (0.41%). Then again it increased gradually to 1.16 on 63rd day. Although T_2 also followed the same pattern of variation and but on 63rd day acidity value was slightly lower (0.76%). Acidity of T_1 and T_3 on 21st day was 0.66 and 0.76% respectively.

The pattern changes of lactic acid in different treatments were similar to acidity (Table 5). The lactic acid decreased in different treatments on 21st day compared to 14th day in storage. Thereafter lactic acid of T_2 gradually increased to 1.40, on 42nd day and then on 63rd day it decreased to 1.08% whereas lactic acid of T_4 increased to 1.64 up to 63rd day. Due to fungal infection it was not possible to store beyond 63rd days.

Significant difference on ascorbic acid content among treatments on 7, 14 and 21st day was observed. Ascorbic acid of KMS treatment *i.e.*, T_3 and T_4 remained significantly higher compared to pasteurization treatments *i.e.*, T_1 and T_3 on 7th day of storage. Up to 21st day of storage ascorbic acid content slightly decreased in T_2, T_3 and T_4 (29.60mg100g^{-1}, 41.80mg100g^{-1} and 32.12mg100g^{-1}) but in T_1 it increased marginally (32.80mg100g^{-1}). After 21st days, ascorbic acid of T_2 and T_4 increased in storage to 44.10mg100g^{-1} and 52.00mg100g^{-1} on 63rd day of storage where as T_1 and T_3 was not storable beyond 21st day due to quality deterioration and fungal infection.

Sensory evaluation for colour and texture is presented in table 6. On 7th day colour and texture of all the treatments (T_1, T_2, T_3 and T_4) were excellent (8.00) except texture of T_1 which was very good (7.00). Both colour and texture of T_1 and T_3 deteriorated at a faster rate and on 21st day it was fair to poor (4.00). But the scoring of T_2 and T_4 indicated that colour and texture on 21st day was good (5.00 to 7.00) and on 63rd day of storage the score was 4.00 and 5.95 respectively. Sensory evaluation for flavour and acceptability (Table 7) revealed that T_1 and T_3 *i.e.*, treatment at ambient condition deteriorated faster and on 21st day the scores was recorded 4.00 (fair to poor) whereas T_2 and T_4 could be stored for 63rd days with score of 6.00 and 7.00 respectively.

Thus at low temperature (6-8 ºC) irrespective of pasteurization and KMS treatments in general sauerkraut quality and shelf life could be increased. Among the low temperature treatments, KMS + low temperature *i.e.*, T_4 was comparatively better than pasteurization + low temperature (T_2) as revealed from chemical quality and sensory score.

Previous report also supported successful packaging of sauerkraut in glass bottles (also cans and plastic pouches) (Fleming *et al*., 1995). The efficacy of potassium metabisulphite preservatives in refrigerated storage of unpasteurized sauerkraut has been confirmed by Wood (1998). However Wood (1998) could not specify the shelf life of sauerkraut by application of KMS. In the present investigation sauerkraut with KMS + low temperature (T_4) could be preserved up to 63rd days with good colour, texture, flavour and overall acceptability, high ascorbic acid and lactic acid. The prolong period of storability of T_2 (*i.e.*, pasteurization + Low temperature) is attributed to shelf stability of pasteurization treatment followed by ascetical filling in sterilized bottles (Wood (1998), (Adams and Moss, 1996).

The prolong shelf life (63rd days) at low temperature with KMS *i.e.*, T_4 and pasteurization (T_2) might be due to successful fermentation at low temperature (6-8ºC) storage and growth of *Lactobacillus mesenteroides* at the expense of other lactic acid bacteria (Pederson and Albury, 1969). In present experiment ambient condition (25-30ºC) fungal growth deteriorated and completely spoiled the sauerkraut after 21st days of storage irrespective of pasteurization or KMS treatments (T_1 and T_3) corroborated the recent findings of Pandir and Jain (2010). However they could store sauerkraut 120th days because of a less fluctuating temperature (21ºC to 24ºC) of storage. It has been possible to increase shelf life of sauerkraut by using reduced salt and starter culture (Johanningsmeier *et al.*, 2007) and application of high hydrostatic pressure (Goodridge *et al*., 2006).

Sauerkraut after completion of fermentation *i,e.* after 21 days of fermentation was subjected to potassium metabisulphite (KMS) and pasteurization treatment. The treated sauerkraut was filled in sterilized bottles, sealed and stored in ambient temperature (25-30p C) and low temperature (6 to 8p C) to study the shelf life.

In fermented sauerkraut compared to fresh cabbage, pH decreased while TSS, acidity, lactic acid and ascorbic acid increased appreciably. Subsequently on 14th day, pH of T_1 (Pasteurization + Ambient temperature), T_2 (Pasteurization + Low temperature) and T_4 (KMS + Low temperature) increased to 4.25, 4.20 and 4.10 respectively and thereafter on 21st day pH decreased marginally. On the other hand pH of T_3 (KMS + Ambient temperature) increased from 3.35 on 7th day to 4.52 on 21st day of storage. Observation of pH value of T_1 (Pasteurization + Ambient temperature) and T_3 (KMS + Ambient temperature) was not possible after 21st days since sauerkraut of these two treatments (T_1 and T_3) deteriorated and not available due to fungal growth and darkening of product indicating that ambient condition was not suitable for storage irrespective of KMS or pasteurization treatments.

TSS of fresh sauerkraut (7.8p Brix) increased appreciably in storage up to 14th day in T_1 (8.8p Brix) and 7th day in T_2 (8.6p Brix), T_3 (8.6p Brix) and T_4 (8.6p Brix). At low temperature (*i.e.*, T_2 and T_4) sauerkraut was available up to 63rd days and TSS of T_2 and T_4 was 8.2p Brix and 8.4p Brix respectively. Acidity of fresh sauerkraut (0.87%) was higher than fresh cabbage but in storage on 7th day it decreased in all the treatments except in T_4. Acidity of T_4 increased up to 14th day of storage (1.28%) than decreased on 21st day (0.41%). It again increased gradually to 1.16 on 63rd day. Although T_2 also followed the same pattern of variation but on 63rd day acidity value was slightly lower (0.76%). The pattern changes of lactic acid in different treatments were similar to acidity. Ascorbic acid of KMS treatment *i.e.*, T_3 and T_4 remained significantly higher compared to pasteurization treatments *i.e.*, T_1 and T_2 on 7th day of storage. Up to 21st day of storage ascorbic acid content slightly decreased in T_2, T_3 and T_4 (29.60mg100g^{-1}, 41.80mg100g^{-1} and 32.12mg100g^{-1} respectively) but in T_1 it increased marginally (32.80mg100g^{-1}). After 21st days, ascorbic acid of T_2 and T_4 increased in storage to 44.10mg100g^{-1} and 52.00mg100g^{-1} on 63rd day of storage where as T_1 and T_3 was not storable beyond 21st day due to quality deterioration and fungal infection.

Both colour and texture of T_1 and T_3 deteriorated at a faster rate and on 21st day it was fair to poor (4.00). But the scoring of T_2 and T_4 indicated that colour and texture on 21st day was good (5.00 to 7.00) and on 63rd day of storage the score was 4.00 and 5.95 respectively.

Thus at low temperature (6-8^{0}C) irrespective of pasteurization and KMS treatments in general sauerkraut quality and shelf life could be increased. Among the low temperature treatments, KMS + low temperature *i.e.*, T_4, was comparatively better than pasteurization + low temperature (T_2) as revealed from chemical quality and sensory score.

ACKNOWLEDGEMENT

All the authors sincerely acknowledge to the Department of Post Harvest Technology of Horticultural Crops, Faculty of Horticulture, BCKV, India for providing the necessary facilities and technical support to conduct the experiment.

REFERENCES

A.O.A.C. 2000. Official Methods of Analysis of AOAC International. 17th Edn. Vol. II. Washington, D. C., pp. 16.

Adams, M.R. and Moss, M.O. 1996. Food Microbiology, New Age International Pvt. Ltd. pp. 274-278.

Cappuccino, J.G. and Sherman, N. 1996. Microbiology- A Laboratory manual. 4th Edn. Benjamin/Cumming Publishing, USA., pp. 186.

Daeschel, M.A. and Fleming, H.P. 1987. Selection of lactic acid bacteria for use in vegetable fermentation. *Food Microbiol*., **1:** 303-313.

De-Valdez, G.F., de Giori, G.S., Garro, M., Mozzi, F. and Oliver, G. 1990. Lactic acid bacteria from naturally fermented vegetables. Microbiologie *Aliments Nutr*., **8:** 175.

Doyle, M. P., Beuchal, L.R. and Montville, T. J. 2001. Food Microbiology: Fundamental and Frontiers, 2nd ed. ASM Press, Washington, D. C., pp. 768.

Fleming, H.P., Kyung, K.H. and Breidt, F. 1995. Vegetable fermentation in Biotechnology, 2nd ed, Vol.9 (eds. H. J. Rehm. and G. Reed), VCH, New York, pp. 629-631.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research (2nd Edn.). Wiley-Inter Science publication, New York, USA.

Goodridge, L. D., Willford, J. and Kalchayanand, N. 2006. Destruction of Salmonella enteritidis inoculated onto raw almond by high hydrostatic pressure. *Food Res. Int*., **38**: 408-412.

Holzapfel ,W., Schillinger, U. and Buckenhüskes, H. J. 2003. Sauerkraut. In: E. R. Farnworth (Edn.), Handbook of fermented functional foods, Raton, FL: CRC Press, pp. 343-359.

Johanningsmeier, S., McFeeters, R.F., Fleming, H.P. and Thompson, R.L. 2007. Effects of Leuconostoc mesenteroides starter culture on fermentation of cabbage with reduced salt concentrations. *J. Food Sci.*, **72:** 166-172.

Keith, H.S. 1996. Hand Book of indigenous fermented foods, Marcel, New York, USA.

Lakshmana, A. and Rajanna, K. M. 2002. Preparation, Preservation and comparative studies on Sauerkraut of cabbage Hybrids. *Mysore J. Agric. Sci*., **36:** 218-221.

Mennes, E.M.1994. Make your own sauerkraut. Cooperative Extension Publication. UW-Extension. B2087, pp. 1-7.

Pandir, R.K. and Jain, P. 2010. Change in Microflora of Sauerkraut During Fermentation and Storage. *World J. Dairy Food Sci*., **5**: 221-225.

Pederson, C.S. and Albury, M. N.1969. The sauerkraut fermentation. Geneva, N.Y. New York State Agric. Exp. Station Bull., pp. 824.

Penas, E., Frias, J., Sidro, B. and Vidal Valverde, C. 2010. Impact of fermentation conditions and refrigerated storage on microbial quality and biogenic amine content of sauerkraut. *Food Chem*., **123**: 143-150.

Roberts, J.S. 2002. Development of sauerkraut blends to Stimulate the Market and the senses. In: Processing of the 2002 New York State Vegetable Conference, Liverpool, New York.

Srivastava, M.L. 2008. Fermentation Technology. Narosa Book Distributors Pvt. Ltd. New Delhi, India. pp. 259-268.

Srivastava, R.P. and Kumar, S. 1998. Fruit and Vegetable Preservation (Principles and Practies). Int. Book Distrib. Co. Lucknow, India,

Trail, A.C., Fleming, H.P., Young, C.T. and McFeeters, R.F. 1996. Chemical and sensory characterization of commercial sauerkraut. *J. Food Qual*., **19**: 15-30.

Tuorila, H. and Hellemann, U. 1993. Elintarvikkeet aistien puntarissa (Sensory Evaluation of Foods), University of Helsinki, pp. 37-39.

Wiander, B. and Ryhanen, E.L. 2005. Laboratory and large-scale fermentation of white cabbage into sauerkraut and sauerkraut juice by using starters in combination with mineral salt with a low NaCl content. *Eur. Food Res. Technol*., **220:** 191-195.

Wood, J.B. 1998. Microbiology of fermented foods. Blackie Academic and Professional, London, pp. 45-72.