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Effect of Potassium Salt Replacement on Physicochemical, Sensorial and Microbiological Properties of Mango Pickle

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Abstract

The common salt is the major source of sodium to the diet. Excessive salt intake has various negative effects on health. Pickle is the product containing high amount of salt. The aim of this work was to reduce sodium content and to study the effect of sodium chloride replacement with potassium chloride on physiochemical, sensorial and microbiological qualities of mango pickle during storage at room temperature (25±5°C) in glass jar and laminated foil pouch. From sensory analysis as insignificant differences were observed in overall acceptability score of pickles made by replacing 25% and 50% of sodium chloride with potassium chloride (8.17 and 8.14) compared with control (8.18) the pickle made with maximum 50% potassium chloride in replacement of sodium chloride was considered for further physicochemical, sensorial and microbial study during storage. No significant difference among proximate constituents was observed in control and selected potassium salt replaced sample (MPK_2). The overall acceptability of MPK_2 was found about 8.53 in glass jar and 7.02 in laminated foil pouch up to 9 and 7 months respectively. The moisture content, water activity and titrable acidity of MPK_2 were found to be increased while pH was decreased during storage in both packaging materials. The sample found microbiologically safe up to 9 months and 7 months. Thus, it was possible to reduce the sodium content of mango pickle by replacing 50% sodium chloride with potassium chloride and could be stored safely up to 9 months and 7 months in glass jar and laminated foil pouch respectively.

***Key words*:** Sodium, Potassium, Organoleptic qualities, Glass jar

Pickling is the process of preserving food in regular salt or vinegar, with the addition of spices and oil. Pickles are prepared by fermenting variety of fruits and vegetables naturally [1]. The name "pickle" comes from the Dutch word ‘pekel’ which means brine or salt (Wikipedia 2022). Pickle is known by the different names as ‘Achar’ in Hindi, Bengali, Punjabi, ‘Uppinakaayi’ in Kannada, ‘Lonacha’ in Marathi, ‘Orukai’ in Tamil and ‘Oragaya’ in Telugu. Pickling originated as a means of preserving food for use during off-seasons and lengthy travels, particularly by water. The origins of pickling date back to 2030 B.C., when pickles were made from cucumbers. Depending on the type of raw material utilized, different pickles have differing nutritional values. Along with nutritional importance pickles act as a food accompaniment, palatability enhancers and facilitate digestion by encouraging the passage of gastric juices [2]. Variety of pickles made from mango, lemon, jackfruit, tamarind, aonla, turnip, chilli, horse radish etc. are available in market. It is one of the most important processed food products in India. India is the largest producer of pickles with a volume estimated at 65000 tons valued at Rs.5 billion [3]. Sesame, rapeseed, and mustard oils are typically used in Indian pickles while imported pickles are preserved in vinegar. In Indian cuisine, particularly in the preparation of pickles, sesame oil, rapeseed oil (also known as canola oil), and mustard oil are commonly used as preserving agents and for their distinct flavors. These oils not only help in preserving the pickles but also impart unique tastes and aromas to the final product.

Mango is one of the seasonal types of fruit and is used for a very long period in all stages of development. Pickle is one of the most traditional and well-known raw green mango products among the different products like chutney, pickle, amchoor, and green mango beverage. Mango cultivars with stiff textures and strong acidity are used to make pickles. In many cultures, particularly in South Asia, green, unripe mangoes are popularly used to make pickles due to their firm texture and tartness. Pickled mangoes, often known simply as mango pickle, are a traditional and well-loved condiment enjoyed across the region. The tartness of green mangoes adds a refreshing and tangy element to the pickles, balancing out the rich and savory flavors of the spices. Certain mango cultivars, such Rumani and Konkan Ruchi in Maharashtra, are only used for pickling [4-5]. For the average Indians, mango pickle is an important item in the diet. A meal may not be regarded complete without use of pickle as pickles breathe life into otherwise bland food [6]. Pickling involves dipping of fruit pieces in a high concentration of salt solution to promote fermentation. Pickles are among the foods that have a high salt content because they typically contain between 15% and 20% salt [7]. Sodium chloride is one of the most widely used agents

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in food preservation which increases storage time by decreasing water activity. This sodium chloride is the chief source of sodium ion in regular diet. Although sodium is an essential micronutrient its excessive consumption resulted in negative health effects such as hypertension, cardiovascular diseases and stroke [8]. Different National and International organizations including World Health Organization [9] state that that average population salt intake should be less than 5 g per day. However, according to the most recent data the average salt consumption among the people in India's various regions is between 9 and 12 g per day [10]. Pickles high salt content could have a negative impact on people's health. It also has become challenging for the food industry to reduce the use of sodium chloride without causing much effect on the taste, functionality and utility.

Sodium reduction can be achieved through the different strategies such as with the use of flavor enhancers, naturally brewed soya sauce, organic acids, some herbs & spices, then by decreasing the level of common salt while food preparation, replacing salt with other chloride salts, changing the form of salt and through public awareness. Finding effective methods to lower salt levels in food is a complex issue which depends on the type of product, its composition, and the type of industrial processing [11]. Sodium chloride mainly consists of two elements namely sodium Na^+ and chloride Cl^- where the primary cause of the food's saltiness is Na+. Whenever think for replacing sodium with other chloride salts potassium, calcium, or magnesium are usually suggested [12]. Among them the most common sodium reduction solution used in place of NaCl is KCl. The flavour of potassium chloride resembles to that of salt. However, potassium chloride differs from sodium chloride as it often develops bitter and metallic aftertaste. Thus, only partial substitution of Sodium Chloride (NaCl) by Potassium Chloride (KCl) seems to provide an alternative for reducing sodium content. This difference in taste between potassium chloride and sodium chloride can limit its direct substitution for reducing sodium content in foods. Many food manufacturers and consumers opt for a partial substitution of sodium chloride with potassium chloride to mitigate the bitter aftertaste while still reducing overall sodium intake. This approach helps in achieving a balance between flavor and health concerns related to excessive sodium consumption. The aim of this work was to reduce the sodium content in mango pickle by replacing sodium chloride with potassium chloride in different proportions without affecting its physiochemical, microbiological and organoleptic qualities during storage.

MATERIALS AND METHODS

The present work was completed in the laboratory of Department of Food Science and Technology, Shivaji University Kolhapur. Sodium chloride (TATA), turmeric powder (Everest), chili powder (Charminar), mustard oil (Nature fresh), acetic acid (My favourite brand) and other pure quality ingredients like mustard dal, fenugreek powder were procured from local super market in Kolhapur. Food grade potassium chloride was procured from Balaji Scientific Traders, Kolhapur. Fresh raw green mango fruits of Konkan Ruchi variety were procured from local Kolhapur vegetable market. Chemicals of laboratory grade were used from department. All the equipment's used like chopping plate, stainless still knife, plate was properly cleaned and sanitized with heated water (90°C) before use. Medium sized glass jars used for packaging were pre-sterilized in a hot air oven.

Standardization of formulation for mango pickle

Freshly collected good quality, raw green mango fruits were washed and cut into pieces of about 1cm × 1cm × 1cm size. These pieces were then mixed with quantity of common salt according to different formulations mentioned in (Table 1). After that, two litres of filtered water were added, and the pieces were submerged for four days for curing. After 4 days pieces were taken out, washed thoroughly with warm water and mixed with other spice ingredients and acetic acid as per formulations. Then previously heated & cooled mustard oil was poured over and stored in a clean glass jar. The best formulation was selected on the basis of its sensory characteristics and further used as a control for the preparation of mango pickle in replacement of sodium chloride with potassium chloride.

Table 1 Different formulations for the preparation of mango pickle

Ingredients	Formulation A	Formulation B	Formulation C
Mango pieces (g)	1000	1000	1000
Salt (g)	150	200	150
Chilli powder (g)	36	10	25
Mustard dal (g)	14	-	50
Black cumin (g)	-	-	5
Fenugreek powder (g)	1.3	10	5
Turmeric powder (g)	29	-	5
Cumin powder (g)	-	10	5
Black pepper (g)	-	10	5
Ginger paste (g)	-	-	40
Cinnamon (g)	-	10	-
Asafoetida (g)	-	5	-
Cardamom large (g)	-	10	-
Clove (headless) (g)	-	1.5	-
Aniseed (g)	-	-	5
Acetic acid (ml)	6	-	100
Citric acid (ml)	-	-	5
Sugar (g)	-	-	75
Mustard oil (ml)	390	300	300

Preparation of different samples of mango pickle in replacement of NaCl with KCl

Different samples of standardized mango pickle were prepared according to the process given below (Fig 1). Total five different samples coded as MPK, MPK_1, MPK_2, MPK_3 and MPK_4 were prepared where sodium chloride was replaced with potassium chloride as 0, 25, 50, 75 and 100%. MPK (100% NaCl) was considered as control. Then previously heated and

cooled mustard oil was poured over and stored in a clean glass jar and laminate foil pouch. Photographs related to pickle making process depicted as given below:

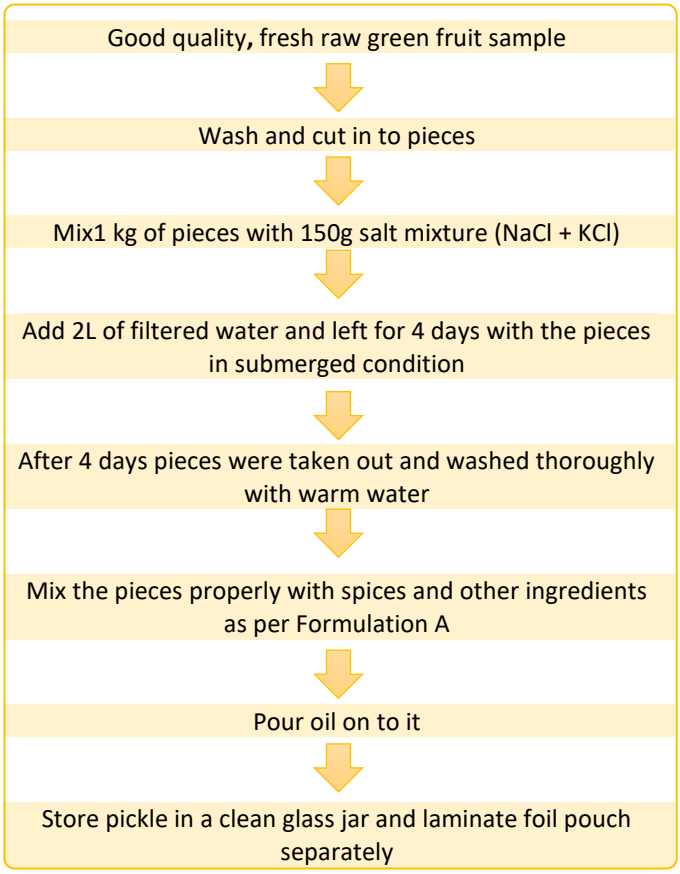

Fig 1 Flowchart for preparation of mango pickle

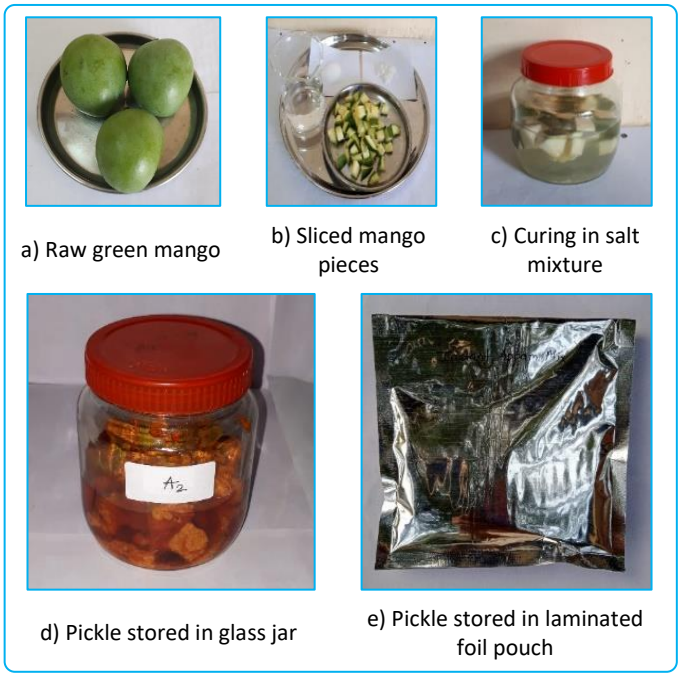

Fig 1 Pickle making process

Sensory analysis

The quality of prepared pickle was judged by sensory evaluation as described by [13]. A panel of ten semi trained judges evaluated the quality of the finished product with respect to colour, flavour, taste, texture and overall acceptability using a 9-point Hedonic scale (1 = disliked extremely, 5 = Neither liked nor disliked, 9 = extremely liked). Mineral water and unsalted crackers were used to clear the palate between samples.

Proximate analysis

The control and sensory based selected potassium salt replaced mango pickle sample with maximum replacement were analyzed for proximate composition. The methods of Ranganna [13] were followed to determine the moisture, crude protein, crude fat, and ash. The total carbohydrate content was determined by subtracting the measured amounts of ash, crude fibre, protein, fat, and moisture from 100 [14-15]. All determinations were made for three times and average was recorded.

Storage study

The control and organoleptically selected pickle sample among the sodium chloride replacement were packed in a glass jar and laminated foil pouches (350 gauge) and stored for shelf-life studies at room temperature (25±5°C). The stored pickles were evaluated for sensory and chemical parameters like overall acceptability, moisture content, titrable acidity, pH and water activity at one month interval up to 9 months of storage. Titrable acidity was measured by titrating with 0.1 N sodium hydroxide solution. An electronic dew point water activity meter (Aqualab Series 4 TE, Decagon Devices, Washington, USA) was used to measure the water activity. The pH was checked with a digital a pH meter. During storage period the pickles were also evaluated microbiologically for total plate count (TPC) and yeast and mould count (YM). Total plate count and yeast and mould count were estimated as per procedure given by [16].

Statistical analysis

Statistical analysis of the collected data was performed using Microsoft Excel 97-2003 of windows 10 software. The standard error (SE) and critical difference (CD) at 5% level were provided.

RESULTS AND DISCUSSION

Standardization of formulation for mango pickle preparation

Among all three different formulations Formulation A yielded the greatest scores 8.75, 8.08, 7.92, 7.96, and 8.18 for colour, flavour, taste, texture, and overall acceptability respectively. The considerably higher proportion of spices like turmeric powder and chilli powder might be responsible for attractive colour and appearance in Formulation A than other two. The appropriate amounts of these turmeric and chilli powder combined with additional ingredients like mustard dal, fenugreek powder and acetic acid might be contributed towards better taste, texture, flavor and overall acceptability of the pickle in Formulation A. Therefore, based on greatest sensory scores Formulation A was chosen for further development of pickle with replacement of sodium chloride by potassium salt.

Development of mango pickle samples in replacement of NaCl with KCl

With addition of ingredients according to Formulation A five different mango pickle samples were prepared by replacing sodium chloride with potassium chloride. (Table 2-3) provides information on the pickle's sensory attributes and proximate composition. According to the findings of the sensory evaluation of five different pickle sample MPK that was control (100% NaCl) had highest overall acceptability score (8.18). There were insignificant differences in overall acceptability scores among MPK_1 and MPK_2 as compared with control. The significant difference was found in MPK_3 as compared with

control that means about 75% replacement of sodium chloride with potassium chloride could be identifiable organoleptically. Thus, by considering insignificant difference in overall acceptability score pickle made with maximum 50% potassium chloride in replacement of sodium chloride (MPK_2) was found better. Similar findings were reported in lemon pickle and Armenian cucumber pickles [7], [17]. Data in (Table 3) denotes the proximate composition of control and organoleptically selected potassium salt replaced (MPK_2) pickle samples. The obtained values for all proximate constituents of both control and selected MPK_2 pickle samples were comparable and in concordance with those found in mango pickles [18-19].

Table 2 Effect of potassium salt replacement against sodium chloride on sensory attributes of mango pickle

Pickle samples	Sensory parameters				
	Colour	Flavour	Taste	Texture	Overall acceptability
MPK (Ctrl)	8.75	8.08	7.92	7.96	8.18
MPK_1	8.75	8.06	7.90	7.95	8.17
MPK_2	8.74	7.98	7.89	7.94	8.14
MPK_3	8.71	5.52	5.11	5.15	6.12
MPK_4	8.69	4.38	2.73	4.03	4.96
S.E.±	0.013	0.870	1.169	0.941	0.747
CD at 5%	0.043	2.767	3.718	2.993	2.376

Sample details: MPK- 100% NaCl (Control), MPK_1- 25% KCl+75% NaCl, MPK_2- 50% KCl+50% NaCl, MPK_3- 75% KCl +25% NaCl, MPK_4- 100% KCl

Table 3 Proximate constituents of control and selected MPK_2 pickle samples

Parameters	Pickle samples		S.E.±	CD at 5%
	MPK (Ctrl)	MPK_2		
Moisture (%)	69.28	68.80	0.170	0.540
Crude protein (%)	2.12	2.12	0.0	0.0
Crude fat (%)	6.13	6.11	0.007	0.022
Ash (%)	3.59	3.62	0.011	0.034
Total carbohydrate (%)	14.89	15.40	0.180	0.573
Crude fibre (%)	3.99	3.95	0.014	0.045

All values are mean SE± of three determinations

Storage studies of control and selected potassium salt replaced mango pickle samples

Both control and selected potassium salt replaced pickle sample (MPK_2) stored at room temperature condition in both glass jar and laminated foil pouch were analyzed for storage quality at interval of 1 month up to 9 months of storage.

Sensory evaluation

Data in (Table 4) depicts the effect of sodium chloride replacement on overall acceptability score of control and MPK_2 pickle samples packed in two different packaging materials during storage period. With a period of storage, an improvement in organoleptic quality was noted for both packaging materials initially. This rise may be explained by the pectin's insoluble component becoming soluble. Reported finding was in conformity with the results in oil less mango pickle, lime pickle and lemon pickle [7], [20-21]. However, the control and selected MPK_2 pickle samples stored in laminated foil pouch showed decline in overall acceptability score after 4 months onwards which might be due to poor protective properties of laminated pouch than glass jar. The overall acceptability of selected MPK_2 was within acceptable limit in both glass jar and laminated foil pouch up to 7 months but there was better retention in pickle stored in glass jars [22].

Chemical analysis

An unexpected increase in moisture content was noted with storage in both packaging materials (Table 4). This could have been caused by the bacteria due to breaking down of natural carbohydrates and proteins. The result was well supported by the findings in lemon pickle and stuffed chilli pickle [7-23]. Same observation was recorded in water activity because the product's level of moisture has an impact on water activity. Similar results were recorded in ber pickle [24].

Table 4 Overall acceptability, moisture content and water activity of control and selected MPK_2 pickle samples during storage at room temperature

Storage months	MPK (Ctrl)						MPK_2					
	Glass jar			Laminated foil pouch			Glass jar			Laminated foil pouch		
	OA	MC	a_w	OA	MC	a_w	OA	MC	a_w	OA	MC	a_w
0	8.18	69.28	0.878	8.18	69.28	0.878	8.14	68.80	0.867	8.14	68.80	0.867
1	8.19	69.64	0.881	8.19	69.86	0.886	8.17	69.78	0.869	8.15	70.42	0.873
2	8.21	70.53	0.889	8.20	72.23	0.893	8.19	71.52	0.871	8.16	72.16	0.878
3	8.34	71.27	0.894	8.35	74.97	0.902	8.25	72.47	0.883	8.21	73.23	0.890
4	8.41	71.65	0.899	8.40	75.34	0.910	8.37	73.89	0.891	8.29	74.33	0.907
5	8.50	72.78	0.907	8.06	75.91	0.918	8.51	74.99	0.895	7.89	76.04	0.914
6	8.52	73.04	0.914	7.22	76.53	9.925	8.52	75.85	0.908	7.22	76.65	0.922
7	8.53	73.72	0.919	7.03	77.22	0.928	8.52	76.63	0.919	7.02	78.94	0.930
8	8.56	74.83	0.925	5.68	78.79	0.931	8.53	78.81	0.920	5.60	80.23	0.939
9	8.56	75.33	0.928	5.23	79.64	0.939	8.53	79.03	0.932	5.21	81.01	0.945

OA- Overall acceptability, MC- Moisture content (%), a_w- Water activity

Table 5 Titrable acidity and pH of control and selected MPK_2 pickle samples during storage at room temperature

Storage months	MPK (Ctrl)				MPK_2			
	Glass jar		Laminated foil pouch		Glass jar		Laminated foil pouch	
	Titrable acidity %	pH	Titrable acidity %	pH	Titrable acidity %	pH	Titrable acidity %	pH
0	3.05	2.80	3.05	2.80	3.07	2.78	3.07	2.78
1	3.09	2.71	3.09	2.71	3.17	2.64	3.17	2.64
2	3.17	2.63	3.16	2.63	3.23	2.55	3.24	2.54
3	3.26	2.50	3.26	2.50	3.29	2.42	3.32	2.40
4	3.32	2.41	3.32	2.41	3.37	2.31	3.39	2.29
5	3.38	2.32	3.39	2.31	3.46	2.24	3.48	2.23
6	3.41	2.22	3.42	2.18	3.50	2.15	3.52	2.14
7	3.46	2.17	3.48	2.16	3.59	2.11	3.61	2.09
8	3.54	2.15	3.56	2.15	3.67	2.06	3.69	2.00
9	3.64	2.15	3.66	2.14	3.73	2.01	3.72	1.96

All values are mean of three determinations

The data in (Table 5) shown the results for titrable acidity and pH of control and MPK_2 pickle samples during storage. Pickle is the high acid containing product. On fermentation the acid content was increased with corresponding decrease in pH values [20]. In was found that the titrable acidity and pH of both pickle samples were constantly increased and decreased respectively throughout the storage in both glass jar and laminated foil pouch. However, this increase and decrease of acidity and pH was progressed speedily with increase in potassium chloride concentration. The titrable acidity and pH levels of pickle samples changed over time during storage, regardless of whether they were stored in glass jars or laminated foil pouches. However, the rate of change in acidity and pH was found to be faster when the concentration of potassium chloride (KCl) increased in the pickles. The present results are in agreement with the results of earlier investigations in cucumber and lemon pickle respectively made with replacement of sodium chloride with potassium chloride [17-7]. Similar results with a sharp decline in pH and an associated rise in acidity were found in raw mango pickles [18-25].

Table 6 TPC and YM count of control and selected MPK_2 pickle samples during storage at room temperature

Storage months	MPK (Ctrl)				MPK_2			
	Glass jar		Laminated foil pouch		Glass jar		Laminated foil pouch	
	TPC	YM	TPC	YM	TPC	YM	TPC	YM
0	0.051	ND	0.051	ND	0.045	ND	0.045	ND
1	0.088	ND	0.090	ND	0.082	ND	0.086	ND
2	0.264	ND	0.299	ND	0.216	ND	0.219	ND
3	0.740	ND	0.832	ND	0.663	ND	0.665	ND
4	1.062	ND	1.103	ND	1.042	ND	1.049	ND
5	1.873	ND	2.342	0.04	1.870	ND	1.875	0.03
6	2.147	ND	3.321	0.77	2.145	ND	2.153	0.66
7	3.124	ND	4.097	0.93	3.127	ND	3.134	0.99
8	3.876	ND	5.180	1.02	3.949	ND	5.260	1.00
9	4.785	ND	5.642	1.10	4.922	ND	5.743	1.12

TPC- Total plate count ($\times 10^5$cfu/g), YM- Yeast and mould count ($\times 10^3$cfu/g)
ND- Not detected and all values are mean of three determinations

Microbial analysis

Results for microbiological quality of both control and selected MPK_2 pickle samples in terms of total plate count and yeast and mould count was mentioned in (Table 6) given below. It was shown that the total plate count of both pickle samples was increased throughout the storage period in both glass jar and laminated foil pouch. This increase was might be due to the multiplication of acid tolerant bacteria. Similar result was found in lime pickle [26]. As per the International Commission on Microbiological Specifications for Foods (ICMSF) the recommended microbial limit for safe food was about (5×10^5 cfu/g) [27]. The total plate count of control and organoleptically best selected sample with maximum proportion of potassium chloride (MPK_2) was 4.785×10^5cfu/g and 4.922×10^5cfu/g respectively up to 9 months of storage in a glass jar, while in laminated foil pouch the TPC exceeds the limit after 7 months of storage. The fungal growth is the major problem in pickle. The maximum safe limit for yeast and mould count of pickled fruit and vegetable product is 1×10^3 cfu/g [28]. The control and MPK_2 pickle samples were free from yeast and mould count throughout the storage period of 9 months. However respective samples in laminated foil pouch shown the excessive fungal growth after 7 months of storage. Thus, both control and selected salt replaced mango pickle samples remained microbiologically safe up to 9 months in glass jar and 7 months in laminated foil pouch. Lemon pickles prepared in replacement of sodium chloride with potassium chloride was microbiologically safe over three month of storage period [7]. The findings emphasize the importance of packaging materials and storage conditions in maintaining the microbial safety and quality of pickled products, particularly when salt substitution is involved. King chilli pickle prepared with suitable proportion of salt, mustard oil and acetic acid could be stored without fungal growth for 12 months [29]. Microbial quality of freshly

prepared Armenian cucumber pickles in replacement sodium chloride with potassium chloride was under safe limit [17].

CONCLUSION

From the study carried out it was found that maximum 50% of the potassium chloride in mango pickles might be substituted in place of sodium chloride. The mango pickle prepared with sodium chloride and potassium chloride (50:50) could be preserved in good condition when packed in glass jar and laminated foil pouch for 9 month and 7 months respectively. Hence, mango pickles made with 50% replacement of sodium salt with potassium salt can be very much beneficial for people suffering from hypertension.

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