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The Use of Some Plant-Based Natural Preservatives in the Preservation of Mango Fruits in Benue State, Nigeria

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ABSTRACT

The shelf life of Dalsha, Peter, Broken mango (*Mangifera indica L.*) species was extended using the extract of some natural preservatives such as Tumeric, Lemon grass and Neem Leaves. The result of the storage studies showed that Dalsha and Peter mangoes had a shelf life of 48 days each as against 8 and 9 days respectively while broken mango had a shelf life of 54 days as against 12 days for the control, result of the physiochemical characteristics showed that pH of the controlled fruit dropped from 3.85-2.91, 3.84-2.93 and 3.82-2.82 for Dalsha, Peter and Broken respectively. The pH value for each sample decreased with storage time. Titratable acidity (TA) showed a gradual decrease with storage time. Total soluble solids (TSS) increased with storage time. The sensory analysis reveals that turmeric treatment showed best scale point of 1 for all parameters whereas controlled samples showed poor scale point. Results of the weight loss indicates that fruits treated with the extract showed lower percentage weight loss as compared to the control generally, weight loss increased with storage time throughout the storage period. The antimicrobial sensitivity revealed that all the fungi and bacteria except Aspergillus Spp and Fasarium were susceptible to all the plant extracts. Thus, the use of natural preservatives (Turmeric, Lemon grass and Neem leaves extract) have shown to be a good and cheap alternative method of preventing post- harvest decay and loses through preservation and shelf life extension of the fruits upon treatment with the extract.

INTRODUCTION

Mango (*Mangifera indica L.*) is one of the top five fruit crops in the world. It is adaptable to a wide range of climates, ranging from wet tropical to dry subtropical (Mahendra K.T *et al*, 2015). Mangoes are rich source of dietary fibres, folate, and vitamins such as A, C, B6, and B9, as per the United States Department of Agriculture (USDA) nutrient database. Among all the tropical fruits production, mangoes ranks as first position in the world. India is the largest producer of mangoes in the world (Gopolakrishman S. 2013).

Mango contains nearly 81 per cent moisture, 0.4 per cent fat, 0.6 per cent proteins, 0.8 per cent of fibers, nearly 17 per cent of carbohydrate. Allied to its economic importance, the fruit is rich with important minerals like Potassium, magnesium, Sodium, Phosphorus, and Sulphur. The mango fruits also contain various antioxidants, vitamins, phytonutrients, carotenoids, omega 3 and 6 fatty acids, polyphenols, amino acids, and dietary minerals such as potassium and copper. Owing to these properties, several literature reported the effectiveness of mango in the inhibition of prostate and skin cancer (Prosad S *et al*, (2008), Rosenda A.B *et al*, (2015) and Saleem M *et al*, (2004). It also protects serum oxidative stress in senile people due to its antioxidant properties (Pardo-Andrea G.A 2006). Mango fruit are climacteric and ripen rapidly after harvest. Disease susceptibility, sensitivity to low storage temperatures (below 13°C), and perishability due to ripening and softening limit the storage, handling and transport potential of the fruit (Ellong E.N *et al*, 2015). Mango fruit are harvested commercially within a range of maturities including immature green (dark green, no shoulders, ripens with poor quality), mature green (lighter green, shoulders formed, ripens with acceptable quality) and ripe (fruit that show colour breaking to red or orange-yellow, ripen with optimum quality) (Bender R J *et al*, 1995) External and internal quality is critical to consumer acceptability, and flavour is an important marketing consideration. The Concentration of flavour volatiles and flavour quality are affected by harvest maturity, and storage temperature. Post-harvest treatment of the fruit is a major issue and there are a lot of conservation methods all around the world. In India, fruits are picked green and stored in ventilated rooms at 15°C - 21°C for a week. In Israel, the fruits are in ethylene for 24 h, then stored 7 - 10 days to have a uniform colour (Bender R J *et al*, 1995). Ripening can be done naturally or artificially, and this step leads the fruit to maturity before consumption or processing. Natural ripening consists in storing fruits 10 to 15 days in the shade of hay or 4 days at 25°C. The uniformity of ripening can be assessed by measuring texture, brix and palatability (ratio soluble dry extract/titratable acidity (Kumblar B.K 1992)

LITERATURE REVIEW

Mangoes are grown in tropical and subtropical regions of the world. The Chemical composition of mango fruits differs with regard to different cultivars and areas of production (Chauhan O.P *et al* 2006). Mangoes are both popular and valuable fruits. The success of mango cultivation could be attributed to the diverse environmental conditions across the country, which

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extends the fruiting season to eleven months a year. In some areas of the country mangoes bear fruits twice a year. Due to poor transportation and storage facilities, mangoes produced in remote areas are sold at very low prices. To help rectify this situation, the possibility of harvesting mango fruits at optimum maturity and good preservation practices to extend the shelf-life of the fresh produce is explored.

The physiological and biochemical activities of over-mature fruits differ from that of mature ones in terms of respiration rate, transpiration, conversion of starch to sugars and storage life. (Abbasi K.S *et al*, 2011) reported that mango maturity could be predicted by measuring size, colour and firmness. Chemical standards used in the assessment of maturity at harvest include Total Soluble Solids, total acidity and pH, acid/sugar ratio, reducing sugars, tannins, volatile substances, ascorbic acid, internal colour of the flesh and oil content (Kadar. A.A *et al*, 2002). The following varieties have been found promising and are recommended for production. Alphonso, Zill, Julie, Palmer, Keitt, Lippens, Saigon, Edward, Haden, Early gold. They mature 3– 4 years after transplanting or in-situ grafting. In Benue State, the following varieties are common; Local (normal), Peter, Julie, Broken, Dalsha, John Bull, John Peter, Hindi, Zill (Suleiman A.Y *et al*, 2007) Post- harvest handling practices result in high post-harvest losses of mango fruit. Traditionally, the harvesting of mangoes usually takes place before the fruit begins to ripen. Prolonging mango harvesting in order to collect fruits of different maturity stages helps to characterize and analyse their aptitude in regard to ripening. Chemical parameters that have established some usefulness for decisive maturity of the fruit before harvest are the solid content, acidity, carbohydrate content, volatile compounds, vitamin content, sugar and phenolic constituents. Physical parameters, such as shape and size, surface and flesh colour and hardness, shoulder development, specific gravity, heat units have been used.

The use of plant extracts could be a useful alternative to synthetic fungicides in the management of rot fungi during post -harvest handling of fruits and vegetables. A new approach to the control of postharvest pathogens, while maintaining fruit quality, has been implemented by the application of essential oils. This approach eliminates the need for synthetic fungicides, thereby complying with consumer preferences, organic requirements and reducing environmental pollution (Jha S.N *et al*, 2007).

Substantial research has been carried out that show the many properties of neem leaves, and lemon grass, as they relate to medicine because of their wide range therapeutic properties including relief of rheumatic and other pain and healing effect on ulcers. Tumeric is known for its use as dye, spice, starch, medicine, beauty aids, colouring agent etc. However no extensive research has been reported on their use as natural preservatives for fruits especially mangoes. This research work will explore these plant extracts' efficacy as bio preservatives on mango fruit preservation and nutritional quality stability. Also the fact that they are naturally occurring plant materials, cheap, medicinal, widely cultivated/readily available, environmental friendly and safe informed their choice for this research.

MATERIALS AND METHODS

Sample Collection

Healthy mango fruits were collected directly from the farms to avoid mechanical injury, and a total of two hundred and thirty one fruits were obtained, seventy seven fruits per variety. These fruits were later transported to the Postgraduate research Laboratory of Benue State University, Makurdi for analysis.

Study Area

The research was conducted in Makurdi, town the Benue State capital. The town is located at latitude 7° 38'N - 7° 50'N and longitude 8° 24'E - 8° 38'N. It is situated in the Benue valley in the North Central Nigeria

Sample Pre-treatment

The fruits were properly washed with distilled water to remove dust particles and surface microbial load. They were air dried and weighed individually to record their initial weights before treatment. The plant materials i.e. the Neem leaves and Lemon grass were both air dried and grounded in to powdered form for extraction. The turmeric rhizome were also be washed, peeled, air dried and grounded in to powdered form for extraction as well

Extraction of the Plant Materials

The powdered samples of the Neem leaves, Lemon grass and Turmeric, 300g each was separately extracted using soxhlet apparatus with methanol and n-hexane as the extracting solvents in each case. The extract were evaporated to dryness under reduced pressure at 90oC by rotary vacuum evaporator to obtain the crude extracts which were placed in dark bottles and stored in refrigerator at 4oC until use (Ugese F. D *et al*, 2012).

The yield estimation was calculated as follows;

$$\text{Yield (\%)} = \frac{weight\ of\ recovered\ extract}{weight\ of\ dry\ powder!}\ x\ 100 \quad - - - (1)$$

Treatment of the Mango Fruit with the Extracts and Storage

The extract solution was prepared in five different concentrations in % weight / volume. 0.5, 1.0, 1.5, 2.0 and 2.5 quantities of the extracts was weighed each in 100 mL volumetric flask and distilled water was added to the mark to get 0.5%, 1.0%, 1.5%, 2.0% and 2.5% respectively with 0.0% conc. as control (Du. P *et al*, 2009).

The immersion was done in small plastic containers immersing fruit by fruit at 5mins of immersion time. These fruits were stored at ambient temperature in the laboratory. Each treatment consisted of five fruits for each concentration i.e. 25 fruits for each variety.

The quality evaluation was carried out every 3 days until the fruits deteriorated.

Quality Evaluation

Quality evaluation was carried out on the treated samples every 3 days to ascertain the effect of the extract at varying concentrations on storage time and fruit variety using selected physicochemical parameters such as total soluble solids, pH, titratable acidity, weight loss, sensory evaluation (flavour, taste, aroma and colour).

Analysis of physicochemical quality parameters of mango fruits

The pH of the blended solution was determined at ambient temperature using a pH meter. 25 g of pulp was blended with about 250 mL deionised water for 30 min using a magnetic stirrer (Shweta. C *et al.* 2014).

Titratable acidity was determined by blending the pulp, 25g of it with about 250 mL deionised water for 30 min using a magnetic stirrer. The TA was then measured without filtration by titration with 0.1M NaOH to equivalence point. The results was expressed in terms of percentage citric acid. It was calculated by the following formula (Negi P. S 2012).

$$TA\ (\%) = \frac{Nb\ x\ Vb\ x\ Ea\ x\ d.f\ x\ 100}{Vs} \quad \text{- - (2)}$$

Where: Nb = normality of the base,
Vb = volume of the base,
Ea = mill equivalent weight of citric acid,
VS = volume of sample,
d. f. = dilution factor

The total soluble solids (TSS) levels of the fruit was determined according to (AOAC 1990) method by using hand Refractometer. An appropriate quantity of sample was placed on the prism-plate of the Refractometer and the reading appearing on the screen was directly recorded as total soluble solids. Results was expressed in Brixº. The weight loss during storage was determined by calculating the difference in weight at every 3 days during the storage period and the initial weight (day zero). The weight loss was expressed in percentage

The mango samples were evaluated for its acceptability during the storage period. Sensory evaluation, i.e. the visual characteristics of the appearance for skin colour, pulp colour, flavour, and taste were scored in day light by a panel of 5 judges who are familiar with fruit assessment using a 5 point hedonic scale, 5 for best and 1 for worst (Adamu. B 2012).

Antimicrobial Analysis of the Extracts

Antibacterial Sensitivity Testing (Agar Well Diffusion Method)

Mueller Hinton agars for bacteria and for fungi were used. Broth media was measured and dissolved in appropriate volume of distilled water, following the manufacturer's guideline and was sterilized by autoclaving. Pour plate technique was used; about 1 mL of the standardized inoculum Was mixed with the medium in a sterile container to ensure that the test organisms were evenly distributed and poured into sterile petri dishes and allowed to gel. Each plate contained equal volume of the media. The antibacterial activity of the Shea butter was determined in accordance with standard agar-well diffusion method (Irobi O.N *et al*, 1994).

A Cork borer (0.6cm) was used to bore wells on the agar medium after which 0.1mL of the extract solution was dispensed into the wells. The plates were incubated at 37°C for bacterial activity, the plates were observed for zones of inhibition after 24 hours. This implies that any clear zone of inhibition observed is due to the activity of the extract. All organisms showed viability with at least 100% surface of the plate. The second control is to test the activity of the solvent (Hexane) used to dissolve the extract to ensure that the activity is not due to action of solvent on the test organisms.

Plates were read by measuring observed clear zones (area without growth) of inhibition around the wells containing the extract. Measuring rule in millimeter was used to take the measurement from the edge of the well to the end of the clear zone of inhibition. The estimation of MIC and MBC of the crude extracts was carried out by standard method (Akinpelu D.A *et al*, 2014).

Minimum Inhibitory Concentration (MIC) and Maximum Bactericidal Concentration (MBC) (Broth diffusion method)

The tubes without bacterial growth were cultured in their appropriate agar and incubated appropriately to check for those that will revive and develop colonies. Those that did not revive and grow were recorded as bactericidal or fungicidal.

RESULTS AND DISCUSSION

Percentage yield of the extracts

The maximum yields were observed in methanol extracts for both Tumeric, Neem leaves and Lemon grass with values 36.305±0.98, 42.82±0.09 and 45.3±0.16 respectively whereas Hexane extract gave minimum yield with values 14.9±0.14, 21.82±0.35 and 28.85±0.15 as seen in figure 1. Methanol was found to give maximum yield in all the three plant extracts and hexane gave the minimum yield.

This results obtained was found to be in agreement with that of Amanptreet K (206) and Barchan. A *et al* (2014) who reported that percentage yields of two cultivars of turmeric extracts and three menthe sp. Extracts prepared by using solvents of different polarity (hexane, di-chloromethane, methanol and water) increased with increase in polarity of solvents. From the result, it was observed that lemon grass showed better percentage yields as compared to neem leaves and turmeric.

During the storage period, physical, sensory and microbial assessments were done. Controlled fruits showed a rapid deterioration with an estimated shelf life period of 8, 9 and 12 days for Dalsha, peter and broken respectively at

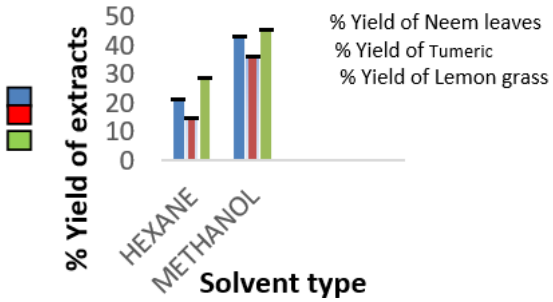

Figure 1: % Yield of Neem Leaves, Tumeric, and Lemon Grass using Hexane and Methanol as Solvents

room temperature with higher weight loss, colour changes accelerated softening and ripening with high incidence decay. On the contrary, the treated samples significantly delayed these parameters. This may be due to the semi permeability created by immersion on the surface of the fruit, which might have modified the internal atmosphere i.e. O_2 and CO_2 concentrations in the fruits and retards ripening. This result is in consonant with that reported by (Chakare. B *et al*, 2012).

Table 1: Effect of storage period and concentration of extracts on the physicochemical characteristics of Dalsha mango fruit

Conc of extracts (%)	pH				Titratable acidity (%)				Total soluble solids (%)			
	Preservatives											
	Ctr	Tm	Nm	Lg	Ctr	Tm	Nm	Lg	Ctr	Tm	Nm	Lg
	Storage at Day Zero											
0.0	3.85				0.97				9.1			
Storage After 3 Days												
0	3.62				0.96				9.1			
0.5		3.97	3.97	3.95		0.96	0.96	0.95		9.2	9.3	9.2
1		3.96	3.96	3.96		0.95	0.96	0.95		9.3	9.3	9.3
1.5		3.97	3.97	3.95		0.96	0.96	0.96		9.2	9.4	9.4
2		3.97	3.96	3.95		0.95	0.95	0.95		9.3	9.3	9.4
2.5		3.96	3.96	3.96		0.95	0.95	0.95		9.3	9.4	9.4
Storage After 6 Days												
0	3.21				0.94				9.2			
0.5		3.97	3.97	3.95		0.96	0.96	0.95		9.2	9.3	9.2
1		3.96	3.96	3.96		0.95	0.96	0.95		9.3	9.3	9.3
1.5		3.97	3.97	3.95		0.96	0.96	0.96		9.2	9.4	9.4
2		3.97	3.96	3.95		0.95	0.95	0.95		9.3	9.3	9.4
2.5		3.96	3.96	3.96		0.95	0.95	0.95		9.3	9.4	9.4
Storage After 9 days												
0	2.91				0.89				9.5			
0.5		3.95	3.95	3.96		0.91	0.91	0.92		9.9	9.8	9.9
1		3.95	3.94	3.95		0.91	0.92	0.91		9.8	9.9	9.8
1.5		3.94	3.95	3.95		0.91	0.91	0.91		9.9	9.9	9.8
2		3.95	3.95	3.94		0.92	0.91	0.91		10	10.1	9.9
2.5		3.94	3.95	3.94		0.91	0.91	0.92		10.1	10	10.1
Storage After 12 days												
0												
0.5		3.93	3.92	3.91		0.9	0.91	0.91		10.2	10.1	10.2
1		3.92	3.91	3.91		0.91	0.9	0.9		10.3	10.2	10.3
1.5		3.92	3.91	3.9		0.92	0.92	0.91		10.2	10.3	10.3

2		3.91	3.91	3.91		0.91	0.91	0.9		10.3	10.3	10.4
2.5		3.91	3.92	3.92		0.91	0.92	0.91		10.3	10.3	10.4
Storage After 15 days												
0												
0.5		3.91	3.89	3.89		0.89	0.89	0.88		10.5	10.6	10.5
1		3.9	3.9	3.89		0.9	0.89	0.91		10.6	10.5	10.6
1.5		3.91	3.9	3.88		0.91	0.89	0.9		10.6	10.6	10.6
2		3.9	3.91	3.88		0.89	0.9	0.89		10.7	10.7	10.6
2.5		3.9	3.89	3.89		0.89	0.91	0.89		10.7	10.7	10.7
Storage After 18 days												
0												
0.5		3.89	3.89	3.87		0.89	0.89	0.87		10.8	10.9	10.9
1		3.88	3.89	3.87		0.87	0.88	0.87		11.1	11.2	11
1.5		3.89	3.88	3.88		0.88	0.87	0.86		11.2	11.3	11.1
2		3.89	3.89	3.87		0.89	0.88	0.88		11.2	11.2	11.2
2.5		3.89	3.88	3.87		0.89	0.88	0.86		11.3	11.3	11.3
Storage After 21 days												
0												
0.5		3.87	3.86	3.85		0.85	0.84	0.84		11.5	11.5	11.6
1		3.85	3.86	3.84		0.83	0.84	0.83		11.6	11.7	11.6
1.5		3.86	3.85	3.84		0.84	0.83	0.83		11.7	11.6	11.7
2		3.85	3.86	3.84		0.85	0.84	0.84		11.6	11.6	11.6
2.5		3.85	3.85	3.83		0.83	0.82	0.83		11.7	11.7	11.7
Storage After 24 days												
0												
0.5		3.79	3.78	3.76		0.79	0.78	0.79		12.1	12.2	12.2
1		3.78	3.79	3.78		0.78	0.77	0.78		12.2	12.1	12.1
1.5		3.79	3.79	3.77		0.79	0.78	0.77		12.2	12.2	12.3
2		3.78	3.78	3.78		0.77	0.77	0.77		12.3	12.3	12.2
2.5		3.78	3.79	3.77		0.78	0.77	0.77		12.2	12.2	12.3
Storage After 27 days												
0												
0.5		3.69	3.78	3.72		0.75	0.75	0.74		12.3	12.5	12.6
1		3.68	3.69	3.71		0.74	0.73	0.73		12.4	12.5	12.5
1.5		3.68	3.68	3.71		0.75	0.74	0.74		12.4	12.6	12.6
2		3.67	3.67	3.7		0.75	0.73	0.73		12.6	12.6	12.6
2.5		3.68	3.67	3.71		0.74	0.73	0.73		12.6	12.6	12.7
Storage After 30 days												
0												
0.5		3.57	3.58	3.58		0.72	0.71	0.71		12.7	12.7	12.7
1		3.58	3.58	3.55		0.71	0.72	0.72		12.8	12.8	12.8
1.5		3.57	3.57	3.57		0.71	0.71	0.72		12.8	12.7	12.7
2		3.57	3.57	3.58		0.71	0.71	0.71		12.8	12.8	12.8
2.5		3.57	3.57	3.59		0.71	0.71	0.71		12.9	12.9	12.8
Storage After 33 days												
0												
0.5		3.35	3.34	3.32		0.73	0.72	0.72		13	13.1	13.2

1		3.33	3.33	3.31		0.72	0.71	0.71		13.2	13.1	13.3
1.5		3.34	3.33	3.32		0.73	0.72	0.71		13.3	13.2	13.2
2		3.33	3.34	3.31		0.71	0.73	0.72		13.2	13.2	13.2
2.5		3.33	3.34	3.33		0.71	0.73	0.71		13.3	13.3	13.3
Storage After 36 days												
0												
0.5		3.31	3.31	3.29		0.68	0.7	0.71		13.4	13.5	13.6
1		3.31	3.3	3.28		0.69	0.71	0.7		13.5	13.6	13.6
1.5		3.3	3.3	3.29		0.7	0.69	0.71		13.6	13.6	13.5
2		3.31	3.3	3.3		0.71	0.7	0.7		13.6	13.6	13.5
2.5		3.31	3.31	3.28		0.68	0.71	0.71		13.6	13.6	13.6
Storage After 39 days												
0												
0.5		3.29	3.29	3.27		0.69	0.68	0.69		13.9	13.9	13.8
1		3.29	3.28	3.26		0.68	0.68	0.69		13.8	13.8	13.9
1.5		3.28	3.25	3.25		0.69	0.68	0.68		13.9	13.9	13.9
2		3.28	3.23	3.21		0.68	0.69	0.68		13.7	13.9	13.9
2.5		3.28	3.26	3.22		0.67	0.69	0.67		13.8	13.9	13.9
Storage After 42 days												
0												
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		3.1	2.98	2.87		0.68	0.69	0.67		14.1	14.1	14.1
2.5		3.1	2.98	2.86		0.65	0.64	0.64		14.2	14.1	14.2
Storage After 45 days												
0												
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		-	-	-		-	-	-		-	-	-
2.5		2.95	2.92	2.75		0.61	0.61	0.62		14.2	14.2	14.2
Storage After 48 days												
0												
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		-	-	-		-	-	-		-	-	-
2.5		2.92	2.91	2.89		0.61	0.6	0.62		14.2	14.2	14.2

Table 2: Effect of storage period and concentration of extracts on the physicochemical characteristics of Peter mango fruit

Conc of extracts (%)	**pH**				**Titratable acidity (%)**				**Total soluble solids (%)**			
	Preservatives											
	Ctr	**Tm**	**Nm**	**Lg**	**Ctr**	**Tm**	**Nm**	**Lg**	**Ctr**	**Tm**	**Nm**	**Lg**
	Storage at Day Zero											
0.0	3.84				0.99				9.3			
Storage After 3 Days												
0	3.65				0.98				9.3			

0.5		3.95	3.94	3.94		0.97	0.96	0.97		93	93	92
1		3.94	3.95	3.96		0.96	0.97	0.96		93	93	92
1.5		3.95	3.95	3.95		0.97	0.97	0.96		93	93	93
2		3.94	3.95	3.95		0.97	0.96	0.97		93	93	93
2.5		3.95	3.94	3.95		0.96	0.96	0.96		93	93	93
Storage After 6 Days												
0	3.31				0.94				9.5			
0.5		3.92	3.91	3.93		0.93	0.92	0.91		9.4	9.4	9.3
1		3.93	3.92	3.92		0.91	0.93	0.92		9.4	9.5	9.3
1.5		3.91	3.91	3.92		0.92	0.92	0.91		9.4	9.4	9.4
2		3.91	3.92	3.91		0.91	0.91	0.93		9.5	9.5	9.5
2.5		3.92	3.91	3.92		0.91	0.91	0.91		9.5	9.5	9.5
Storage After 9 days												
0	2.93				0.88				9.7			
0.5		3.89	3.91	3.89		0.91	0.91	0.91		9.6	9.6	9.6
1		3.9	3.89	3.9		0.9	0.91	0.9		9.5	9.6	9.5
1.5		3.89	3.9	3.91		0.91	0.9	0.91		9.5	9.5	9.5
2		3.89	3.9	3.89		0.9	0.9	0.9		9.6	9.6	9.6
2.5		3.88	3.89	3.88		0.9	0.9	0.9		9.6	9.6	9.6
Storage After 12 days												
0												
0.5		3.88	3.87	3.87		0.89	0.9	0.89		9.8	9.8	9.9
1		3.87	3.88	3.87		0.89	0.89	0.9		9.8	9.8	9.9
1.5		3.86	3.86	3.86		0.89	0.89	0.89		9.8	9.8	9.8
2		3.86	3.86	3.86		0.88	0.88	0.89		9.9	9.8	9.8
2.5		3.86	3.85	3.85		0.88	0.88	0.88		9.8	9.9	9.9
Storage after 15 days												
0												
0.5		3.84	3.84	3.84		0.89	0.88	0.89		10.2	10.1	10.2
1		3.83	3.83	3.84		0.87	0.88	0.87		10.2	10.2	10.1
1.5		3.84	3.84	3.85		0.88	0.88	0.88		10.3	10.3	10.2
2		3.85	3.84	3.84		0.87	0.87	0.87		10.3	10.3	10.3
2.5		3.84	3.83	3.84		0.87	0.87	0.87		10.3	10.3	10.3
Storage after 18 days												
0												
0.5		3.81	3.82	3.81		0.86	0.85	0.85		10.8	10.8	10.9
1		3.81	3.81	3.81		0.85	0.85	0.86		10.8	10.9	10.8
1.5		3.82	3.81	3.82		0.86	0.86	0.85		10.9	10.8	10.8
2		3.81	3.81	3.81		0.85	0.84	0.84		10.9	10.9	10.9
2.5		3.81	3.81	3.81		0.85	0.84	0.84		10.9	10.9	10.9
Storage after 21 days												
0												
0.5		3.78	3.79	3.78		0.82	0.81	0.81		11.2	11.1	11.2
1		3.79	3.78	3.79		0.81	0.81	0.82		11.2	11.2	11.1
1.5		3.78	3.77	3.78		0.82	0.82	0.81		11.1	11.1	11.2
2		3.77	3.78	3.78		0.81	0.81	0.81		11.2	11.2	11.2
2.5		3.77	3.78	3.78		0.81	0.81	0.81		11.2	11.2	11.2

Storage After 24 days												
0												
0.5		3.75	3.75	3.75		0.78	0.79	0.78		11.7	11.8	11.8
1		3.74	3.74	3.74		0.79	0.78	0.77		11.8	11.7	11.8
1.5		3.75	3.75	3.74		0.78	0.78	0.78		11.8	11.8	11.8
2		3.73	3.73	3.73		0.77	0.77	0.77		11.8	11.8	11.8
2.5		3.74	3.74	3.74		0.77	0.77	0.77		11.9	11.9	11.8
Storage After 27 days												
0												
0.5		-	-	-		0.74	0.74	0.75		12.2	12.3	12.2
1		3.7	3.71	3.72		0.73	0.73	0.74		12.3	12.2	12.3
1.5		3.71	3.72	3.7		0.74	0.73	0.73		12.2	12.3	12.3
2		3.7	3.7	3.71		0.73	0.73	0.73		12.3	12.3	12.3
2.5		3.71	3.7	3.71		0.73	0.73	0.73		12.3	12.3	12.3
Storage After 30 days												
0												
0.5		3.67	3.68	3.68		0.71	0.7	0.71		12.7	12.8	12.7
1		3.65	3.66	3.66		0.71	0.7	0.72		12.8	12.7	12.8
1.5		3.66	3.65	3.67		0.72	0.71	0.71		12.8	12.8	12.8
2		3.65	3.66	3.66		0.71	0.71	0.7		12.8	12.9	12.9
2.5		3.65	3.65	3.66		0.7	0.71	0.7		12.9	12.9	12.9
Storage After 33 days												
0												
0.5		3.6	3.61	3.62		0.68	0.67	0.67		13.3	13.2	13.3
1		3.61	3.61	3.61		0.67	0.66	0.67		13.2	13.3	13.2
1.5		3.6	3.61	3.61		0.66	0.67	0.66		13.3	13.4	13.3
2		3.6	3.61	3.6		0.66	0.66	0.67		13.4	13.4	13.4
2.5		3.6	3.6	3.6		0.66	0.66	0.66		13.4	13.4	13.4
Storage After 36 days												
0												
0.5		3.49	3.56	3.57		0.66	0.65	0.65		13.8	13.8	13.9
1		3.5	3.56	3.56		0.65	0.64	0.65		13.8	13.9	13.9
1.5		3.51	3.57	3.57		0.64	0.64	0.64		13.9	13.9	13.9
2		3.5	3.56	3.56		0.63	0.64	0.63		13.9	13.9	13.9
2.5		3.5	3.56	3.55		0.64	0.64	0.63		13.9	13.9	13.9
Storage After 39 days												
0												
0.5		3.41	3.43	3.42		0.61	0.62	0.61		14.3	14.3	14.3
1		3.42	3.42	3.41		0.62	0.62	0.62		14.3	14.3	14.3
1.5		3.41	3.41	3.42		0.61	0.61	0.61		14.3	14.3	14.3
2		3.4	3.41	3.41		0.61	0.61	0.61		14.3	14.3	14.3
2.5		3.41	3.41	3.41		0.61	0.61	0.61		14.3	14.3	14.3
Storage After 42 days												
0		-	-	-		-	-	-		-	-	-
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		3.26	3.25	3.24		0.57	0.57	0.57		14.4	14.4	14.4

2.5		3.24	3.25	3.23		0.57	0.57	0.56		14.4	14.4	14.4
Storage After 45 days												
0		-	-	-		-	-	-		-	-	-
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		-	-	-		-	-	-		-	-	-
2.5		2.98	2.98	2.77		0.57	0.56	0.57		14.4	14.4	14.4
Storage After 48 days												
0		-	-	-		-	-	-		-	-	-
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		2.83	2.87	2.89		-	-	-		-	-	-
2.5		2.79	2.76	2.75		0.58	0.59	0.58		14.4	14.4	14.4

Table 3: Effect of storage period and concentration of extracts on the physicochemical characteristics of Broken mango fruit

Conc of extracts (%)	**pH**				**Titratable acidity (%)**				**Total soluble solids (%)**			
	Preservatives											
	Ctr	**Tm**	**Nm**	**Lg**	**Ctr**	**Tm**	**Nm**	**Lg**	**Ctr**	**Tm**	**Nm**	**Lg**
	Storage at Day Zero											
0.0	3.82				0.98				9.2			
Storage After 3 Days												
0	3.61				0.96				9.2			
0.5		3.88	3.88	3.89		0.97	0.97	0.97		9.2	9.2	9.3
1		3.88	3.88	3.88		0.96	0.97	0.97		9.3	9.2	9.3
1.5		3.87	3.89	3.88		0.97	0.96	0.96		9.3	9.3	9.3
2		3.88	3.88	3.88		0.96	0.96	0.96		9.3	9.3	9.3
2.5		3.88	3.88	3.88		0.96	0.96	0.96		9.3	9.3	9.3
Storage After 6 Days												
0	3.32				0.93				9.4			
0.5		3.86	3.86	3.87		0.94	0.93	0.94		9.4	9.5	9.5
1		3.87	3.86	3.87		0.94	0.94	0.93		9.5	9.4	9.4
1.5		3.86	3.87	3.88		0.93	0.93	0.94		9.4	9.5	9.4
2		3.86	3.86	3.86		0.94	0.93	0.93		9.4	9.5	9.4
2.5		3.86	3.86	3.86		0.93	0.93	0.93		9.4	9.4	9.4
Storage After 9 days												
0	2.92				0.91				9.6			
0.5		3.84	3.84	3.85		0.91	0.9	0.91		9.6	9.7	9.6
1		3.85	3.84	3.84		0.9	0.91	0.9		9.7	9.6	9.7
1.5		3.84	3.83	3.84		0.91	0.9	0.91		9.6	9.6	9.6
2		3.83	3.83	3.84		0.91	0.91	0.91		9.6	9.6	9.6
2.5		3.84	3.84	3.83		0.91	0.91	0.91		9.7	9.7	9.7
Storage After 12 days												
0.0	2.82				0.88				10.1			
0.5		3.84	3.84	3.83		0.90	0.90	0.91		10.1	10.0	10.1
1.0		3.83	3.83	3.83		0.91	0.90	0.90		10.0	10.1	10.0

1.5		3.84	3.83	3.83		0.91	0.90	0.91		10.1	10.0	10.2
2.0		3.83	3.84	3.83		0.91	0.91	0.90		10.2	10.1	10.1
2.5		3.83	3.83	3.83		0.90	0.90	0.90		10.1	10.1	10.1
Storage After 15 days												
0	-				-				-			
0.5		3.79	3.8	3.79		0.88	0.89	0.88		10.3	10.4	10.3
1		3.79	3.79	3.8		0.87	0.88	0.89		10.4	10.3	10.4
1.5		3.8	3.8	3.79		0.89	0.88	0.87		10.3	10.3	10.3
2		3.79	3.79	3.79		0.88	0.88	0.88		10.4	10.3	10.4
2.5		3.79	3.79	3.79		0.87	0.87	0.87		10.4	10.4	10.4
Storage After 18 days												
0	-				-				-			
0.5		3.79	3.79	3.76		0.87	0.86	0.86		10.7	10.8	10.7
1		3.78	3.78	3.77		0.86	0.87	0.86		10.8	10.7	10.8
1.5		3.78	3.78	3.77		0.87	0.86	0.86		10.7	10.7	10.8
2		3.78	3.78	3.78		0.86	0.86	0.86		10.7	10.8	10.8
2.5		3.78	3.78	3.78		0.86	0.86	0.86		10.8	10.8	10.8
Storage After 21 days												
0	-				-				-			
0.5		3.75	3.74	3.75		0.83	0.84	0.84		11.1	11	11.1
1		3.75	3.75	3.74		0.83	0.84	0.83		11	11.1	11
1.5		3.74	3.74	3.74		0.84	0.83	0.83		11.2	11.2	11.1
2		3.74	3.74	3.74		0.83	0.84	0.83		11	11.1	11.1
2.5		3.74	3.74	3.74		0.83	0.83	0.83		11.1	11.1	11.1
Storage After 24 days												
0	-				-				-			
0.5		3.72	3.73	3.72		0.8	0.81	0.8		11.5	11.5	11.6
1		3.73	3.73	3.73		0.81	0.8	0.81		11.6	11.6	11.5
1.5		3.72	3.72	3.72		0.81	0.81	0.8		11.5	11.5	11.5
2		3.72	3.72	3.72		0.8	0.8	0.8		11.5	11.6	11.5
2.5		3.72	3.72	3.72		0.81	0.8	0.8		11.5	11.5	11.5
Storage After 27 days												
0	-				-				-			
0.5		3.69	3.7	3.7		0.78	0.77	0.79		11.8	11.7	11.9
1		3.7	3.69	3.69		0.78	0.78	0.78		11.8	11.8	11.8
1.5		3.69	3.69	3.7		0.79	0.79	0.78		11.9	11.9	11.9
2		3.69	3.69	3.69		0.78	0.78	0.78		11.8	11.9	11.8
2.5		3.69	3.69	3.69		0.78	0.78	0.78		11.9	11.9	11.9
Storage After 30 days												
0	-				-				-			
0.5		3.67	3.68	3.67		0.75	0.75	0.74		12.2	12.1	12
1		3.67	3.69	3.68		0.74	0.74	0.74		12.1	12.2	12.2
1.5		3.67	3.68	3.67		0.75	0.75	0.75		12.2	12.1	12.1
2		3.66	3.67	3.67		0.74	0.74	0.74		12.2	12.2	12.2
2.5		3.66	3.67	3.66		0.74	0.74	0.74		12.2	12.2	12.2
Storage After 33 days												
0	-				-				-			
0.5		3.61	3.62	3.61		0.73	0.74	0.74		12.6	12.7	12.6

1		3.62	3.61	3.62		0.74	0.73	0.73		12.6	12.6	12.7
1.5		3.61	3.61	3.61		0.73	0.74	0.74		12.7	12.7	12.6
2		3.61	3.61	3.61		0.73	0.73	0.73		12.7	12.7	12.7
2.5		3.61	3.61	3.61		0.73	0.73	0.73		12.7	12.7	12.7
Storage After 36 days												
0	-				-				-			
0.5		3.58	3.57	3.58		0.68	0.69	0.68		12.8	12.9	12.8
1		3.57	3.58	3.57		0.69	0.68	0.67		12.8	12.8	12.9
1.5		3.57	3.57	3.57		0.68	0.67	0.67		12.9	12.9	12.8
2		3.57	3.58	3.57		0.67	0.67	0.67		12.9	12.9	12.9
2.5		3.57	3.57	3.57		0.67	0.67	0.67		12.9	12.9	12.9
Storage After 39 days												
0	-				-				-			
0.5		3.52	3.53	3.52		0.65	0.64	0.64		13	13.1	13.2
1		3.51	3.52	3.53		0.65	0.65	0.64		13.2	13.2	13.1
1.5		3.52	3.52	3.52		0.64	0.64	0.65		13.1	13.1	13.1
2		3.52	3.52	3.52		0.65	0.64	0.64		13.2	13.2	13.2
2.5		3.52	3.52	3.52		0.64	0.64	0.64		13.2	13.2	13.2
Storage After 42 days												
0		-	-	-		-	-	-		-	-	-
0.5		3.35	3.34	3.35		0.62	0.63	0.63		13.4	13.5	13.5
1		3.34	3.34	3.35		0.64	0.63	0.62		13.5	13.4	13.4
1.5		3.34	3.35	3.34		0.63	0.63	0.63		13.4	13.4	13.4
2		3.34	3.34	3.34		0.63	0.62	0.62		13.5	13.5	13.5
2.5		3.34	3.34	3.34		0.63	0.63	0.63		13.5	13.5	13.5
Storage After 45 days												
0		-	-	-		-	-	-		-	-	-
0.5		3.31	3.29	3.29		0.63	0.63	0.62		13.7	13.8	13.8
1		3.29	3.3	3.3		0.63	0.63	0.62		13.8	13.8	13.7
1.5		3.29	3.29	3.29		0.62	0.62	0.62		13.7	13.8	13.8
2		3.29	3.29	3.29		0.62	0.62	0.61		13.8	13.7	13.8
2.5		3.29	3.29	3.29		0.62	0.62	0.61		13.8	13.8	13.8
Storage After 48 days												
0		-	-	-		-	-	-		-	-	-
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		-	-	-		-	-	-		-	-	-
2.5		2.95	2.96	2.96		0.6	0.61	0.6		14.2	14.3	14.2
Storage After 51 days												
0		-	-	-		-	-	-		-	-	-
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		-	-	-		-	-	-		-	-	-
2.5		2.95	2.96	2.96		0.6	0.61	0.6		14.2	14.3	14.2

Where Ctr = Control, Tm = Turmeric, Nm = Neem leaves, Lg = Lemon grass i.e are the preservatives/extracts The pH of the controlled fruits dropped from 3.85-2.91, 3.84-2.93 and 3.82-2.82 for Dalsha, Peter and Broken respectively as seen in Table 1, 2 and3 this may be as a result of microbial degradation of nutrients, fermenting sugars to produce acids and alcohols, measurement of pH and other parameters for the controlled sample terminated after 8, 9 and 12 days for dalsha, peter and broken respectively probably because the samples had grown moulds that caused spoilage, the low pH favoured the growth of moulds. The result were similar to previously measured values by Chakare B. *et al* (2012), where the pH of each sample decreased with time. Moraes I.C.F *et al* (2010) also reported a similar result.

The result of TA shows a gradual decrease in titratable acidity (TA) with storage time across the three mango varieties. The decrease in acidity during storage (i.e ripening) could be as a result of starch hydrolysis (to simple sugars) leading to an increase in total sugars and decrease in acidity. The total soluble solids (TSS) show an increase in TSS during storage in the ripening stages. This implied TSS increased with storage time. This could be as a result of accumulation of sugars and organic acids and hydrolysis of polysaccharides which constitute the increase in sweetness. TSS is one of the major maturity index for harvesting of mango fruits. It is one of the main chemical parameter of fruit quality. As mango ripens, soluble sugars (sucrose, glucose and fructose) increase as starch content is hydrolysed to simple sugars.

From literature, it is reported that greater than 14 brix of soluble solids indicates the good quality of mangoes (Dos Santos I.C.N *et al*, 2013). The present findings agreed with the result of the TSS content, ranging between 16.90-27.65% brix as reported by Kabir M.A *et al* (2007) and between 6.90-28.26 % brix as reported by Majumder D.A.N *et al* (2011). It also agrees with the result of Mahendra K.T *et al* (2015).

Table 4: Percentage weight loss of the mango fruits during storage

Conc of extracts (%)	Dalsha				Peter				Broken			
	Treatments											
	Ctr	Tm	Nm	Lg	Ctr	Tm	Nm	Lg	Ctr	Tm	Nm	Lg
Storage After 3 days												
0	1.89				1.91				1.88			
0.5		1.81	1.81	1.81		1.78	1.78	1.79		1.86	1.86	1.86
1		1.8	1.82	1.81		1.77	1.78	1.78		1.86	1.86	1.86
1.5		1.81	1.81	1.82		1.78	1.78	1.77		1.86	1.86	1.86
2		1.8	1.8	1.8		1.77	1.77	1.77		1.85	1.85	1.85
2.5		1.8	1.8	1.8		1.77	1.77	1.77		1.85	1.85	1.85
Storage After 9 days												
0	2.82				2.86				2.81			
0.5		1.22	1.21	1.22		1.24	1.24	1.23		1.24	1.24	1.25
1		1.23	1.2	1.22		1.23	1.23	1.24		1.23	1.24	1.24
1.5		1.22	1.22	1.22		1.24	1.23	1.23		1.24	1.23	1.23
2		1.2	1.2	1.2		1.23	1.23	1.23		1.23	1.23	1.23
2.5		1.2	1.2	1.2		1.23	1.23	1.22		1.23	1.23	1.23
Storage After 12 days												
0	6.32				6.42				6.21			
0.5		2.64	2.65	2.62		2.62	2.63	2.64		2.58	2.58	2.57
1		2.62	2.62	2.63		2.63	2.62	2.63		2.57	2.58	2.58
1.5		2.63	2.63	2.62		2.62	2.62	2.62		2.58	2.57	2.57
2		2.62	2.62	2.62		2.61	2.61	2.62		2.57	2.57	2.58
2.5		2.62	2.62	2.62		2.62	2.61	2.61		2.57	2.57	2.57
Storage After 15 days												
0.0	2.82				0.88				10.1			
0.5		3.84	3.84	3.83		0.90	0.90	0.91		10.1	10.0	10.1
0	-				-				-			
0.5		2.88	2.87	2.87		2.86	2.85	2.89		2.84	2.85	2.84
1		2.89	2.89	2.89		2.87	2.89	2.87		2.83	2.84	2.85
1.5		2.87	2.88	2.88		2.86	2.88	2.86		2.84	2.83	2.84

2		2.87	2.87	2.87		2.86	2.86	2.87		2.84	2.84	2.84
2.5		2.87	2.87	2.87		2.87	2.86	2.86		2.83	2.84	2.83
Storage After 18 days												
0	-				-				-			
0.5		3.45	3.42	3.43		3.52	3.51	3.52		3.38	3.36	3.37
1		3.44	3.46	3.42		3.51	3.53	3.52		3.36	3.36	3.35
1.5		3.43	3.43	3.42		3.52	3.52	3.51		3.37	3.37	3.36
2		3.44	3.43	3.42		3.52	3.5	3.5		3.37	3.36	3.35
2.5		3.43	3.42	3.43		3.51	3.5	3.5		3.36	3.35	3.35
Storage After 21 days												
0	-				-				-			
0.5		3.2	3.22	3.21		3.31	3.3	3.32		3.1	3	3.15
1		3.21	3.2	3.21		3.32	3.31	3.32		3.1	3	3.1
1.5		3.22	3.2	3.21		3.33	3.3	3.31		2.95	3.1	2.94
2		3.2	3.21	3.2		3.3	3.31	3.32		3	3.1	3
2.5		3.2	3.19	3.21		3.32	3.3	3.31		3.1	2.94	2.95
Storage After 24 days												
0	-				-				-			
0.5		4.14	4.13	4.12		4.15	4.16	4.16		4.12	4.11	4.1
1		4.13	4.14	4.13		4.16	4.15	4.15		4.1	4.12	4.11
1.5		4.14	4.12	4.12		4.16	4.15	4.16		4.1	4.11	4.12
2		4.13	4.12	4.14		4.15	4.16	4.15		4.12	4.1	4.1
2.5		4.12	4.13	4.13		4.15	4.15	4.16		4.1	4.11	4.1
Storage After 27 days												
0	-				-				-			
0.5		4.78	4.75	4.76		4.82	4.83	4.81		4.68	4.67	4.69
1		4.76	4.76	4.78		4.83	4.82	4.81		4.65	4.66	4.68
1.5		4.77	4.75	4.75		4.81	4.81	4.82		4.66	4.67	4.67
2		4.76	4.77	4.76		4.8	4.82	4.82		4.65	4.666	4.67
2.5		4.76	4.75	4.76		4.81	4.81	4.81		4.65	4.66	4.66
Storage After 30 days												
0	-				-				-			
0.5		5.22	5.24	4.23		5.31	5.32	4.31		5.12	5.15	5.14
1		5.2	5.22	4.22		5.32	5.3	4.32		5.13	5.12	5.13
1.5		5.21	5.21	4.2		5.3	5.31	4.3		5.15	5.13	5.12
2		5.2	5.22	4.2		5.31	5.32	4.31		5.13	5.12	5.13
2.5		5.2	5.21	4.21		4.3	5.31	4.3		5.14	5.14	5.13
Storage After 33 days												
0.0	-				-				-			
0.5		5.78	5.79	5.78		5.86	5.87	5.85		5.65	5.62	5.64
1.0		5.77	5.78	5.78		5.85	5.86	5.86		5.64	5.63	5.65
1.5		5.76	5.77	5.76		5.87	5.87	5.87		5.63	5.64	5.64
2.0		5.77	5.76	5.77		5.86	5.85	5.86		5.65	5.65	5.65
2.5		5.76	5.77	5.76		5.85	5.86	5.85		5.64	5.64	5.63
Storage After 36 days												
0	-				-				-			
0.5		6.45	6.47	6.45		6.67	6.65	6.68		6.25	6.26	6.24
1		6.46	6.48	6.45		6.65	6.66	6.67		6.31	6.28	6.27

1.5		6.44	6.45	6.46		6.68	6.67	6.65		6.32	6.27	6.28
2		6.46	6.46	6.45		6.65	6.65	6.66		6.28	6.28	6.27
2.5		6.45	6.45	6.44		6.66	6.65	6.65		6.27	6.27	6.27
Storage After 39 days												
0	-				-				-			
0.5		7.27	7.26	7.28		7.4	7.42	7.43		7.15	7.14	7.12
1		7.26	7.27	7.26		7.42	7.4	7.41		7.14	7.13	7.13
1.5		7.26	7.26	7.27		7.41	7.42	7.42		7.15	7.14	7.14
2		7.27	7.25	7.25		7.42	7.41	7.42		7.14	7.14	7.13
2.5		7.26	7.25	7.25		7.41	7.42	7.42		7.15	7.14	7.14
Storage After 42 days												
0		-	-	-		-	-	-		-	-	-
0.5		7.86	7.89	7.89		7.84	7.82	7.79		7.64	7.62	7.6
1		7.88	7.86	7.87		7.82	7.81	7.8		7.61	7.6	7.62
1.5		7.87	7.87	7.86		7.8	7.81	7.81		7.62	7.62	7.61
2		7.86	7.87	7.86		7.82	7.82	7.82		7.61	7.6	7.62
2.5		7.85	7.85	7.86		7.8	7.81	7.8		7.6	7.61	7.61
Storage After 45 days												
0		-	-	-		-	-	-		-	-	-
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		7.86	7.84	7.85
2		7.96	7.98	7.89		7.95	7.94	7.96		7.85	7.82	7.82
2.5		7.98	7.96	7.97		7.95	7.95	7.96		7.84	7.82	7.82
Storage After 48 days												
0		-	-	-		-	-	-		-	-	-
0.5		-	-	-		-	-	-		-	-	-
1		-	-	-		-	-	-		-	-	-
1.5		-	-	-		-	-	-		-	-	-
2		-	-	-		-	-	-		8.1	8	8.12
2.5		8.24	8.26	8.24		8.42	8.41	8.4		8.1	8.12	8.1

Where Ctr = Control, Tm = Turmeric, Nm = Neem leaves, Lg = Lemon grass i.e are the preservatives/extracts Fruits treated with the extracts showed lower percentage weight loss as compared to those without the extract as shown in Table 4. This could probably be as a result of property of the plant extract that prevents the action of ethylene which has a direct relation with respiration and fruit ripening (Sister E.C *et al*, (2013) and Silva S.M *et al*, (2003). This result is in line with observation of Silva *et al* (2004) who reported that mango fruits treated with (methylcyclopropene) showed reduced weight loss as compared to non-treated control in two mango cultivars. The result also agreed with the report of Lemma *et al* (2012).

Generally, weight loss increased with storage time throughout the storage period. The minimum weight losses are recorded at the beginning of each storage period while the maximum values were towards the end of the storage period. This phenomenon was also reported by Zeweter A (2008).

Table 5: Quality Parameters and methods of sensory evaluation

Quality Parameter	Methods of evaluation using 5 – point scale
Skin colour	1 = excellent, 2 = good, 3 = slightly dull, 4 = <50% brownish, 5 = >50% brownish
Pulp colour	1 = good (yellow), 2 = good (pale yellow), 3 = 50% good (light brown), 4 = 25% good (brown), 5 = poor quality (dark brown and black)
Flavor (Aroma)	1 = excellent, 2 = good, 3 = acceptable, 4 = poor, 5 = unacceptable
Taste	1 = excellent, 2 = good, 3 = acceptable, 4 = poor, 5 = unacceptable

Table 6: Sensory evaluation of mango fruits during storage

S/No	Treatment/conc of extracts		Skin Colour	Pulp Colour	(Aroma) Flavour	Taste
	Turmeric	0.5	1	1	1	1
		1.0	1	1	1	1
		1.5	1	1	1	1
		2.0	1	1	1	1
		2.5	1	1	1	1
	Neem Leaves	0.5	1	1	1	1
		1.0	1	1	1	1
		1.5	1	1	1	1
		2.0	2	1	1	2
		2.5	2	1	1	2
	Lemon Grass	0.5	1	1	1	1
		1.0	1	1	1	1
		1.5	1	1	1	1
		2.0	2	1	1	1
		2.5	2	1	2	1
	Control	0.0	5	5	5	5

Sensory Evaluation (organoleptic evaluation)

The sensory analysis revealed beneficial effects in terms of delaying mango fruit skin browning/darkening and dehydration and maintenance of the visual aspect of the fruits without any detrimental effect on taste, aroma, or flavours. Turmeric treatment showed best scale point of one for all parameters, whereas controlled samples showed all scale points. The three treatments showed best score for pulp colour, aroma and taste as well. The untreated or controlled sample showed rancid smell and poor taste, due to the biochemical changes in carbohydrates, proteins, amino acid, lipids and phenolic compounds that are active components of natural additives and can influence the pleasant flavour, aroma and taste. Additives influence the pleasant aroma, flavour and taste of fruits Shweta C. *et al* (2014). Edible coatings protects perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality which help retain volatile flavour compounds, and reduces microbial growth.

Table 7: Antimicrobial susceptibility test – Zones of inhibition (mm).

Microbial specie	Tomeric Extract	Lemon grass Extract	Neem leaves Extract
Staphylococcus	13.00 ± 1.4^{c}	14.50 ± 2.29^{b}	10.50 ± 2.12^{a}
Bacillus	8.00 ± 00^{d}	11.50 ± 0.71^{bc}	11.00 ± 1.41^{a}
Klebsiella	12.00 ± 1.4^{c}	15.00 ± 1.41^{a}	14.50 ± 2.12^{a}
Pseudomonas	$7.50. \pm 0.71^{bc}$	10.00 ± 0.00	13.00 ± 1.41^{a}
Proteus	14.00 ± 1.41^{bc}	14.50 ± 2.12^{ab}	12.00 ± 0.00^{a}
Saccharomyces	16.00 ± 0.00^{ab}	12.00 ± 1.41^{abc}	12.00 ± 0.00^{a}
Mucor	17.00 ± 1.41^{a}	10.00 ± 1.41^{c}	4.00 ± 5.66^{b}
Aspergilles	12.50 ± 0.71c	0.00 ± 0.00^{d}	00.00 ± 0.00^{b}
Fusarium	$13.50 \pm 0,71^{c}$	11.00 ± 1.41^{c}	00.00 ± 0.00^{b}
P-value	0.00	0.00	0.00

The results of the antimicrobial susceptibility test which was used to determine the susceptibility or otherwise of the microbes against the extracts of Tumeric, Lemon grass and Neem leaves as presented in Table 7 reveals that, Tumeric extract exerts it highest inhibition zone on mucor specie (17.00±1.41mm) following closesly is saccharomyces (16.00±0.00), proteus (14.00±1.41mm) while the least zone was on bacillus specie (8.00±0.00mm). Lemon grass on the other hand was most effective on klebsiella (15.00±1.41mm) followed by staphylococcus and protease species (14.50±2.12mm). Conversely Lemon grass extract do not have any antimicrobial activity against Aspergillus specie (0.00mm). The same trend is found in neem leave extract which is also non- reactive to fusarium spp. There is significance difference in the zone of inhibition of the three extracts on the microbes ($p < 0.05$). This results implies that tumeric extract showed antimicrobial activity to both the fungi and bacteria isolates, with lemon grass showing antimicrobial activity to all except Aspergillus spp. while neem leaves reacted

to all except Aspergillus spp. and Fusarium spp. This explains the ability of these extracts to extend the shelf life of the fruits by preventing such microbes from acting on the mango fruits hence their preservation. (Lemma A. *et al*, (2012).

CONCLUSION

The present work demonstrates that the extracts of turmeric, lemon grass and neem leaves extracts can be potentially used as natural preservatives to improve and extend the shelf life of mango fruits being an alternative and cheap way to prevent and reduce post-harvest loses and decay. Weight loss and some other physicochemical parameters revealed that broken mango had the longest shelf life of 54 days. The antimicrobial analysis shows that turmeric extract exerts it highest inhibition of zone on mucor specie (17±1.41mm). Sensory evaluation showed that turmeric showed best scale point of 1 for all parameters.

Hurdle technology which implies the deliberate combination of existing and novel preservation techniques in order to establish a series of preservation factors or hurdles that any microorganisms present should not be able to overcome resulting in increased shelf life of the mango fruits is recommended.

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Conflict of interests

No conflict of interests.

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