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EFFECT OF RADIATION IN COMBINED METHOD AS A HURDLE IN DEVELOPMENT OF SHELF STABLE INTERMEDIATE MOISTURE PINEAPPLE (ANANAS COMOSUS)

ABSTRACT

Development of safe, shelf stable foods are necessary to reduce dependence on refrigeration during their storage and distribution. Studies were conducted to develop Shelf stable intermediate moisture (IM) Pineapple (Ananas comosus) based on 'hurdle technology', (HT) using gamma irradiation. Processing conditions were established to observe the effect of radiation on development of shelf stable IM pineapple. The most important hurdles used were reduction of water activity (aw) by osmosis, infrared drying (IR), 400 gauge polyethylene bags along with mild dose of irradiation(R) (1kGY).

IM pineapple subjected to Infrared drying and radiation (IRR) and non radiated (IR) were evaluated for shelf life at ambient (34 ± 2 ºC and 65% RH) temperature. The shelf life of the IRR was found to be 4 months where as IR spoiled within 3 months at ambient temperature.

On storage, IRR showed no significant ($p>0.05$) changes in $a_{w,}$ moisture and reducing sugars. Total sugars, total soluble solids and acidity increased in both the treatments significantly ($p>0.05$). pH, ascorbic acid decreased significantly as storage period increased. Vitamin 'C' retention was up to 65.3% in IRR treatment.

The combination of hurdles including osmotic dehydration, infrared drying and gamma radiation dose of 1 kGy, successfully reduced the microbial load and showed high product quality. This treatment can be considered the most adequate for obtaining high quality IM pineapple with optimum sensory, microbial nutritional quality and storability. These IM pineapples are energy efficient, satisfactory and give great prospects to commercial application opening new possibilities for processed food markets.

Keywords Shelf stable, intermediate moisture, hurdle technology, infrared drying, gamma radiation, sensory quality, nutritional quality

1. INTRODUCTION

Fruits are important components of the daily diet due to their contribution in fibres, carbohydrates, minerals and vitamins. Pineapple (Ananas comosus) is one of the most popular tropical fruits. The fruit is known for its nutritive and health promoting properties. It is commonly used as table fruit or in desserts. The shelf life of ripe pineapple is short and limited to 4-6 days [1]. Fresh pineapple contains thick, thorny inedible peel and a large crown, which consumes storage space and also results in higher transportation costs[2] Therefore, value addition by processing to a RTE product, is an attractive alternative. Pineapple slices dipped in sugar syrup and canned are normally used around the world[3].The canned pineapple is shelf stable but it is not liked by some consumers, due to its high level of sweetness. The shelf life of peeled, sliced and polyethylene packed pineapple sold in market is 4-6 days, when stored at room temperature, whereas, pineapple slices when kept at 8-10 ºC, do not stay more than 8-10 days.

Intermediate moisture (IM) fruits have the advantage over traditionally dried ones, where instead of removing most of the water, just enough water is removed, or bound through the addition of humectants to retard microbial growth[4,5]. However, IM foods have not achieved the expected consumer acceptance because of poor palatability caused by the high concentration of humectants and the high requirement for antimicrobial additives to maintain their stability. With the introduction of the hurdle technology (HT) concept[6,7] there is now a worldwide interest in HT foods based on the combination of preservation using two or more methods, none of which is individually sufficient to prevent microbial spoilage. A mild and effective preservation of foods, i.e. a synergistic effect[8] is possible if the preservation measures are based on intelligent selection and combination of hurdles taken from different target classes[9]. Intermediate moisture foods are characterized by semi moist consistency so these foods have enough moisture content to permit easy chewing but low water to prevent spoilage. Production of IM foods is based on an increased scientific understanding of the chemical reactions involved in traditional food preservation methods[10].

The objective of the present study is to standardize a simple method for shelf stable IM pineapple using radiation as mild HT with the combination of infrared drying and osmotic dehydration at ambient temperature and to evaluate the effect of radiation on physical, nutritional, and sensory qualities during storage.

2. MATERIALS AND METHODS

2.1 Pineapple processing

Pineapples procured from a local market from single vendor to maintain homogeneity in sample. The pine apples were cleaned with water and crowns were removed manually. Pineapple was peeled, cored and made in to quarter slices of diameter 2.5cm and 1 cm of thickness with sharp, clean stainless steel knives. The slices were subjected to various pre treatments to obtain optimum conditions for processing IM pineapple. Standardization was carried out with respect to

2.1.1 Standardization of pre-treatments

The fruits were exposed to different concentrations of sugar syrups and temperatures and soaked for different length of time as shown in Figure:1 to assess the best osmotic dehydration point.

The fruit samples were weighed and suspended in the vessel containing the sugar solution of 50^0 brix , 60^0 brix, 70^0 brix and 80^0 brix. Samples from each concentration of sugar solution were further divided and exposed to different temperatures 40^0C, 45^0C, 50^0C in hot air oven. The samples were then withdrawn at regular intervals of 3hrs, 6hrs, 9hrs, and 12hrs, drained, weighed and analyzed for moisture content using the standard AOAC method in hot air oven at 80^0C.

2.1.2 Standardization of optimum drying conditions

After identifying optimum osmotic dehydration point the pineapple slices were processed at various temperatures and time using infrared drying (IR) to standardize the optimum drying time and temperature till the desired moisture level (~ 30%) attained.

2.1.3 Standardization of the packaging material

The fruits were dried in Infra red drier up to 30-40% moisture content and were packed in 200, 400 gauge polyethylene bags and in aluminum foil cups with clin wrap. Sealed packs were subjected to different levels of radiation doses of 0.25, 0.50, 0.75, 1.00, 2kGy and stored at both ambient 30^0C-35^0C and low temperatures 14^0C along with control. Gamma radiation treatment was carried out in acobalt-60 GammaChamber-5000 at ANGRAU. Non irradiated samples were used as control. Shelf life of the products was analyzed at 0, 30, 60, 90 days to select appropriate dose and package.

2.2 Experimental Design and Treatment for shelf life studies

The standardized protocols (Table2) were used for preparation of IM pineapple.

The following treatments were designed to ascertain the effect radiation on shelf stability.
Treatment 1Infra red dried (IR)
Treatment 2Infra red dried and radiated (IRR)

Standardized IM pineapple **was** aliquoted into separate packages and stored under ambient conditions. At predetermined interval of storage period (i.e., 0, 30, 60, 90, 120, 150 and 180 days) the IM products in triplicate are removed and analyzed for physical, nutritional, microbiological and sensory acceptability.

2.2.1. **Physical:** Color estimation using Hunter lab Color spectrometer, Physiological loss of weight [11].

2.2.2 **Chemical:** Water activity (aw) measurement was analyzed using water activity meter (Lab Master-aw supplied by Sunjay biotech solutions Mumbai), Moisture [12,13], Total soluble solids TSS (^{o}Brix) determined using 'Erma' hand refractometer and expressed as percent. Vitamin C and acidity were estimated by titration method[11] for estimation of pH[14] was adopted after modification. Total and reducing sugars were estimated by colorimetric Method developed by[15].

2.2.3 **Microbial analysis:** For estimating viable bacterial, yeast and mould count dilution plate method was followed. For bacterial estimation, plate count agar was used and for yeast and mould potato dextrose agar was used[16].

2.2.4 **Organoleptic evaluation:** Taste, flavor, color, texture appearance and overall acceptability (5 point hedonic scale)[17].

2.2.5 **Statistical Analysis: A**ll the experiments were repeated three times and data obtained was statistically analyzed using Analysis of Variance ANOVA[18] single factor with replications to assess the significant difference at 0.05 % and 0.01% level using AGRES software. The effects of treatments between and within were compared. Once the product was spoilt that treatment was eliminated from analysis and only other three treatments were considered for two factor analysis.

3. RESULTS AND DISCUSSION

3.1 Effect of pineapple processing

Osmotic dehydration (DO) is a food preservation technique that relies on the reduction of water activity and humidity of the product, which has advantages over other dehydration techniques because it preserves the sensory and nutritional characteristics of foods [19,20]. Maximum decrease in moisture content was found at 70^{0}brix concentration containing 0.036% potassium metabisulfite, 1.8% citric acid, 0.24% sorbate at 50^{0} C temperature , 6hrs of soaking time The osmotic dehydration reduced the moisture content up to 60.61% and aw of pineapple slices from 0.97 to 0.9. .Osmatic dehydration processes involve simultaneous water loss and solute gain[21], in which the mass transfer depends on variables such as pressure, temperature[22], concentration of solutes[22] fruit/syrup ratio and degree of agitation, among others[2]. Osmo dehydrated products are part of the so-called intermediate moisture products and should be consumed in a relatively short time or be subjected to conservation steps[2,23]. One area for improvement for these products is their microbial load, since it may affect the shelf life of packaged products, especially cut ones[24,25]. For these reasons, to improve the stability 1.8% citric acid was added to the osmodehydration solution. This combination agree with studies Zapata et al [24] who reported clearly positive effect adapting an acidic pH that is unfavorable for the growth of molds and yeasts, without negatively affecting the sensory acceptance of the osmo dehydrated product . Bolin[26] also noted that reduction of pH in case of fruits having a pH of 4.5 and above also functions as an effective hurdle. Adams and Moss[27] reported that enzymatic browning can be inhibited by dipping in potassium metabisulfite solution. The disruption of pH homeostasis by sorbic acid could account for the delay in spore germination and retardation of the onset of subsequent mycelial growth. The antimicrobial activity of these acids in aqueous solution is pH dependent,

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with the maximum effect occurring at low pH, thus favoring the undissociated state of the acid. Sorbic acid is an effective antifungal agent that delays spore germination and retards mycelial growth[28].

Water activity was reduced further below 0.82 only after drying in infrared drier. Drying by infrared radiation found to restore texture[29] this texture retention could be due to sugar infusion into the intercellular spaces[30].Infrared radiation also controlled enzymatic browning .Samples stored in aluminum foil cups with clin wrap packing showed more natural texture and color. However, 50% moisture loss was observed in aluminum foil cups with clin wrap in the first month of storage. When samples were packed in polyethylene bags 68% to 73% of moisture retained even after three months of storage at ambient temperature and hence showed lower physiological loss in weight. Considering the moisture retention levels the 400 gauge polyethylene covers was found to be best followed by 200 gauge for IM vegetables and fruits. A study by Sagar and Kumar[31] also reported that 200 gauge HDPE most suitable for retention better quality in respect of colour, flavor, texture and overall quality of the intermediate moisture foods for 4 months at room temperature and 6 months at low temperature (7.0±20C) followed by 400 gauge LDPE and 150 gauge PP pouches during the storage. Among the treatments the 1 KGy dosage recorded lower PLW losses compared to the remaining treatments. Therefore, with the data obtained, the protocols used for preparation of IM pineapple were presented in table1.

3.2 Effect of infra red drying, radiation and packing on physicochemical parameters of IM Pineapple on storage at ambient temperature were presented in table 2 to 4.

3.2.1 Shelf life

Infrared drying in combination with radiation technology showed high product quality and shelf stability up to 4 months at 30% moisture level when packed in 400 gauge polyethylene covers at ambient temperature (27°C, 65% RH and 14°C , 95% RH).

3.2.2 Moisture content

On ZERO day moisture content of IM pineapple was 30 per cent. During storage the content of moisture decreased. The effect of infra red drying, radiation and packing on percent of moisture of IM Pineapple found to be insignificant in both the radiated and non radiated samples stored at ambient temperature as shown in table2.

3.2.3 Color values

Radiated samples showed slightly higher L* values than non radiated. Maximum decrease of L* values 14.28 units in the scale of color was observed in IRR after 4 months of storage and 13.45 units in IR after 3 months of storage period was observed. a* values of IR increased during storage period at ambient temperature. b* values decreased at the end the storage period in both IRR and IR . Chroma values increased. All values of L*. a* b* presented in table3 showed significant difference on storage. Several studies show that irradiation can cause changes in pectin and cellulosic substances resulting in a discoloration of soft tissues

3.2.4 Acidity

There was significant change in acidity among different treatments, storage period and interactions at both the temperatures. Acidity increased gradually in IM pineapple during storage in both the treatments (table4)

3.2.5 pH

pH of IM pineapple reduced to below 2.94 after osmotic dehydration. pH decreased gradually throughout the storage period in both the

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radiated and non radiated IM pineapple samples stored at ambient and low temperatures Change in pH during storage period was significant and treatments were non significant(table4).Radiated samples recorded lower pH compared to non radiated samples. The decrease in pH of the IM fruits with storage might be due to the increase in acidity with storage. In a similar study, Kinh et al[32]. observed a significant increase in acidity and a decrease in pH during the storage life of apple products The manifestation that the samples with increased rate of darkening corresponded to increased rate of pH drop describes that the same process of quality deterioration are responsible for both[33,34] reported that browning reaction was slowed down on decreasing pH and it was inhibited by itself due to pH decrease with loss of basic group of the amino acid. The effect of pH on browning reaction was highly dependent on the moisture content.

3.2.6Ascorbic acid

There was significant change in acidity among different treatments and, storage period .where as Interactions was insignificant. Higher retention 84.1% was found in non radiated samples by the end of 3 months of storage period. Radiated samples recorded significantly higher loss and retained only 78.9%.

3.2.7 Total soluble solids

During storage total soluble solids increased significantly in both non radiated and radiated. Change in total soluble solids among different treatments and storage period was significant and interactions were not significant. Maximum increase was found in radiated samples than non irradiated samples.

3.2.8 Total sugars and Reducing sugars

There was significant change in total sugars among different treatment, storage period interactions where as there was non significant change in reducing sugars Total sugars and reducing sugars increased with increase in storage period. Radiated samples recorded significantly higher increase of total sugars and reducing sugars compared to non radiated samples Singh et al.[35] reported that with the increase in the storage period the physiological loss in weight, spoilage percentage, total soluble solids content, total sugar content and reducing sugar content increased, whereas acidity and ascorbic acid content decreased.

3.2.9 Sensory evaluation

Radiation has no effect on overall acceptability and scored higher scores than the non radiated samples. Pretreatment retained flavor, texture and color of original fresh fruits may be due to prevention of enzymatic and oxidative browning as fruit pieces were surrounded by sugar thus making it possible to retain good color Similar effects of such pre-treatments have also been reported by Karim et al [36].The combination of potassium metabisulfite dip, osmotic dehydration and infrared drying treatments, were fairly successful in maintaining texture table5 López-Malo and Palou[37] also reported the insignificant effect of combined preservation methods such as blanching and osmotic dehydration, on texture of pineapple slices. However on storage overall sensory score of product showed a decreasing trend with advances in storage period. The score of color was affected drastically may be due to non enzymatic browning which lead to significant decrease in average scores for other attributes like texture, aroma, taste and overall acceptability . Similar findings have been reported[38] in guava slices. An increase in browning was also observed at lower irradiation rates [39] at 1.74 kGy irradiation of Witloof chicory increased its membrane permeability, and facilitated browning through enzyme substrate contact These findings are contradictory with Hajare et al.,[26] who reported no significant effect of 2 kGy radiation dose, on sensory parameters of minimally processed pineapple slices, when stored at 10 ^{0}C for 12 days. Interaction effects were not significant.

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3.2.10 TBC &TMC

The mean values of TBC and TMC in fresh pineapple found to be in the range of 10^2 to 10^3 cfu/g. There was an increase in TBC and TMC in non irradiated samples on storage table6 but was found to be not significant.This shows that combination of osmotic dehydration, infrared drying with mild preservations improved the microbial stability and controlled the growth of microbes. When radiation treatment employed along with these hurdle technologies the counts of TBC and TMC fell below the detection limits increasing the stability of the product up to 4 months at ambient temperature. No Coli forms were observed in any sample throughout the storage period, indicating that the product was stable with respect to bacteria, yeast and mold growth. Pathogenic organisms were absent and the product was found to be microbiologically safe for direct consumption. The slightly higher standard plate counts and coli forms in the product at initial stage became nil after storage, indicating that HT is an effective method and did not allow microbial proliferation during storage. This confirms the earlier finding by Webster et al.[40] who reported that in a model system, citrate/benzoate at slightly reduced aw levels was a promising food preservation system. Similarly, Alzamora et al.[41] stated that yeast and mold and aerobic mesophilic analysis performed during four months of storage at 27^{0}C in processed pineapple slices with 0.97 Aw, pH 3.1 and sorbate/sulfate indicated not only a null growth of microorganisms, but also that the counts were practically negative after 30 days of incubation.

4. CONCLUSION

HT has been applied to develop a shelf-stable intermediate moisture pineapple. The combination of hurdles osmotic dehydration, infrared drying, HDPE packaging and a radiation dose of 1 kGy were proved to be effective in extending the shelf life of pineapple slices up to 4 months under ambient storage temperature. Therefore, the use of different hurdles in product development has advantage in terms of effective microbial control. The combination of gentle hurdles is more effective than the use of a single preservative in large amounts because the different preservatives might hit different targets within the microbial cell and act synergistically. Radiation in combination with other preservation processes offers promise to develop high quality shelf-stable intermediate moisture products which could be kept at ambient condition for many months.

5. Tables and Figures

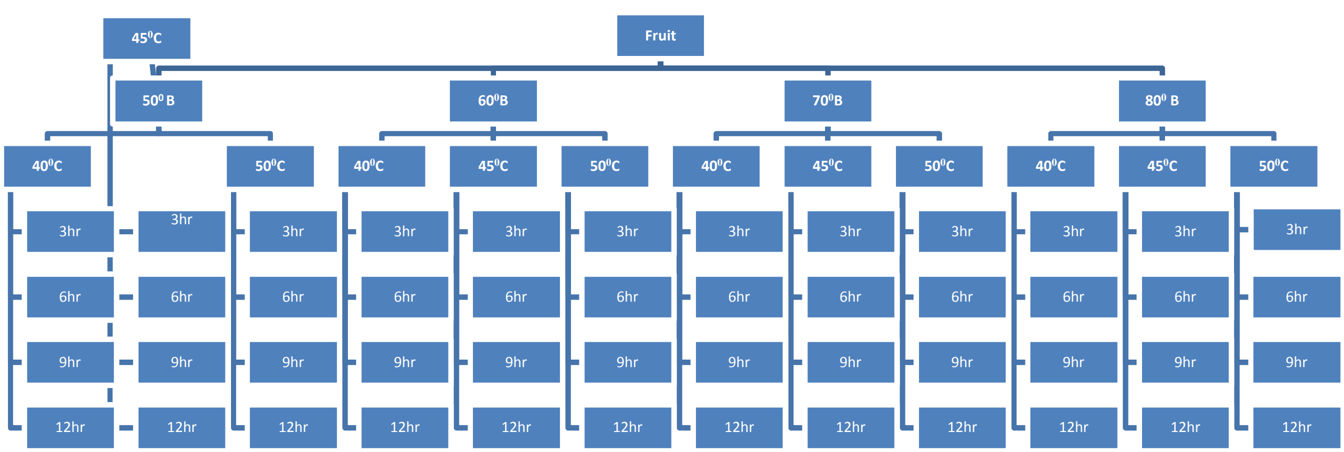

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Figure 1: Assessing optimum osmotic dehydration point

Osmatic dehydration			Infrared Drying		Packaging material	Optimum radiation dose(kGy)	Per cent moisture
Concentration brix	Temperature ^{0}C	Time hr:min	Temperature ^{0}C	Time hr:min	400 gauge polyethene bags	1kgy	<30
80^0	50	6:00	60	0:10			

Table 1: protocols used for preparation of IM pineapple

Table3a: Percent of moisture of IM Pineapple on storage at Ambient temperature					
Treatment	storage period				
	0day	1month	2month	3month	4month
IR	30±0.42	30.5±0.45	30±0.45	29.5±0.32 (1.70%)	
IRR	30±0.48	30.2±0.52	29.8±0.47	29.5±0.36	29.03± 0.51 (3.23%)
	T	P	T*P		P
SED	0.17139	0.24238	0.34278		0.2608
CD >0.05	0.39523	0.55894	0.79047		0.6704
CD >0.01	0.5751	0.81331	1.1502		1.0515

Table **2 : Effect of infra red drying, radiation and packing on percent of moisture of IM Pineapple stored at ambient temperature**

Values represented are the Mean $\pm$ S.D of three independent determinations

Figures in parenthesis represent percent change over initial value

IR Infra red dried; IRR Infrared dried and radiated; CD-Critical difference

Sed(T)-Standard error deviation between treatments;

Sed(P) – Stanard error deviation between periods,

Sed(TxP) Standard error deviation between treatments and periods

Sed(**P**) – Stanard error deviation between periods;(four months data i,e only for IRR treatment.

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Parameters	L*Value				a* value				b* value				DE**			
Treatments	IR		IRR		IR		IRR		IR		IRR		IR		IRR	
Storage period	0 day	3m	0 day	4m	0 day	3m	0 day	4m	0 day	3m	0 day	4m	0 day	3m	0 day	4m
Values	53.03 ± 2.2	36.56 ± 3.1	53.30 ± 2.10	45.89 ± 5.1	3.57 ± 0.52	7.84 ± 6.19	3.57 ± 0.68	7.66 ± 6.25	36.56 ± 3.56	31.43 ± 7.9	36.56 ± 2.59	31.27 ± 6.7	4.11 ± 0.15	37.66 ± 4.12	4.11 ± 0.56	24.01 ± 4.23
	T*	P*	T*P*	**P***	T	P*	T*P*	**P**	T*	P*	T*P	**P***	T*	P*	T*P*	**P***
SED	0.021	0.034	0.048	0.06	0.008	0.013	0.018	0.019	0.008	0.013	0.019	0.018	0.009	0.014	0.021	0.0173
CD >0.05	0.048	0.076	0.107	0.148	0.018	0.029	0.041	0.046	0.019	0.030	0.043	0.045	0.020	0.032	0.046	0.0424
CD >0.01	0.068	0.108	0.153	0.224	0.026	0.041	0.058	0.071	0.027	0.043	0.061	0.068	0.029	0.045	0.065	0.0642
CV%	0.08%			0.13	0.17%			0.31	0.04%			0.06	0.05%			0.1

Values represented are the mean scores on zero day and at the end of the storage period ± S.D of panelists

IR Infra red dried; IRR Infrared dried and radiated; CD-Critical difference

Sed(T)-Standard error deviation between treatments; (for three months data)

Sed(P) – Stanard error deviation between periods;(for three months data)

Sed(TxP) Standard error deviation between treatments and periods;(for three months data)

Sed(**P**) – Stanard error deviation between periods;(for four months data i,e only for IRR treatment.)

Table 3: Effect of infra red drying, radiation and packing on color of IM Pineapple stored at ambient temperature

Treatment	pH of IM Pineapple on storage					Acidity of IM Pineapple on storage					Vitamin 'C' of IM Pineapple on storage					
	storage period					storage period					storage period					
	0day	1m	2m	3m	4m	0day	1m	2m	3m	4 m	0day	1m	2m	3m	4 m	
IR	2.94	2.55	2.11	2.01 (31.6%)		1.344	1.376	1.408	1.44 (7.4%)		82.7	79.3	72.7	69.5 (84.1%)		
IRR	2.94	2.56	2.15	2.05	1.98 (32.7 %)	1.344	1.363	1.395	1.44 (7.4%)	1.472	81.7	78.6	72.9	69.1 (78.9%)	65.3	
	T	P*	T*P		P*	T*	P*	T*P		P*	T**	P*	T*P		P	
SED	0.01	0.016	0.022		0.0224	0.001	0.002	0.002		0.002	0.1	0.158	0.224		0.073	
CD >0.05	0.022	0.035	0.049		0.0547	0.002	0.004	0.004		0.005	0.224	0.352	0.498		0.188	
CD >0.01	0.032	0.050	0.071		0.0829	0.003	0.005	0.007		0.007	0.318	0.501	0.709		0.295	

Figures in parenthesis represent percent change over initial value

IR Infra red dried; IRR Infrared dried and radiated; CD-Critical difference

Sed(T)-Standard error deviation between treatments;

Sed(P) – Stanard error deviation between periods;

Sed(TxP) Standard error deviation between treatments and periods;

Sed(**P**) – Stanard error deviation between periods;(for four months data i,e only for IRR treatment.)

Table 4: Effect of infra red drying, radiation and packing on nutritional quality of IM Pineapple stored at ambient temperature

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Parameters	Taste				Flavour				Texture				Colour				Overall acceptability			
	Treatments				Treatments				Treatments				Treatments				Treatments			
	IR		IRR		IR		IRR		IR		IRR		IR		IRR		IR		IRR	
Storage period	0 day	3m	0 day	4m	0 day	3m	0 day	4m	0 day	3m	0 day	4m	0 day	3m	0 day	4m	0 day	3m	0 day	4m
Score	4.86 ± 0.1	3.8 ± 0.49	4.85 ± 0.43	3.2 ± 0.68	4.93 ± 0.12	4.0 ± 0.40	4.91 ± 0.23	3.61 ± 0.53	4.36 ± 0.12	3.01 ± 0.56	4.87 ± 0.10	3.65 ± 0.46	4.69 ± 0.56	2.10 ± 1.08	4.87 ± 0.23	1.12 ± 1.51	4.71 ± 0.23	3.23 ± 0.62	4.88 ± 0.16	3.1 ± 0.78
3 months	T	P	T*P	**P**	T	P	T*P	**P**	T	P	T*P	**P**	T	P	T*P	**P**	T	P	T*P	**P**
Grand Mean	4.264			3.98	4.353			4.16	4.014			4.21	3.49			3.15	4.0363			3.888
SED	0.011	0.016	0.022	0.018	0.011	0.016	0.022	0.021	0.012	0.017	0.024	0.024	0.054	0.076	0.107	0.134	0.011	0.016	0.022	0.021
CD >0.05	0.026	0.036	0.052	0.046	0.026	0.036	0.052	0.054	0.028	0.039	0.055	0.061	0.124	0.175	0.247	0.345	0.026	0.036	0.052	0.054
CD >0.01	0.038	0.053	0.075	0.072	0.038	0.053	0.075	0.085	0.040	0.057	0.080	0.095	0.180	0.254	0.360	0.542	0.038	0.053	0.075	0.054

Values represented are the mean scores on zero day and at the end of the storage period ± S.D of panelists

IR Infra red dried; IRR Infrared dried and radiated; CD-Critical difference

Sed(T)-Standard error deviation between treatments;

Sed(P) – Stanard error deviation between periods;

Sed(TxP) Standard error deviation between treatments and periods;

Sed(**P**)-Standard error deviation between period of **IRR** treatment

Table 5: Effect of infra red drying, radiation and packing on sensory attributes of IM Pineapple stored at ambient temperature

	TBC of IM Pineapple on storage (log cfu/gm)					TMC of IM Pineapple on storage (log cfu/gm)				
storage period	0day	1month	2month	3month	4month	0day	1month	2month	3month	4month
IR	nvc	1.06	1.25	2.02	discarded	nvc	1.02	1.8	1.9	discarded
IRR	nvc	nvc	nvc	nvc	nvc	nvc	nvc	nvc	Nvc	nvc

The data expressed as logarithm of colony forming unit (cfu/g) and represents the mean of three independent determinants

Note: TBC- Total bacterial count, TMC- Total Microbial count

IR-Infra red dried, IRR-Infra red dried radiated.

Table 6: Effect of drying and radiation on microbial quality of IM Pineapple stored at ambient temperature

6. ACKNOWLEDGMENT

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