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Physico-chemical and Organoleptic Properties of Intermediate Moisture (IM) Slices from Pineapple [*Ananas comosus* (L.) Merr.]

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ABSTRACT

Background: Pineapple is produced round the year in the tropics and therefore, market gluts are very common and post harvest losses of around 20-30% are reported. Intermediate Moisture Fruits (IMF) have a water activity ranging between 0.65-0.90 and moisture content of 15-40%. Hence, the present study was undertaken to develop intermediate moisture fruit slices by evaluating the effect of various osmotic agents and pineapple varieties on the physico-chemical and organoleptic qualities of the product.

Methods: Pineapple varieties 'Mauritius', 'Kew' and 'MD-2' were selected for the study. Fruit slices were steam blanched, followed by immersion in osmotic solutions (fruit : solution ratio of 1: 4), containing six different osmotic agents *viz*. sucrose, sucrose+sorbitol, glucose syrup, sucrose+NaCl, palm sugar and honey separately, in combination with 0.5% ascorbic acid and 0.25% potassium metabisulphite, for six hours and were subsequently dehydrated at 50°C in a tray dryer.

Result: Moisture content varied between 19.42 and 29.71% and water activity values in between 0.60 and 0.73.Decline in L* and b* values with a corresponding increase in a* value was observed in IM slices. Intermediate moisture pineapple slices had ascorbic acid content in the range of 17.64 to 200 mg 100 g^{-1}.

Key words: Intermediate moisture (IM) pineapple, Organoleptic, Physico-chemical.

INTRODUCTION

Pineapple [*Ananas comosus* (L.) Merr.] belongs to the family Bromeliaceae and is widely cultivated in the tropical regions of the world. Pineapple is ranked sixth in global fruit production. Pineapple production in India stands at 1.79 million tonnes with a productivity of 16.83 tonnes per hectare (NHB, 2020). India produces more than 8% of total output of pineapple (Nazaneen *et al*. 2017). Being a commercial fruit of the south Indian State of Kerala, pineapple is produced round the year and therefore, market gluts are very common and post harvest losses of around 20-30% are reported. IMF have a water activity between 0.65-0.90 and moisture content of 15-40%, which is a result of a slight thermal treatment, pH reduction, as well as the addition of humectants and preservatives, all placed in the context of hurdle technology for the preservation of food (FAO, 2003).Hence, the present study was undertaken to develop economically viable intermediate moisture fruit slices by evaluating the effect of various osmotic agents and pineapple varieties on the nutritional, sensory and microbial quality of the product.

MATERIALS AND METHODS

Preparation of intermediate moisture pineapple slices

The study was carried out at the College of Agriculture, Vellanikkara (Kerala Agricultural University) during 2020-21. Pineapple varieties 'Mauritius', 'Kew' and 'MD-2' were selected for the study. The fruits were washed and peeled using a sharp stainless steel knife, after removal of the crown. Peeled fruits were washed in fresh tap water and subsequently, eyes on the surface of the peeled fruit were removed. The hard core of the fruit was removed using a stainless steel pineapple corer. These fruits were then sliced into rings of 2.0 cm thickness, followed by steam blanching for 2 minutes. The blanched slices were subsequently cooled in fresh tap water for 10 minutes, followed by immersion in osmotic solutions (fruit : solution ratio of 1: 4), containing six different osmotic agents separately, in combination with 0.5% ascorbic acid and 0.25% potassium metabisulphite, for six hours. The fruit slices were then drained of the osmotic solution followed by adsorption of excess solution with a bloating paper, and were subsequently dehydrated at 50°C in a tray dryer. The moisture content was constantly monitored throughout the drying process, until it remained constant between two successive hours. The experiment consisted of six treatments *viz*. T_1- Sucrose (60° Brix+0.5% ascorbic acid+0.25% potassium metabisulphite), T_2- Sucrose+sorbitol (1:1) (60° Brix+0.5% ascorbic acid+0.25% potassium metabisulphite), T_3- Glucose syrup (60° Brix+ 0.5% ascorbic acid+0.25% potassium metabisulphite), T_4- Sucrose+0.5% sodium chloride (60°Brix+0.5% ascorbic

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acid+0.25% potassium metabisulphite), T_5-Palm sugar (concentrated product of sap from the palm, *Borassus* sp) (60°Brix+0.5% ascorbic acid+0.25% potassium metabisulphite), T_6- Honey (60°Brix+0.5% ascorbic acid+ 0.25% potassium metabisulphite).

Physico-chemical and organoleptic quality characteristics

The moisture content was determined by an infra-red moisture analyser (HallmarkMechatronics, Model-Sartorius, MA 150C, Germany). Water activityvalues were obtained directly from a digital output (Aqua lab, Model- Pre 40412, Decagon Devices, USA). Colour values (L,* a* and b*) were determined by reflectance measurement, with a Minolta CM-3600D spectrophotometer (Konica Minolta Sensing, Inc., Osaka, Japan). Determination of ascorbic acid was done as per the method of AOAC (1998). Fresh and IM pineapple were evaluated by 25 non-trained panelists for appearance, colour, flavour, taste, aroma, texture and overall acceptability on a nine point hedonic scale (Lawless and Heymann, 2003). Kruskal-Wallis test was done to determine the significant difference between treatments. The experiment was repeated thrice and three replicates were taken for testing each quality parameter. The data was expressed on the basis of Mean and Standard Deviation (SD). A two-way analysis of variance (ANOVA) was conducted using completely randomised design (CRD) to arrive at the influence of osmotic solutions and dehydration on pineapple varieties in the development of intermediate moisture slices.

RESULTS AND DISCUSSION

Physico-chemical composition of pineapple varieties

Pineapple varieties MD-2, Mauritius and Kew varied significantly in all the chemical parameters (Table 1). Total soluble solids varied between 14. 4 in Kew and 17.4° Brix in MD-2. Moisture content and water activity values of pineapple varieties did not vary significantly. Lowest moisture content (84%) was recorded in the varieties MD-2 and 'Mauritius', while it was 87 in Kew. Similar values for moisture content were reported by (Nazaneen *et al*. 2017) and (Surabhi *et al*. 2007) in pineapple varieties. Water activity value of all three varieties was 0.99. The varieties Mauritius and Kew had the same titratable acidity of 0.38%, while it was 0.64 in MD-2. Acidity in the range of 0.6 to 1.2% and TSS content of 12 to 16°Brix were reported in the varieties, Kew and Queen respectively (Surabhi *et al*. 2007). The variety Mauritius had the highest ascorbic acid content of 28.0 mg100 g^{-1}. The chemical composition of fruits in general depends on the genotype, environmental factors and cultural practices followed during the growing period. Organoleptic evaluation of fresh fruits of the three varieties showed no significant difference with respect to any of the sensory attributes except colour (Table 1). However, the variety 'MD-2' had the highest organoleptic score of 7.68. Organoleptic quality of fresh fruits involves human sense organs and the perception of flavour and texture by an individual is a complex process, which varies from individual to individual.

Physico-chemical and organoleptic characteristics of IM pineapple slices

Moisture content

Moisture content of food is negatively correlated to shelf life. IM pineapple slices had moisture content in the range of 19.42 to 29.71% (Table 2). The lowest moisture content of 19.42% was recorded in the slices of the variety 'MD-2' pre-treated with glucose syrup (T_3) and the highest (29.71) in the slices of the variety 'Mauritius' immersed in honey (T_6). Reduction in moisture content of the product was due to the osmotic effect wherein diffusion of water occurred from the fruit tissue into the solution, induced by the higher osmotic pressure of the hypertonic solution. The reduction in moisture content was further compounded by dehydration at 50°C, which resulted in significant moisture loss compared to the fresh slices. Similar findings were reported by Sagar and Kumar (2007) inosmotically dehydrated guava slices immersed in sugar syrup (60°B), followed by dehydration at 60°C. Saxena *et al* (2009) reported a moisture content of

Table 1: Physico-chemical characteristics and organoleptic quality of pineapple varieties.

Varieties	Moisture content	Water activity	Colour values			TSS	Acidity	Ascorbic acid
			L* value	a* value	b* value	(°Brix)	(%)	(mg 100^{-1})
MD-2	84.00	0.99	15.58	4.22	20.43	17.40	0.64	16
Mauritius	84.00	1.00	7.95	1.63	11.86	17.20	0.38	28
Kew	86.00	0.99	13.47	1.27	15.24	14.40	0.38	16
SE (±m)	0.58	0.01	0.58	0.58	0.58	0.06	-	0.58
C.D	N/A	N/A	2.04	2.04	2.04	0.20	0.02	2.00

Varieties	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability
MD -2	7.41 (38.16)	7.59 (39.54)	7.41 (37.68)	7.36 (36.36)	7.27 (40.07)	7.63 (38.50)	7.41 (38.98)	7.68 (39.00)
Mauritius	7.32 (35.45)	7.50 (39.82)	7.32 (36.02)	7.04 (30.48)	6.95 (33.48)	7.50 (36.23)	7.27 (35.57)	7.41 (33.72)
Kew	6.86 (26.89)	6.41 (21.14)	6.82 (26.79)	7.23 (33.66)	6.64 (26.95)	6.68 (25.77)	6.59 (25.95)	7.09 (27.72)
K W value	4.64	15.01	4.55	1.21	5.68	5.93	5.93	4.20

$\lambda^2 = 5.99$ (2, 0.05)

Table 2: Moisture (%), water activity (a_w) and colour values (L*, a*, b*) of intermediate moisture pineapple slices (*MD: MD-2, *M: Mauritius, *K: Kew).

Treatments	Moisture (%)			Water activity			L* value			a* value			b* value		
	MD*	M*	K*	MD*	M*	K*	MD*	M*	K*	MD*	M*	K*	MD*	M*	K*
T_1	21.46	21.05	24.09	0.61	0.60	0.72	26.74	20.48	28.18	4.04	3.57	4.55	14.28	11.43	14.57
T_2	22.86	21.67	26.56	0.65	0.67	0.67	19.13	12.77	36.38	3.42	1.57	2.94	10.36	6.87	14.22
T_3	19.42	23.48	19.81	0.72	0.65	0.73	19.13	9.99	24.15	3.42	2.41	4.07	10.36	6.27	12.22
T_4	22.07	26.64	26.18	0.70	0.63	0.67	19.13	15.31	22.63	3.42	2.41	3.28	10.36	8.52	10.67
T_5	22.83	23.96	28.26	0.67	0.71	0.64	15.15	15.54	22.39	3.01	2.5	3.28	9.02	8.65	11.46
T_6	25.71	29.71	27.89	0.61	0.67	0.71	15.44	15.54	22.59	3.19	2.5	4.14	9.25	8.65	12.29
SE (± m)		0.58			0.01			0.58			0.58			0.58	
C.D Factor (A)		0.68			0.01			0.68			0.68			0.68	
C.D Factor (B)		0.96			0.01			0.96			-			0.96	
C.D Factor (A × B)		1.66			0.02			1.66			-			1.66	

37% in IM pineapple immersed in 70°B sucrose solution for 16 hours, followed by dehydration. Lowest moisture content in the slices immersed in glucose syrup may be due to the higher viscosity which might have resulted in higher diffusion of water from the fruit tissue into viscous hypertonic solution of glucose syrup. Higher moisture content in the slices treated with honey may be due lower rates of diffusion of water from the fruit tissue into honey as fructose and glucose being predominant sugars in honey, which have lower molecular weight, might have resulted in less diffusion of water from the fruit tissue.

Water activity

Spoilage of food is considerably influenced by its water activity, which ultimately determines the shelf life. Water activity of IM pineapple slices ranged between 0.60 and 0.73 (Table 2). The lowest water activity (0.60) was recorded in the slices of the variety 'Mauritius' immersed in sucrose and the highest (0.73) in the samples of the variety 'Kew' treated with glucose syrup. IM slices of varieties MD-2 and Kew treated with glucose syrup retained higher water activity. Reduction in water activity of IM slices may be due to partial removal of water during osmosis and subsequent decline to a greater extent by dehydration at 50°C. Higher reduction in water activity in the slices of the variety 'Mauritius' treated with sucrose (T_1) may be due to its higher molecular weight (342.3 g/ mol) which may have resulted in higher loss of water from the fruit tissue in this variety. Higher water activity in the slices of the varieties MD-2 and Kew immersed in glucose syrup may be due to the lower molecular weight (180.16g/mol). Low molecular weight solute (glucose) leads to higher water loss and solids uptake than higher molecular weight solute (sucrose) of osmotic dehydrated fruits of apple, banana and kiwi (Panagiotou *et al*. 1999). However, the present investigation proved that water activity was not linked to water content of the product. Naknaen *et al* (2016) also reported water activity values in the range of 0.60 to 0.65 in osmo-dried cantaloupe. They also opined that two products with similar water content could have different water activity. Ahmad Din *et al* (2019) reported a_w values in the range of 0.4 to 0.7 in IM muskmelon chunks. Azoubel *et al* (2009) observed that the a_w of osmotic dehydration of cashew apple pre-treated with sucrose and corn syrup varied from 0.370 to 0.718. Minimum value of a_w was attained for sweet potato slices at a drying temperature of 75°C and sugar concentration of 60°Brix (Singh *et al*, 2014).

Colour measurement

Decline in L* and b* values with a corresponding increase in a* value was observed in IM slices, which indicates the non-enzymatic browning in IM slices (Table 2). Decline in L* and b* values were minimum in IM slices of the variety 'Mauritius' immersed in glucose syrup, which were 9.99 and 6.27 respectively, while decline in a* value was minimum in all the treatments of the same variety. The decline was lowest in the slices of the variety 'Mauritius' with respect to lightness, yellowness and redness. Slices immersed in glucose syrup retained better L* and b* values, while a* was better in the slices treated with sucrose and sorbitol. Better colour values in the slices of the variety' Mauritius' may be due to the initial better values in this variety and immersion in glucose syrup may have acted as protective barrier in retaining colour during dehydration. Decrease in L* value and increase in a* was reported by Naknaen *et al*., (2016) in osmo-dried cantaloupe. Similar findings were also reported by Ahmed Din *et al*., (2019) in muskmelon chunks and also by Saxena *et al*. (2009) in pineapple chunks.

Ascorbic acid (vitamin C)

IM pineapple slices had higher vitamin C content compared to fresh fruits and its content showed significant variation among treatments which ranged between 17.64 and 200 mg100 g^{-1} (Fig 1). Highest ascorbic acid content of 200 mg was obtained in the slices of the variety MD-2 immersed in the osmotic solution containing sucrose and sodium chloride (T_4), which was significantly higher than all other treatments. Addition of ascorbic acid to the osmotic solutions might have compensated its degradation due to leaching during osmosis and subsequent dehydration. Further, being a strong antioxidant, addition of NaCl to the osmotic solution might have retarded the oxidative degradation of ascorbic acid during dehydration. Lowest ascorbic acid content (17.64 mg100 g^{-1}) in the slices immersed in honey might be due to the greater leaching effect during osmosis, followed by dehydration. The results revealed that addition of NaCl to sucrose in combination with added ascorbic acid resulted in higher retention of this vitamin even after osmosis and subsequent dehydration. However, this finding is in contradiction to those reported by Surabhi *et al* (2007), wherein lower ascorbic acid retention was seen in osmo-dehydrated pineapple rings. However, lower ascorbic acid content in osmo-dehydrated pineapple (25.77) was reported by Nazaneen *et al* (2017) than that of fresh fruit (33.57 mg100 g^{-1}), in which extra ascorbic acid was not added to osmotic solution.

Organoleptic quality

Organoleptic quality of IM slices showed significant difference with regard to the various quality attributes as well as treatments (Plate 1, Table 3). Pineapple slices immersed in sucrose and sorbitol (T_2) recorded the highest overall acceptability score in all the three varieties. Among varieties, MD-2 recorded the highest overall acceptability of 8.0 and it was 7.93 for both the varieties 'Mauritius' and Kew. The results revealed that the overall acceptability of IM pineapple slices improved compared to the fresh fruit samples, in all the varieties. Higher organoleptic score for the product from the variety MD-2 may be due to its initial higher score of the fresh sample. Further, higher organoleptic score for slices immersed in the combination treatment of sucrose and sorbitol in all the three varieties may be due to the soft texture imparted by the partial replacement of sucrose with the polyol, sorbitol. Further, sorbitol also has

Table 3: Organoleptic quality of intermediate moisture pineapple slices (*MD: MD-2, *M: Mauritius, *K: Kew)

Treatments	Appearance			Colour			Flavour			Texture			Odour			Taste			After taste			Overall acceptability		
	MD*	M*	K*	MD	M	K	MD -2	M	K	MD -2	M	K	MD -2	M	K	MD -2	M	K	MD -2	M	K	MD -2	M	K
T_1	7.20	6.93	6.93	7.47	6.80	6.80	7.27	6.60	6.60	7.33	6.80	6.80	7.33	6.73	6.73	7.27	7.20	7.20	7.00	6.80	6.80	7.53	7.13	7.13
T_2	8.20	8.07	8.07	8.13	8.07	8.07	7.73	7.53	7.53	7.60	7.67	7.67	7.80	7.67	7.67	8.00	8.00	8.00	7.53	7.80	7.80	8.00	7.93	7.93
T_3	6.87	6.93	6.93	6.73	6.73	6.73	6.80	6.20	6.20	6.87	6.60	6.60	6.73	6.27	6.27	6.80	6.53	6.53	6.53	6.53	6.53	6.67	6.53	6.53
T_4	7.07	7.20	7.20	7.40	7.20	7.20	7.40	7.13	7.13	7.20	7.20	7.20	7.13	6.80	6.80	7.20	7.33	7.33	7.00	7.13	7.13	7.40	7.27	7.27
T_5	5.53	4.67	4.67	5.60	4.80	4.80	5.47	5.00	5.00	5.73	5.20	5.20	5.47	5.20	5.20	5.47	5.07	5.07	5.40	5.13	5.13	5.40	5.13	5.13
T_6	6.67	6.53	6.53	6.73	6.67	6.67	7.07	6.47	6.47	7.00	6.67	6.67	7.13	6.47	6.47	7.00	6.73	6.73	7.07	6.80	6.80	7.13	6.87	6.87
K W value	32.07	35.22	18.36	33.19	33.94	22.23	21.30	22.98	26.39	15.35	21.31	24.47	24.31	24.61	15.33	26.43	31.20	35.04	18.90	24.90	33.69	29.30	27.98	29.85

λ^2 = 11.07 (5, 0.05)

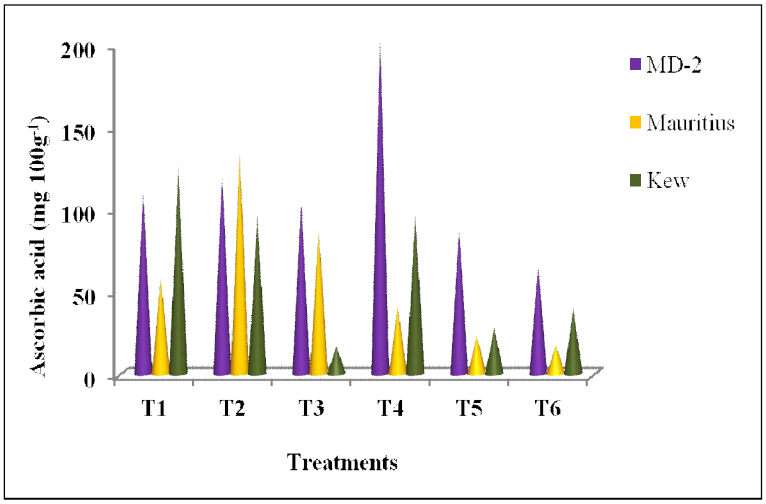

Fig 1: Ascorbic acid (mg 100^{-1} g) content of intermediate moisture pineapple slices.

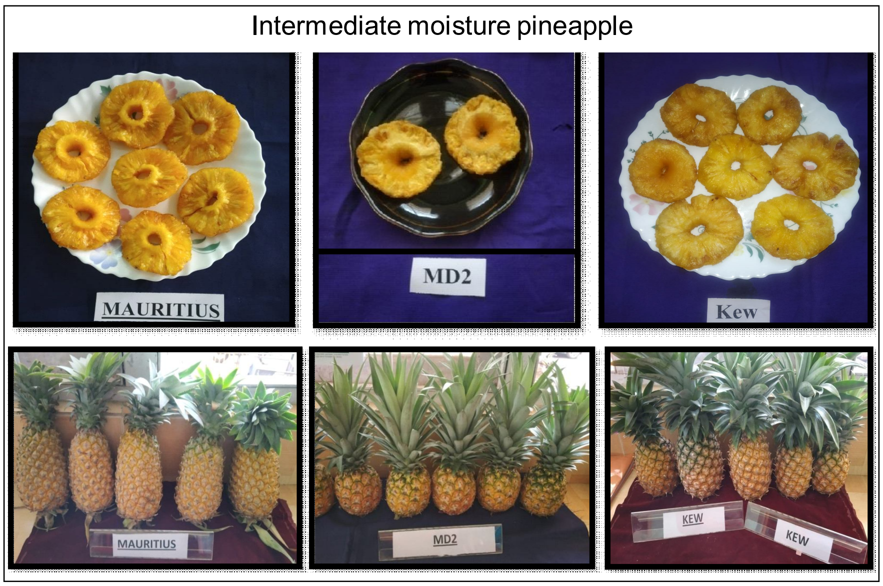

Plate 1: Intermediate moisture pineapple developed from cultivars Mauritius, MD-2 and Kew.

the additional property of retaining water in the bound form. An increase in the amount of sorbitol in the sucrose-sorbitol mixture caused a decrease in the hardness of osmo-dried cantaloupe (Naknaen *et al*. 2016). Significant reduction in hardness was reported in sorbitol treated osmotically dehydrated apple slices (Chauhan *et al*. 2011). Sucrose solution at 60°B at 50°C dehydration temperature in a tray drier showed better organoleptic quality in pineapple slices (Chaudhary *et. al*, 2019).

CONCLUSION

The technology adopted helped in better retention of nutritional compounds along with significant reduction in water activity and moisture content. The product had higher organoleptic scores than the fresh fruit and sucrose+sorbitol mixture was the best osmotic agent in terms of organoleptic properties. The variety MD-2 had higher sensory scores compared to Kew and 'Mauritius' in the fresh as well as in the final product.

Conflict of interest: None.

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