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Quality variation in tamarind (*Tamarindus indica* L.) pulp during storage

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Abstract: The tamarind pulp subjected to various treatments were assessed for their quality parameters during storage for a period of one year. Among the packaging materials assessed, deterioration in the pulp packed in aluminium foil was slow when ompared to polyethylene bags of 200, 300 and 800 gauge, 200 gauge polypropylene ag, porcelain and plastic container and mud pot packaging. The low (0.2569 OD) ptical density was recorded in pulp packed in aluminium foil, while in the conventional nud pot, the optical density was 0.3111 on 360th day of storage with acceptable quality. among the additive treatments, sulphur 0.2 per cent and ascorbic acid 5.0 per cent reated pulp recorded a low optical density of 0.2600 OD value, while the pulp without ny treatment recorded 0.3050 OD value. Sodium chloride 10.0 per cent treated pulp ecorded low (16.60 per cent) acidity while it was higher in ascorbic acid treated pulp, and in control it was 17.20 per cent. The pulp subjected to two types of sealing vacuum sealing and normal sealing) and storage temperatures (refrigerated at 4±2°C and ambient at 25±2°C) revealed that the pulp packed under vacuum sealing and stored under refrigerated temperature retained the brown colour (0.2540 OD value) upto 330 lays of storage. Variations in other biochemical parameters from the initial values vere non-significant during the period of storage. The comparative analysis of the esults obtained indicated that vacuum packing of the pulp and storage under refrigerated condition could be adopted for extended storage stability and for export market. Under ndian conditions, using the aluminium foil as packing material for tamarind pulp vas found economical and feasible for the poor tamarind growers which could also naintain good quality of pulp even under prolonged storage period.

Key words: Tamarind pulp, Post-harvest deterioration, Packaging, Additives, Vacuum sealing.

Introduction

The fruit pulp is the chief agent for souring curries, sauces, chutneys and certain beverages throughout the greater part of India. It is a common article of trade and is preserved and stored for marketing in a number of ways. Tamarind has many problems associated with quality parameters owing to high moisture level, seed, fibre and rind contents. Tamarind is adulterated with foreign matter, which are organic and inorganic in nature. However, the quality of the stocks gets deteriorated after one or two months on account of faster discolouration and also due to moisture at the time of packing. Quality deterioration is considered due to poor post-harvest management practices including processing (George and Rao, 1997). Tamarind crop has a biennial bearing habit with a lean year followed by two fairly good crop. If the pulp could be stored without deterioration in colour and quality, it will help the grower to get better price in the market during the lean year. Since there is great potential for the export of tamarind from India, research on the post-harvest quality parameter and improvement in the post-harvest practices needs to be studied in detail and methodology standardised to process, pack and store tamarind without deterioration in the quality and colour of the pulp. Hence, this study on the prevention of post harvest deterioration of tamarind pulp was taken up at the Department of Spices and Plantation Crops, Horticulture College and Research Institute, TamilNadu Agricultural University, Coimbatore.

Materials and Methods

The fruits of tamarind are harvested when they were fully matured, ripe and fell from the tree on shaking. The pods were harvested

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by shaking the branches of the tree and not by beating the pods. Beating the pods with sticks at the time of harvest will cause injury to the shell of the fruit and lead to contamination of the fruit pulp when they fall on the ground. The fruits harvested were allowed to dry under sunlight for three days continuously till the shells become brittle and easy to separate. The shell or the outer skin of the pod was separated by placing the fruits on a hard surface and beating them with a stick. The deshelled and deveined fruits were dried for one day under direct sunlight and were utilized for the trial. Subsequently, the seeds and fibres were separated. Pulp 100 g. was weighed and packed in 200 gauge polyethylene bags. Twelve sets were prepared and stored.

The biochemical constituents of the pulp were assessed at the beginning of the experiment and subsequently at 30 days interval. Moisture, titrable acidity, protein, total soluble solids, total sugars, reducing sugars, and proteins were estimated by standard methods as outlined in AOAC (1960). The degree of browning of the samples was measured as follows. Two g of sample was extracted thoroughly with 60 per cent of hot alcohol and made upto 100 ml after centrifuging. The absorbancy of supernatant was measured at 440 nm wave length in a spectronic 20 colorimeter using 60 per cent alcohol as blank and expressed as optical density values (Ranganna, 1977).

Experiment-1

One hundred g of pulp was weighed using a digital electronic balance and utilised. The treatments were as follows: P1-Fruit pulp packed in 200 gauge polyethylene bag; P2-Fruit pulp packed in 300 gauge polyethylene bag; P3-Fruit pulp packed in 800 gauge polyethylene bag; P4-Fruit pulp packed in 200 gauge polypropylene bag; P5-Fruit pulp packed in aluminium foil; P6-Fruit pulp packed in plastic gunny; P7-Fruit pulp packed in plastic container; P8-Fruit pulp packed in porcelain container and P9-Fruit pulp packed in mud pots (Control). The design adopted was CRD with three replications.

Experiment-2

Fruit pulp of 100 g was spread as a thin layer manually on the surface of a clean plastic sheet spread on top of a table. Additives were weighed based on the treatment schedule and mixed thoroughly. Pulp was made into a ball and packed in 200 - gauge polyethylene bag. The bags were sealed using pedal operated AERMEC sealing machine. Treatments involved were: A1-Fruit pulp alone (Control); A2-Fruit pulp + Sodium chloride 10.0 per cent (common salt); A3-Fruit pulp + Tocopherol 5.0 per cent; A4-Fruit pulp + Ascorbic acid 5.0 per cent; A5-Fruit pulp + Butylated Hydroxy Anisole 0.02 per cent ; A6-Fruit pulp + Gingelly oil 5.0 per cent and A7-Fruit pulp treated with sulphur fumes (0.2 per cent). The design adopted was CRD with three replications.

Experiment-3

Fruit pulp of 100 g was weighed in the bags. Vacuum packaging was done using the Sevena's quick seal vacuum packaging - cum gas flushing machine of Qs 400 VSC model. Normal packing was done using the AERMEC pedal operated sealing machine. Three-factor completely randomized design with two replications was adopted. The Treatment details are : Main factor - Type of packing (V) : V1 - Vacuum packing. V2 - Normal packing ; Sub-factor - Storage temperature (A) : A1 - Storage under refrigerated condition (4±2°C), A2 - Storage under ambient condition (25±2°C) ; Sub - sub factor : Period of storage (M).

Results and Discussion

Tamarind pulp packed in aluminium foil possessed a lighter brown colour with an OD value of 0.2665 on 360th day of storage (Table 1) while the samples packed in the conventional method (in mud pots) were the darkest and recorded an OD value of 0.3885. Pulp of tamarind treated with sulphur 0.2 per cent and ascorbic acid 5.0 per cent treated pulp registered lesser mean OD value (0.2600) and was less dark (light brown) among the various additive treatments while the control exhibited 0.2658 OD value. The OD value of the samples packed under vacuum and stored under refrigerated conditions and ambient conditions ranged between 0.2510 and 0.2540; however, the OD values were on par upto 330 days in the sample stored under refrigeration while the OD values 'able 1. Quality variation of Tamarind pulp on 360th day of storage.

'articulars		Optical Density	Moisture (%)	Total Sugars (%)	Red. Sugars (%)	Activity (%)	Protein (mg/g)
;xpt.1	P1	0.3050	20.26	27.31	22.60	17.20	19.01
	P2	0.3050	20.21	27.56	26.38	17.18	19.10
	P3	0.2680	20.14	30.47	26.56	16.74	19.12
	P4	0.2920	20.13	30.22	26.71	16.87	19.55
	P5	0.2665	20.11	35.08	25.34	16.81	18.95
	P6	0.3225	20.57	25.72	28.56	17.34	19.35
	P7	0.2795	20.99	27.84	28.66	16.76	19.30
	P8	0.3405	20.20	33.85	28.51	17.01	19.55
	P9	0.3885	21.42	30.78	25.68	17.42	19.65
;xpt.2	A1	03050	20.26	27.31	27.50	17.20	19.35
	A2	0.3115	20.28	27.31	28.06	16.60	19.25
	A3	0.3050	20.29	27.31	28.24	17.16	19.25
	A4	0.3125	20.26	27.29	28.43	17.29	19.35
	A5	0.3110	20.29	27.31	28.60	17.03	19.35
	A6	0.3050	20.29	27.33	28.11	16.86	19.30
	A7	0.2730	20.06	27.30	28.13	16.81	19.25
;xpt.3	V1A1	0.2550	16.48	34.69	27.06	17.40	18.65
	V2A1	0.2575	16.75	30.93	26.56	17.43	19.30
	V2A2	0.2795	16.74	30.43	26.56	17.08	19.40

Table 2. Analysis of Variance

Particulars	Optical Density	Moisture (%)	Total Sugars (%)	Red. Sugars (%)	Activity (%)	Protein (mg/g)
Expt.1						
SE	0.0018	0.0181	0.2835	0.1018	0.0099	0.0279
CD(5%)	0.0035	0.0359	0.5620	0.2018	0.0195	0.0553
CD(1%)	00047	0.0475	0.7437	0.2670	0.0259	0.0731
Expt.2						
SE	0.0020	0.0061	0.0522	0.0279	0.0117	0.0362
CD(5%)	0.0039	0.0121	0.1038	0.0555	0.0233	0.0719
CD(1%)	0.0052	0.0160	0.1375	0.0735	0.0309	0.0953
Expt.3						
SE	0.0004	0.0027	0.0142	0.0079	0.0084	0.0259
CD(5%)	0.0007	0.0055	0.0286	0.0160	0.0168	0.0520
CD(1%)	0.0010	0.0073	0.0382	0.0213	0.0224	0.0694

were on par upto 240 days only when stored under ambient conditions.

Lower gauge polyethylene bags were more transparent than higher gauge polyethylene bags through which light penetration was aided. The availability of oxygen from atmospheric air and energy from light rays could have accelerated the browning reaction. Fruit pulp packed in polypropylene bags of 200 gauge was darker than the pulp packed in polyethylene bag of 800 gauge (Fig. 1). The polypropylene bags are glossy and highly transparent in nature. Owing to this, the penetration of light rays inside the polypropylene bags must have aided in the darkening of pulp. This finding is in corroboration to the earlier works obtained by Bolin *et al.* (1964) who recorded browning in fruits when exposed to light. The darkening of the pulp when packed in plastic gunny bags was higher, the variation from the initial value being 29 per cent. The colour development in plastic gunny might be attributed to the free passage of atmospheric air and moisture, aiding the oxidation of phenols, which causes discolouration.

It was observed that the pulp treated with sulphur 0.2% retained a light brown colouration (0.2730 OD value) (Fig. 2) indicating better storage stability. The pulp treated with ascorbic acid was darker (0.3125 OD value) closely followed by sodium chloride 10% treatment (0.3125 OD value). The present work deviated from that of Anon (1972), who demonstrated retardation of enzymatic browning in peaches using one per cent ascorbic acid and 0.25% malic acid dip. Kanner and Budowski (1978) observed that the prooxidant activity of ascorbic acid at intermediate A_w (water activity) increased the antioxidant activity at higher concentrations. Tamarind pulp expressed intermediate moisture content that could have pushed the prooxidant activity of ascorbic acid to the forefront, which might have permitted the oxidative degradation of the pulp causing discolouration.

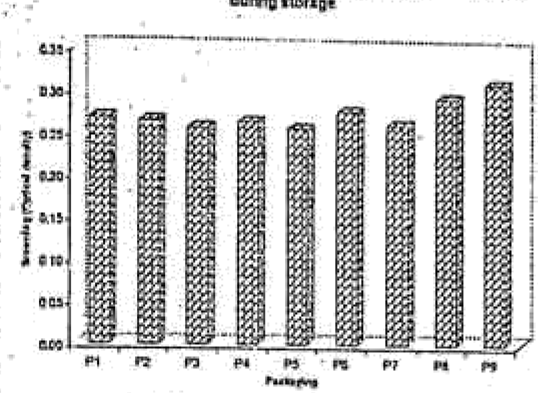
The interaction between type of sealing and storage temperature was highly beneficial for the colour retention and the OD value ranged between 0.2510 and 0.2540 upto 330 days of storage (Fig.3 & 4). Non availability of oxygen (under vacuum condition) and low temperature 4+2°C would have prevented both enzymatic and non-enzymatic oxidation process which ought have slowed down the darkening. Work of Lee and Nagy (1988) is supportive to the current study, who reported higher temperature favoured the accumulation of 5-hydroxy methyl furfural (HMF), potential polymer building block and a precursor of browning.

Considering the moisture absorbtion of the pulp when packed in 200 gauge polyethylene and polypropylene bags, the moisture absorbtion was more in pulp packed in polyethylene bags. The water vapour transmission rate was reported to be higher in polyethylene films (18 g/24 h/sq.m) and low in polypropylene films (8-10 g/24 h/sq.m) by Athalye (1992). The observation obtained in the current study could be justified due to the phenomenon narrated by Athalye. The variation in absorbtion could be accounted by the water vapour resistance property of packaging materials. The pulp stored in porcelain container also absorbed moisture during the period of storage. The absorption of moisture could have been facilitated from moisture present in the head space present in the container. Moisture content of the pulp packed in mud pots was more when the various packings were considered. A similar observation have been reported by Ramakumar *et al.* (1997) in tamarind pulp packed in bamboo and pheolnix mats wherein weight gain upto 7.16 per cent was observed.

The moisture content of the vacuum sealed pulp was lesser than the pulp sealed under normal condition. The pulp present in normally sealed packing might have absorbed the moisture that was present inside the packing. In the current study, the moisture absorption of the pulp at ambient temperature and refrigerated storage was not remarkable. This ought to be due to the packing of the pulp in 800 gauge polyethylene with very low vapour transmission rate. Vacuum packed pulp stored under refrigeration recorded negligible absorption of water.

The per cent increase in the acidity of the pulp when packed in higher gauge polyethylene

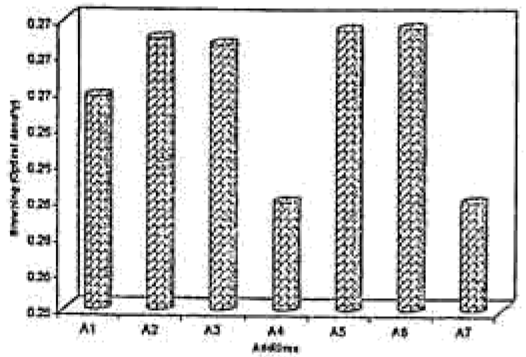
Fig.1. Influence of packaging materials on browning of tamarind pulp during storage



Legend

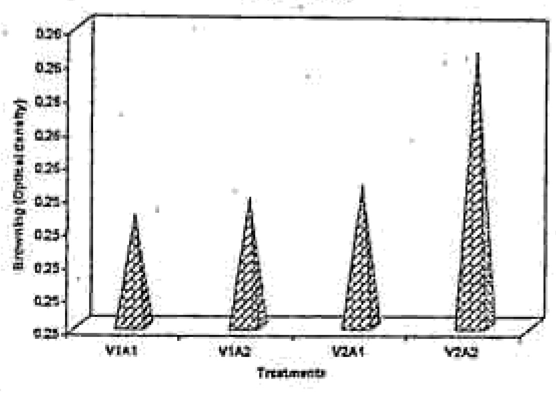
P1	Fruit pulp packed in 200 gauge polyethylene bag
P2	Fruit pulp packed in 300 gauge polyethylene bag
P3	Fruit pulp packed in 800 gauge polyethylene bag
P4	Fruit pulp packed in 200 gauge polypropylene bag
P5	Fruit pulp packed in aluminium foil
P6	Fruit pulp packed in plastic gunny
P7	Fruit pulp packed in plastic container
P8	Fruit pulp packed in porcelain container
P9	Fruit pulp packed in mud pots (Control)

Fig.2. Influence of additives on browning of tamarind pulp during storage



A1	Fruit pulp alone packed in 200-gauge polyethylene bag (Control)
A2	Fruit pulp + Sodium chloride 10.0 per cent (common salt) packed in 200 gauge polyethylene bag
A3	Fruit pulp + Tocopherol 5.0 per cent packed in 200 gauge polyethylene bag
A4	Fruit pulp + Ascorbic acid 5.0 per cent packed in 200 gauge polyethylene bag
A5	Fruit pulp + Butylated Hydroxy Anisole 0.02 per cent packed in 200 gauge polyethylene bag
A6	Fruit pulp + Gingelly oil 5.0 per cent packed in 200 gauge polyethylene bag
A7	Fruit pulp treated with sulphur fumes (0.2 per cent) and packed in 200 gauge polyethylene bag

Fig.3. Effect of sealing and storage temperature on browning of tamarind pulp



Legend

Type of packing (V)

V1 - Vacuum packing

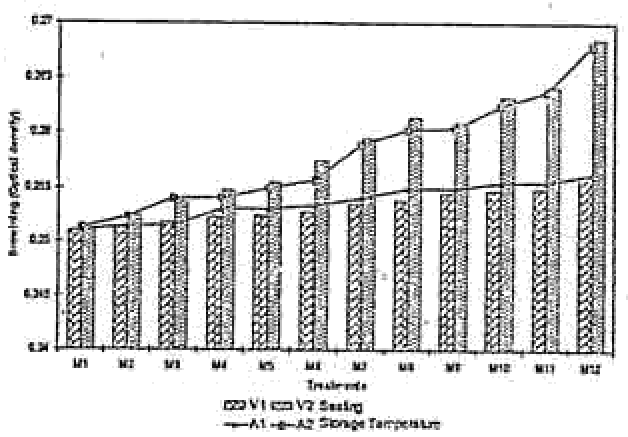
V2 - Normal packing

Storage temperature (A)

A1 - Storage under refrigerated condition (4±2°C)

A2 - Storage under ambient condition (25±2°C)

Fig.4. Variation in the colour of tamarind pulp as influenced by sealing type and storage temperature over a period of one year



bags was less (1.7 per cent) when compared with the pulp packed in lower gauge polyethylene bags. The increase in acidity of the pulp packed in polypropylene bag was also lesser than that of pulp packed in 200 gauge and 300 gauge polyethylene bags. This could be attributed to the barrier properties of the packing materials. The pulp packed in plastic gunny registered 17.34 per cent moisture as against the initial value of 16.46 per cent. The permeability of the plastic gunny would have facilitated the air entry and in turn the oxidation process.

Robertson and Christensen (1996) stated that the enzyme involved in the browning reaction could be irreversibly inactivated at pH values of 3 or less and that could be achieved by the addition of sufficient acidulents such as citric, malic or phosphoric acids. They also opined that browning could be prevented by excluding oxygen from the reaction site or protecting the phenolic substrates. Ascorbic acid treatment of the tamarind pulp increased the acidity of the pulp. This higher acidity might be due to the combined effect of tartaric acid of the pulp and ascorbic acid that was added. The acidity of the pulp increased with the period of storage. The acidity increased at a slow rate when pulp was stored under refrigirated temperature on vacuum realing. The samples when vacuum sealed and stored under refrigeration registered static acidic value than that of sample stored under ambient conditions. This could be attributed to the limitation in the conversion of carbohydrates and proteins in the samples to other fractions leading to acidic by products under vacuum packing, since the air in the head space was evacuated. The absence of oxygen in the micro-environment might have prevented oxidation- reduction reaction and thus prevented accumulation of acidic substances.

Over the period of storage, the total sugar content of the pulp decreased gradually while the reducing sugar content increased. The decrease in the total sugar content of the pulp was higher in the lower gauge polyethylene bags. A reduction of 18.52 per cent was observed in 800 gauge polyethylene bag packing while in 200 gauge packing, the decrease was 26.90 per cent. The polypropylene packing of pulp induced to decrease the total sugars by19.19 per cent in the pulp. The rise and fall in the total and reducing sugar content of the pulp could be postulated due to the degradation of polysaccharides present in the pulp into simple sugars (to galactose, fructose, arabinose, ribose, xylose etc). The greater extent of variation of total sugars and reducing sugars in the pulp packed in permeable materials might be due to the increase in the conversion of polysaccharides because of the availability of Oxygen radical from atmosphere and Hydrogen radical from atmospheric humidity. The oxygen permeability of polyethylene films has been reported to be > 41000 cc/ml/sq.m/24 h while that of polypropylene is > 1300 cc/ml/sq.m/24 h (Athalye, 1992).

The inclusion of additives to the tamarind pulp increased the reducing sugar content of the pulp during storage period. All the additives expressed an equivalent effect. The pulp not treated with any additive recorded gradual increase compared to additive treated ones. The additives might have acted as catalysts or synergist for the conversion of polysaccharides to reducing sugars. The possibility of a reducing sugar as the reactant factor for darkening could be applied at this point of study, wherein the rate of browning was observed to increase with the increase in the reducing sugar content. However, Stadtman (1948) succeeded in proving that both ascorbic acid and reducing sugars are important in the browning reactions by removing reducing sugars from apricot syrup by fermentation and decreased the rate of browning by half and could not prevent the browning; this phenomenon goes hand in hand with the present investigation.

The total sugar content of the pulp at the end of the storage in pulp vacuum sealed and stored under refrigerated condition was higher (34.69%) in comparison to the pulp vacuum sealed and stored at ambient temperature (32.92%). Whereas, the reducing sugar content was lesser (27.38 per cent) in pulp sealed under vacuum and stored under refrigeration than the pulp vacuum sealed and stored under ambient temperature. The presence of higher quantity of reducing sugars might be due to the combined effect of reduced oxygen level at higher temperature. The reduced oxygen level and low temperature might have helped in the maintenance of redox equilibrium.

Pulp packed in 200 gauge polyethylene bags recorded lesser protein content (19.01 mg g^{-1}) while pulp packed in mud pots (Control) showed higher protein content (19.65 kg g^{-1}) on 360th day of storage. A gradual increase in protein content was observed during the period of storage. Variation in the protein content of the pulp was lesser when vacuum sealed and stored under refrigeration; this treatment recorded less protein content of 18.65 kg g^{-1} of pulp. Pulp sealed under normal conditions and stored under ambient temperature registered higher protein content (19.40 mg g^{-1}) on 360th day of storage. The protein content of the pulp increased with the period of storage. The combined treatment of vacuum packing and refrigerated storage recorded negligible increase in protein content during the period of storage. The exclusion of oxygen and low temperature conditions could have inactivated the biochemical processes, which justifies the negligible variation in the constituents when the pulp was vacuum-sealed and stored under refrigeration.

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