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Shelf Life Extension of Minimally Processed Jackfruit (*Artocarpus heterophyllus* Lam.) Portion

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ABSTRACT

Background: In spite of vast potential and usefulness, jackfruit is still an underutilized fruit and more scientific research is needed to exploit it as a commercial fruit crop. Extension of shelf life of minimally processed jackfruit portion with quality could facilitate efficient marketing and transportation resulting in minimizing the post-harvest losses.

Method: Jackfruit portions of mature firm (varikka) and soft (koozha) fleshed types were pre-treated and subjected to seven packaging treatments *viz*., 150 gauge polypropylene with 5% ventilation, cling film wrapping with 15 µ LDPE film, shrink wrapping using 15µ polyolefin film, vacuum packaging in PP/LDPE laminated pouches, MAP in PP/LDPE laminated pouches with $KMnO_{4,}$ MAP in PP/ LDPE laminated pouches with silica gel and an unwrapped sample and stored in refrigerated and ambient conditions.

Result: Vacuum packaging of 200-250 g minimally processed jackfruit portions without spiny rind in laminated pouches of PP/LDPE after pre-treatment with 0.5% KMS and citric acid and storage under refrigeration is recommended as the best treatment for both types. Vacuum packaged firm fleshed portions had 94.54% marketability after 20.33 storage days and soft fleshed had 88.75% marketability after 15.33 days. Minimally processed jackfruit portion provides convenience in transportation and marketing of large and difficult to peel fruits to nuclear family.

Key word: *Artocarpus heterophyllus* Lam, Mature, Minimally processed, Refrigerated storage, Vacuum packaging.

INTRODUCTION

Production of fruits and vegetables is of significance only when they reach the consumer in good condition and at a reasonable price. Due to post-harvest losses, there is a considerable gap between gross production and net availability of fruits to consumers and this loss has been attributed to several factors, among which lack of packaging and storage facilities are the major ones. Hence, there is an urgent need to adopt proper post-harvest management practices including improved packaging techniques. Packaging is one of the most commonly used postharvest practices that puts the produce into unitized volumes which are easy to handle while protecting them from hazards of transportation and storage.

Jackfruit (*Artocarpus heterophyllus* Lam.), is a delicious nutritious tropical fruit available in plenty in Kerala during the month of April-August and its market system is highly unorganized. Selling fruits, cut portions or even bulbs of jackfruit under unhygienic conditions without any package through road side stalls and also by push cart vendors is very common in domestic markets. In Kerala, there are soft fleshed (Koozha) and firm fleshed (Varikka) types. Kerala Government has recently declared jackfruit as Kerala's official fruit; hence the fruit has received attention recently and hence, it is the most appropriate fruit to be studied. In spite of such a vast potential and usefulness, jackfruit has remained as an underutilized fruit species and more scientific research is needed to exploit it as a commercial fruit crop. Developing appropriate packaging technology for shelf-life extension may facilitate quality sale and transportation, thereby minimizing postharvest loss. While investigating the effect of different modified atmosphere packaging techniques for fresh-cut jackfruit bulbs kept under low temperature conditions, Saxena *et al.,* (2008) could get a shelf-life of 35 days when packaged in 3 kPa O_2 + 5 kPa CO_2 (with balance of N_2) gas mixture flushed PE bags. Prathibha *et al*. (2019) reported that pre-treatment with mixture of 1% $CaCl_2$ and 0.25% ascorbic acid and vacuum packing of bulbs resulted in 33 days shelf life. But portion packaging will be a better and convenient option for the nuclear family, where purchase of this largest tree borne fruit will be a mere waste. As studies regarding packaging of jackfruit portions are lacking, an experiment was undertaken at the Department of Postharvest Technology, College of Agriculture, Vellayani during 2020-2021with the objective to standardize portion packaging and storage

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technique for extending shelf life of mature firm fleshed and soft fleshed jackfruit types.

MATERIALS AND METHODS

Good quality jackfruits of uniform size and maturity belonging to mature firm and soft fleshed, free from pests, diseases and mechanical damages were harvested from Instructional Farm, washed thoroughly under running water, outer spiny rind removed, cut into pieces or portions of approximately 200-250 g weight, with the help of stainless steel knife. The portions were treated with 0.5% solution of potassium metabisulphite and citric acid for 10 minutes, drained to remove excess moisture and then subjected to seven different packaging treatments *viz*., T_1: 150 gauge polypropylene cover with 5% ventilation and sealed by using heat sealing machine (with 240 AC volts and 380 WATTS), $T_{2:}$ Cling film wrapping with 15 micron food grade LDPE film using cling film wrapper, $T_{3:}$ Shrink wrapping (polyolefin film of 15 µ) using shrink-wrapping machine with 180°C shrink temperature and 1.5 seconds. shrink time, T_4: Vacuum packaging in transparent PP/LDPE laminated pouches using a vacuum packaging machine with 700 mm HgVacuum, 2.5 seconds sealing time and 9 seconds cooling time,T_5: Modified Atmospheric Packaging (MAP) in transparent PP/LDPE laminated pouches with $KMnO_{4,}$ T_6: Modified Atmospheric Packaging (MAP) in transparent PP/LDPE laminated pouches with silica gel and T_7: Unwrapped (control). In T_5, Jackfruit portions were placed in 180 cm^2 PP/LDPE laminated pouches enclosing 40 cm^2 muslin cloth sachets containing @ 8% ethylene scrubber, $KMnO_4$ in such a way that the contact between jackfruit portions and $KMnO_4$ was avoided and the pouches with $KMnO_4$ sachets were sealed using heat sealing machine so as to form Modified Atmospheric Packaging (MAP). Treatment T_6 was same as T_5, where $KMnO_4$ was replaced by the moisture scavenger, silica gel. All the above seven treatments were subjected to two different storage conditions *viz*., S_1- refrigerated storage and S_2- ambient storage, so as to form 14 treatments with 3 replications in factorial completely randomised design. The same sets of treatments were imposed independently on mature firm fleshed and soft fleshed jackfruit types.

Shelf life, Physiological loss in weight (PLW) and marketability of the portion packed and stored jackfruit samples were recorded. The descriptive quality attributes *viz*., level of decay, colour, firmness, shrivelling and surface defects were assessed subjectively using a 1 to 9 rating scale with 1= unusable; 3= unsalable; 5= good; 7= very good; and 9= excellent, was used to evaluate the marketability. The number of fruits receiving a rating of 5 and above was considered marketable, while those rated less than 5 as unmarketable and marketability was assessed as the percentage of marketable fruits during storage (Mohammed *et al*. 1999).

Sensory parameters like color and texture of the jackfruit bulbs extracted from packaged portions were evaluated on alternate days of storage by conducting organoleptic evaluation by a 30 member semi-trained panel (Amerine *et al*., 1965) using a nine point hedonic scale. Data generated from the experiments were analyzed statistically using factorial completely randomized design. In organoleptic parameters, the scores were analyzed using Kruskall-Wallis by chi square test (Riffenburgh, 2006). Based on the physiological, organoleptic parameters and marketability, the best portion packaging and storage system capable of quality retention of jackfruit portions were selected for the two jackfruit types independently.

RESULTS AND DISCUSSION

Shelf life (days)

Effect of packaging and storage treatments on shelf life of minimally processed jackfruit portion have been shown in Fig 1. There was significant difference among the seven treatments in shelf life of both mature firm fleshed and soft fleshed portions stored under refrigeration and under ambient conditions. The vacuum packed firm fleshed and soft fleshed portions under refrigeration showed the highest shelf life of 20.33 days and 15.33 days, respectively. In both types, vacuum packaged portions had highest shelf life as

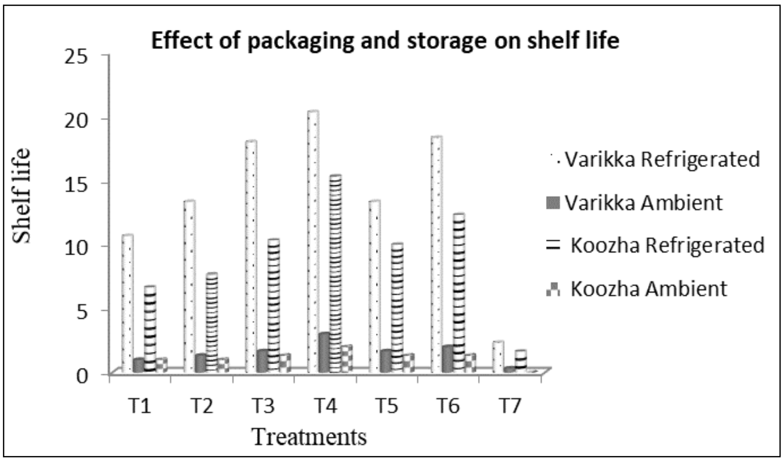

Fig 1: Effect of packaging and storage on shelf life of jack fruit portions.

compared to remaining treatment combinations. Vacuum packaging removes substantial amount of oxygen from the packaging system and reduction in ambient air from the package helps in reduction of deterioration progress (Wiley, 2009). Vacuum packaging of respiring foods is clearly a form of modified atmospheric packaging; by removal of the air, biological action continues to alter or modify the atmosphere inside the package. As a general rule, when the oxygen concentration was decreased, the respiration rate and the storage life were extended. This was followed by portions under Modified Atmospheric Packaging in laminated pouches with silica gel with a shelf life of 18.33 days which was on par with shrink wrapped portions with shelf life of 18.00 days. In soft fleshed type also, portions under MAP with silica gel had 12.33 days shelf life. Least shelf life (2.33 and 1.66 days) was recorded by unwrapped firm and soft fleshed portions under refrigeration. Under ambient conditions, the vacuum packed firm fleshed and soft fleshed portions had the highest shelf life of only 3.00 and 2.00 days, respectively. Under ambient conditions, all unwrapped firm fleshed portions had the least shelf life (0.33 days) and soft fleshed portions were spoilt within a day (0.00 days shelf life).

Physiological loss in weight (%)

Effect of packaging on physiological loss in weight (PLW) of minimally processed jackfruit portions stored under refrigeration is shown in Fig 2a and 2b. The data revealed that the physiological loss in weight increased during storage period for all the portions indicating deterioration at the end of shelf life. Mean physiological loss in weight was least (1.08%) for the firm fleshed portions under vacuum packaging followed by portions packed under MAP with silica gel (1.59%) after 20 days of storage (Fig 2a.). The results of the present study were similar in soft fleshed portions also, where the mean PLW after 15 days was least (1.10%) for portions under vacuum packaging (Fig 2b.) which was followed by portions packed under MAP with silica gel (1.30%) sachet. Highest mean weight loss (16.97 and 15.00%) was recorded by the unwrapped firm and soft fleshed portions. respectively under refrigerated storage. Chemical additives with various modified atmosphere packaging techniques at low temperature conditions was beneficial in reducing decay, maintaining quality and extending the shelf-life of minimally processed jackfruit bulbs (Saxena *et al.,* 2008). Jackfruit portions are also a type of minimally processed products and portions in vacuum had least PLW which is a direct measure of shelf life and quality.

The minimally processed portioned jackfruits under ambient storage were spoilt within 2 days. Under ambient condition mean PLW was least for both fruit types (0.21 for firm fleshed and 0.43% for soft fleshed) after 2 days of storage under vacuum packaging (Fig 3).

Marketability

The effect of packaging on marketability of jackfruit portions is shown in Fig 4 and b. As the ambient storage portions spoilt within three days, marketability could be made only for portions under refrigeration. Both types of jack fruit portions showed reduction in marketability during storage. The vacuum packed firm fleshed portions had high mean marketability of 94.54% after 20 days of storage and soft fleshed had highest marketability of 88.75% after 15 days of storage. Unwrapped firm fleshed portions lost marketability within six days of storage with mean marketability of 13.63% (Fig 4a) and unwrapped soft fleshed portions had lowest marketability of 15.41% (Fig 4b.) Packaging had a significant effect on physiological weight loss, decay percentage, color score, overall acceptability and marketability, as reported by Haile1(2018).

Organoleptic parameters

As the ambient stored minimally processed jackfruit portions were spoilt within three days of storage and hence organoleptic analysis could be made only for refrigerated portions.

Effect of packaging and storage on colour score of minimally processed jackfruit portions is shown in Table 1 and 2. Color score of both types decreased during storage irrespective of packaging materials. Mean color score of firm fleshed was maximum (7.5) for portions packed under vacuum packaging at 20th day of storage followed by

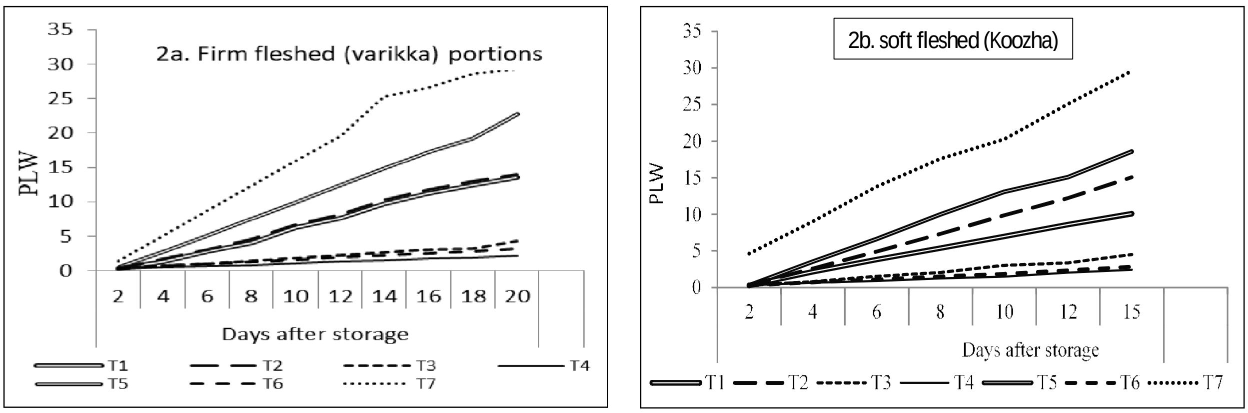

Fig 2: Effect of packaging on PLW of mature jack fruit portions under refrigeration.

portions packed under MAP with silica gel (6.7). Unwrapped jackfruit portions had least (3.1) mean color score on 2nd day of storage (Table 1). Vacuum packed mature soft fleshed portions had maximum (7.1) mean score for colour on 15th day of storage and least (3.2) color score was recorded by the unwrapped jackfruit portions on 2nd day of storage.

Effect of packaging and storage conditions on organoleptic score for texture of minimally processed jackfruit portions, as judged by sensory scoring is shown in Table 1 and 2. Texture scores of all jack fruit types decreased during storage irrespective of packaging materials. Maximum (7.9) mean score for texture was for portioned firm fleshed under vacuum packaging followed by portions under MAP with silica gel (6.1) after 20 days of storage. Least textural score (2.9) was recorded by unwrapped portioned jackfruit (Table 1) on 2nd day of storage. Maximum mean score for texture (6.9) was for soft fleshed portions under vacuum packaging on 15th day of storage and least (3.1) mean score for texture was for unwrapped portioned jackfruit after 2nd day of storage (Table 2).

Effect of packaging and storage on taste of jackfruit portions, as judged by sensory scoring is shown in Tables 1 and 2. The highest (7.5) mean score for taste was for firm fleshed portions under vacuum packaging followed by sample packed under MAP with silica gel (6.7) on 20th day of storage. Unwrapped jackfruit had least mean score (3.1) for taste on 2nd day (Table 1). Maximum (6.8) mean score for taste was recorded by the soft fleshed portions under vacuum packaging on 15 days after storage, whereas least (2.9) mean score for taste was recorded by the unwrapped jackfruit portions after 2nd day of storage (Table 2).

In general, packaging and storage treatments influenced all physiological parameters such as shelf life, PLW and marketabilty of all jack fruit types significantly. Vacuum packed portions stored under refrigeration showed the highest shelf life, least physiological loss in weight (PLW), high marketability and maximum mean rank value for colour, texture and taste in both types of jackfruit portions evaluated. The product under the present study was a type of fresh cut produce or a minimally processed product with high metabolic activity compared to intact whole jackfruit. Gorny *et. al.,* (2000) reported the capability of MAP in lengthening shelf life of several fresh cut horticultural products. Vacuum packaging, a type of modification of atmosphere condition with in the package prolongs the freshness of the product due to reduced concentration of air around the product.

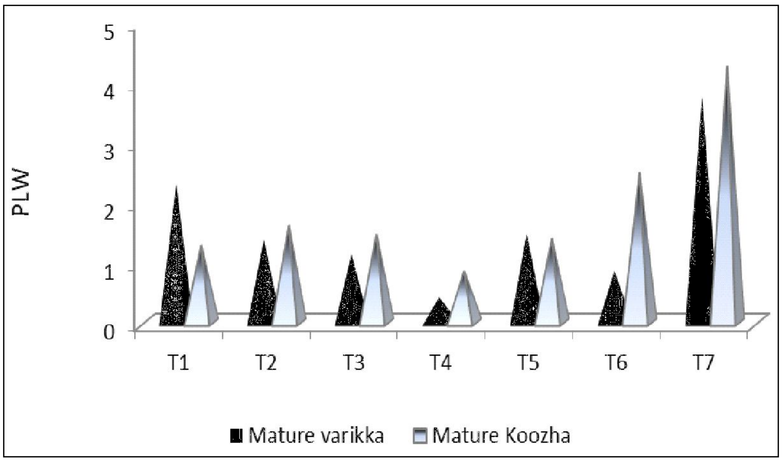

Fig 3: Effect of packaging on PLW of portions under ambient storage.

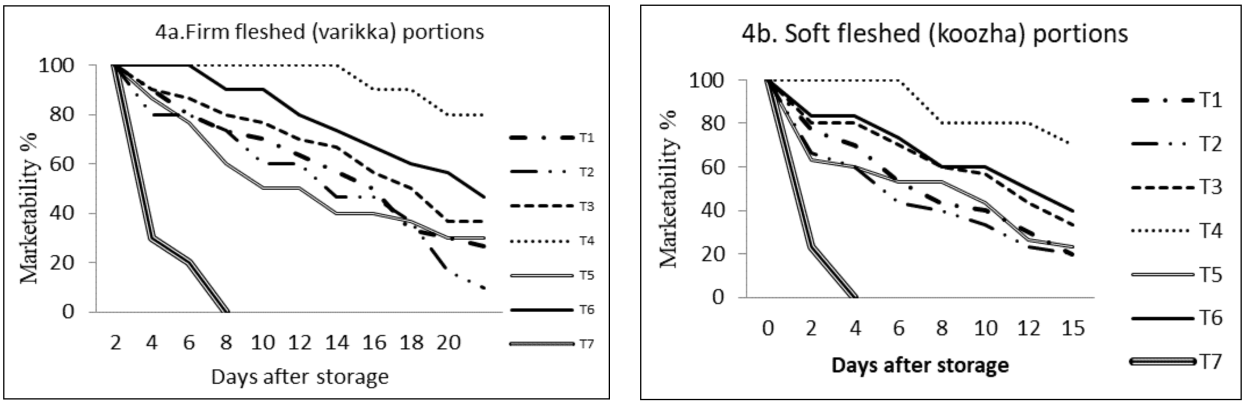

Fig 4: Effect of packaging on marketability of jack fruit portions under refrigeration.

Vacuum packaging, refrigeration and use of laminated pouches had helped in protecting the jack portions from deterioration by extending shelf life with high marketability and overall acceptability.

Silica gel is an approved desiccant or moisture scrubber used in fruit and vegetable packaging, which was kept in the form of moisture absorbing sachet. According to Chauhan *et al.,* (2006) application of moisture scrubber enhanced the shelf life of banana up to 18 days. As a result of respiration of the product, water vapour accumulates inside the package and depending on the product nature; this may bring about undesirable changes such as absorption of surface moisture, generation of liquid water and condensation on the packaging material. The resulting effect on the appearance of the product may lead to rejection by the consumer. As the product under the present experiment is a highly respiring fresh cut commodity, accumulation of liquid water and condensation was high inside the package, which was absorbed by the silica gel, kept inside the package. Desiccants protect sensitive products against water and humidity (Brody *et al*., 2001). Offered in clay, molecular sieve and silica gel forms, they absorb moisture that enters or remains in a package. There was no desiccation of the product as evidenced by reduced PLW.

The portions kept under shrink wrap packaging were also equal to MAP with silica gel. Shrink wrap film maintains high humidity levels reducing water loss from packaged produce and the potential for mould and bacterial growth and spoilage is reduced by the anti- fogging treatment, thus enhancing shelf life of the commodity (John, 2010). The results of present findings are in accordance with reports of Nanda *et al*. (2000) and Dhall *et al.* (2012) who had observed enhanced shelf life of pomegranate and cucumbers, respectively under shrink wrapping.

Cling film used in the present experiment was a LDPE film of 15 micron thickness and wrapping the produce with a low gauge PE film could not give any protection to the product. Though they have low water vapour transmission rate, their gas permeability is high, resulting in permeation of gases through the package film and ultimate damage of the commodity (John, 2010). As the film formed intimate package with the produce, jackfruit portions was fresh looking initially.

Modified atmospheric packaging (MAP) with $KMnO_4$ could not maintain the quality characters of jackfruit portions. Ethylene, a plant hormone produced during the ripening of

Table 1: Effect of packaging on sensory score of minimally processed varikka portions under refrigeration.

Treatments	Mean sensory scores										
	Days after storage										
	0	2	4	6	8	10	12	14	16	18	20
						Colour score					
T_1	9	7.5	7.5	7.2	6.9	6.9	6.5	6.0	5.7	5.1	5.1
T_2	9	7.3	7.3	7.3	7.3	7.1	7.1	6.2	5.8	5.3	5.3
T_3	9	8.3	8.3	8.3	8.1	7.9	7.9	7.2	7.2	6.5	6.5
T_4	9	8.9	8.9	8.9	8.9	8.8	8.6	8.4	8.3	8.1	7.5
T_5	9	5.5	5.5	5.1	5.1	4.5	4.1	4.0	3.9	3.2	3.2
T_6	9	8.4	8.4	8.3	8.3	8.2	7.6	7.2	6.9	6.7	6.7
T_7	9	-	-	-	-	-	-	-	-	-	-
						Taste score					
T_1	9	7.5	7.5	7.2	6.9	6.9	6.5	6.0	5.7	5.1	5.1
T_2	9	7.3	7.3	7.3	7.3	7.1	7.1	6.2	5.8	5.3	5.3
T_3	9	8.3	8.3	8.3	8.1	7.9	7.9	7.2	7.2	6.5	6.5
T_4	9	8.9	8.9	8.9	8.9	8.8	8.6	8.4	8.3	8.1	7.5
T_5	9	5.5	5.5	5.1	5.1	4.5	4.1	4.0	3.9	3.2	3.2
T_6	9	8.4	8.4	8.3	8.3	8.2	7.6	7.2	6.9	6.7	6.7
T_7	9	3.1	-	-	-	-	-	-	-	—	-
						Texture score					
T_1	9	7.8	7.8	7.8	7.5	7.1	7.1	6.1	5.9	4.6	4.6
T_2	9	8	8	7.9	7.7	7.4	7.3	6.4	6.1	4.8	4.8
T_3	9	8.2	8.2	8.2	8.1	7.9	7.4	7.2	6.5	5.9	5.8
T_4	9	9	9	8.9	8.8	8.8	8.8	8.6	8.1	7.9	7.9
T_5	9	5.1	5.0	4.5	4.4	4.3	4.2	3.9	3.5	3.1	3.1
T_6	9	8.4	8.4	8.3	8.2	8.0	7.5	7.3	6.6	6.1	6.1
T_7	9	2.9									
KW value	NA	156.1	156.1	155.7	154.5	153.9	152.9	151.7	146.7	145.8	143.9
χ^2 0.05	12.6	11.07									

fruits and vegetables is responsible for modifying their quality and longevity by increasing respiration rates, softening tissues and accelerating ageing. $KMnO_4$, an ethylene scavenger was used along with the packaging material after enclosing in a sachet. $KMnO_4$ oxidizes ethylene to acetate and ethanol, changing colour from purple to brown. Even though the direct contact between $KMnO_4$ and jack fruit portion was avoided by carefully stapling the $KMnO_4$ sachets with the package, condensation of highly respiring jackfruit portions resulted in spreading of colour inside the package affecting appearance of the commodity and reducing acceptability.

Unwrapped fruit portions lost marketability within 6 days of storage and none of the packaging systems was better in maintaining the physiological quality parameters. Unpacked fruit portions resulted in high moisture loss by being in direct contact with outer environment. This clearly indicates the influence of packaging in reducing the physiological weight loss and moisture loss of fruits, thus diminishing the loss of quality and acceptability during distribution and marketing. Even under packaging the product undergoes metabolic activities and resulting deteriorative changes. Similar trend was observed in refrigerated and ambient storage conditions in case of minimally processed jackfruit portions as reported by Survase *et al*. (2021) in red pumpkin, where pre-treated with xanthan gum @ 0.50% *i.e*. T_2 packed in 200 gauge polyethylene bag with 2% vents and stored at refrigerator storage (5±1°C) recorded the minimum physiological loss in weight with maximum retention of physico-chemical composition at the end of 12th day of storage. Ambient storage was not at all efficient in maintaining physiological quality parameters as evidenced by low shelf life, low marketability and high PLW. Refrigeration could retain the produce quality and low temperature storage (4°C) has been reported to extend the shelf life of MP commodities (Piga *et al*., 2000). Compared to other packaging systems, vacuum packaging was comparatively better even under ambient storage too.

Based on effectiveness of packaging materials and storage conditions in maintaining physiological, organoletic quality and marketability, portions under vacuum packaging in laminated pouches of at PP/LDPE under refrigeration was found to be the best treatment for enhancing the shelf life of minimally processed jackfruit portions.

Table 2: Effect of packaging on sensory score of minimally processed koozha portions under refrigeration.

Treatments	Mean sensory scores							
	Days after storage							
	0	2	4	6	8	10	12	15
				Colour score				
T1	9	7.2	7.1	6.4	6.4	5.5	5.5	5.0
T2	9	7.8	7.8	6.6	6.6	6.3	6.3	6.0
T3	9	8.2	8.2	7.4	7.4	7.0	7.0	6.8
T4	9	8.9	8.9	8.8	8.8	8.5	8.5	7.1
T5	9	5.6	5.6	4.9	3.5	3.2	3.2	2.8
T6	9	8.4	8.3	7.4	7.4	7.2	7.2	6.9
T7	9	3.2	-	-	-	-	-	-
				Taste score				
T1	9	7.5	7.5	7.2	7.2	5.6	5.6	4.2
T2	9	7.8	7.8	7.5	7.5	5.8	5.8	4.5
T3	9	8.4	8.4	8.2	8.2	6.9	6.9	5.2
T4	9	8.9	8.9	8.8	8.8	8.5	8.5	6.8
T5	9	8.5	8.5	8.3	8.3	6.5	6.5	5.1
T6	9	5.6	5.6	4.9	3.5	3.2	3.2	2.8
T7	9	2.9	-	-	-	-	-	-
				Texture Score				
T1	9	6.9	6.8	6.5	6.5	5.4	5.4	4.2
T2	9	6.8	6.9	6.6	6.6	5.6	5.6	4.8
T3	9	7.4	7.4	7.2	7.2	6.9	6.9	5.1
T4	9	8.9	8.9	8.5	8.5	7.9	7.9	6.9
T5	9	7.8	7.8	7.4	7.4	7.0	7.0	5.2
T6	9	6.4	6.4	5.1	5.1	3.9	3.9	3.2
T7	9	3.1	-	-	-	-	-	-
KW value	NA	192.8	184.1	163.2	161.2	160.8	159.8	143.9
χ^2 0.05	12.6	11.07						

CONCLUSION

Packaging technology was standardized to transform the current trend of unhygienic marketing system into hygienically packed jackfruit portions with prolonged shelf life and marketing through refrigerated retail outlets. Vacuum packaging of 200-250 g jackfruit portions without the spiny rind in laminated pouches of PP/LDPE after pre-treatment with 0.5% potassium metabisulphite and citric acid and storage under refrigeration can be recommended as the best packaging material and storage condition for mature firm fleshed (Varikka) and soft fleshed (Koozha) jackfruit types.

Conflict of interest: None.

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