Use of Packaging for 'Hawaii' Papaya Conservation, Sold at CEASA of São Luís, Maranhão, Brazil

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Abstract

Surveys carried out in different microregions of Maranhão highlight papaya as one of the fruits with the postharvest losses estimates. In this context, this study aimed to analyze the efficiency of plastic packaging on postharvest conservation of Hawaii papaya to instruct the Maranhão retail market about viable alternatives to mitigate losses related to this fruit. The papayas were purchased from CEASA of São Luís and sent to the laboratory. Posteriorly, they were randomly separated into 65 groups of 2 units, and then, applying the coverings are made. The experimental design was completely randomized in a split-plot at 4x5 times, with four treatment control [(without packaging), plastic film (FP), hermetic-bag (SH), and perforated-bag (SP)] and five evaluation periods (3, 6, 9, 12, and 15 days of storage); four repetitions and 2-fruits per portion (tray). For the individual biometric characterization, was carried out the measuring of the longitudinal and transverse diameters, fresh mass, pulp yield, seed mass, firmness, and fruit mass loss. Furthermore, for chemical analysis, total soluble solids content, total titratable acidity, and pH were measured. It was found, at the end of the study, that the hermetic-bag is efficient for maintaining the loss of fresh mass, firmness, ripening, total soluble solids content, total titratable acidity, and pH, which are relevant attributes of quality for commercialization of the Hawaii papaya. Therefore, the use of the hermetic-bag is recommended to increase the postharvest shelf life of Hawaii papaya fruit under stored at room conditions and at least for 15 days.

Keywords: postharvest, storage, waste

1. Introduction

Papaya Papaya (*Carica papaya L.*) belongs to the Caricaceae family and is native to America. It is a climacteric fruit, intensely cultivated and consumed in all tropical and subtropical regions of the world (Costa et al., 2011). Brazil is the world's second-largest papaya producer with a production of 1,517,696 t/year. The largest national producers are the states of Bahia, followed by Espírito Santo, getting production of 368.8 and 311.1 thousand tons, respectively (Embrapa, 2018). In this context, papaya has been assuming ever greater importance in Brazilian fruit growing, as one of the main fruits destined to the overseas trade (Luz et al., 2015).

Despite the high productivity, papaya postharvest losses are elevated. Globally, it represents about 40 to 50% of fruit production (FAO, 2014). However, in developing countries, about 30 to 40% of production is lost in the postharvest, processing, and distribution stages, representing a waste of resources used in production such as land, water, energy, and inputs (Gustavsson et al., 2011).

In Brazil, fruit and vegetable losses represent a high cost to the retail sector and reach around R$ 600 million per year. Of these, 86% occurs during the exposition of the product for sale; 9% in transportation; and 5% in storage (Melo et al., 2013). According to ABRAS (2015), postharvest losses of products correspond to 8.29% of net income and are the most impactful among all departments.

Several surveys were carried out in different microregions in the state of Maranhão by Ferreira (2019), Figueirinha (2019) and Silva et al. (2018), among 2017 and 2019, highlight papaya as one of the fruits with the highest estimates of postharvest losses, whose results ranged from 11.64 to 17.90%. Among the causal factors, physiological disorders were the most cited, corroborating with results found by Silva et al. (2018) who showed in their studies the valor of up to 91.24% of total losses.

According to Dias et al. (2011) and Pimentel et al. (2011), papaya has climacteric respiration, that is, ethylene peak and respiration after harvest. Therefore, the harvest shall be made at the physiological maturation stage before ripening. In this regard, it may be employed some alternatives to increase their shelf time. One method is the use of a modified atmosphere through the packaging of edible coatings.

These might prevent excessive mass loss as well as reduce gas exchange. When these two phenomena are controlled, the senescence of the product can be delayed, increasing its useful life (Damatto Júnior et al., 2010). Besides, it protects against external damage such as adverse temperature and humidity, and mechanical/phytopathological damage resulting from improper handling, transport, and packaging.

Based on the above considerations, this study aimed to analyze the efficiency of plastic packaging on postharvest conservation of Hawaii papaya sold at CEASA (State Supply Center) of São Luís (MA), to instruct the industry on viable alternatives to mitigate losses related to this fruit.

2. Material and Methods

The experiment was carried out at the Laboratório de Fitotecnia e Pós-Colheita, Universidade Estadual do Maranhão (UEMA), in the period from January to February 2019. The papayas were purchased at CEASA of São Luís (MA) and sent to the laboratory in monobloc boxes. Fruits were selected for size, color, and absence of damage, washed and sanitized with sodium hypochlorite, to 200 ppm for 15 minutes in water at 12 °C.

After drying at room temperature, the separation of fruits was made randomly into 65 groups of 2 units, placed in styrofoam trays, and then, the following treatments were applied: control (without packaging); plastic film (FP), hermetic-bag (SH) and perforated-bag (SP). These were analyzed for 15 days at 3-day intervals.

The experimental design was completely randomized, with the factorial arrangement (4x5) with plots split through time, with four treatments (control, plastic film, hermetic-bag, and perforated-bag), and five evaluation times (3, 6, 9, 12, and 15 days of storage); four repetitions and 2-fruits per plot (tray). The fruits were stored under ambient conditions (T = ± 25 ° C; RH = 48%), to more effectively simulate the environmental conditions occurring in the wholesale/retail markets of Maranhão.

For individual biometric characterization, were measured the longitudinal and transverse diameters using a digital caliper in millimeters (mm); fruit mass, pulp yield, and seed mass using semi-analytical balance, in grams (g); firmness, using a penetrometer, in Newton (N); and fresh mass loss, using a semi-analytical balance, estimated by the following formula, in percentage (%):

$$PM(\%) = \frac{Initial\ mass - Initial\ mass\ at\ each\ time\ interval}{Initial\ mass}\ x100$$

The chemical analysis was made from the fruit maceration of each tray and embraced the information about total soluble solids content, total titratable acidity, and pH. The determination of total soluble solids (TSS) had been made by direct reading of the digital refractometer, whose results were expressed in ºBrix. The hydrogenic potential (pH) was determined by the potentiometer method in a digital pH device, according to the methodology recommended by the Official Analytical Chemistry Association (AOAC) (1995). Acidity (ATT) (% citric acid) was obtained by titration with a standard solution of 0.1N sodium hydroxide, according to AOAC (1995).

The analysis was carried out by analysis of variance (ANOVA), and when the null hypothesis was rejected, it used the Tukey test to compare the means. The InfoStat® statistical software was used in this study. It is important to point out that fresh mass loss data were analyzed in a completely randomized design, only for the last evaluation day.

3. Results and Discussion

In Table 1 are reported the mean values for the mass of the fruit during the storage period. There was no interaction between treatments and storage time.

Table 1. Mean values for fresh Hawaii papaya mass stored in different packages for 15 days at environment conditions

Packages	**Time**					
	3	**6**	**9**	**12**	**15**	**Mean**
			Fresh Mass (g)			
Control	358.1a	295.0b	325.6a	333.7ab	274.3b	317.3C
FP	330.0a	332.5a	339.3a	365.0a	358.3a	345.0B
SH	375.0a	373.7a	393.1a	381.8a	385.6a	381.8A
SP	380.6a	377.5a	374.3a	363.1a	346.8a	368.5A
Mean	360.9A	344.6A	358.1A	360.9A	341.3A	
	Packages	**Time**	**Packages*time (p*)**	**CV (%)**		
	0.001*	0.18	0.06	8.26		

Plastic film (FP), hermetic-bag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

The values ranged from 274.3 to 393.1 g and corroborated with Dantas et al. (2013), who stated that for commercial purposes, Hawaii papaya should weigh around 350 to 600g. Therefore, except for the control (without packaging), it can be inferred poor preservation conditions may impair the quality of this fruit for sale.

The best yields of fresh mass were recorded using a hermetic-bag and perforated-bag, followed by the plastic film (Table 1). Fruits packed with hermetic-bag were presented around 17% more mass than the control (without packaging). According to Santos and Oliveira (2012), this may have occurred because the packaging works as a barrier to water loss in fruit, and thus, increases its shelf life.

As expected from the estimation of the means of fresh mass, the higher losses occurred for the control (without packaging), which was estimated on average twenty-nine times higher than the most effective treatments (hermetic-bag and perforated-bag) (Table 2).

Table 2. Mean values for the loss of fresh Hawaii papaya mass stored in different packages for 15 days and environment conditions

Packages	**Time**					
	3	**6**	**9**	**12**	**15**	**Mean**
			Mass Loss (g)			
Control	4.00eA	8.07dA	13.95cA	18.89bA	25.49aA	14.08A
FP	0.46dAB	2.32cB	4.57bcB	6.55abB	8.71aB	4.52B
SH	0.00aB	0.00aB	0.15aC	0.77aC	1.54aC	0.49C
SP	0.00aB	0.00aB	0.34aC	1.20aC	1.72aC	0.65C
Mean	1.11e	2.60d	4.75c	6.85b	9.37a	
	Packages	**Time**	**Packages*time (p*)**	**CV (%)**		
	0.001	0.001	0.001	34.00		

Plastic film (FP), hermetic -ag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

On the 15th of storage day, it was estimated a loss of fresh mass in the magnitude of up to 25.49% (control), it is twenty times higher than the tolerable limit (5%) recommended by Santos et al. (2008) to commercial conditions. However, for the hermetic-bag, perforated-bag, and plastic film, losses may be considered acceptable on every evaluation day, according to the overall treatment average.

According to Reis (2014), the use of packaging can reduce respiratory activity and increase relative humidity, which delays ripening and water loss through transpiration. Further, Sanches et al. (2017), affirm that the intense process of transpiration causes water deficit in the fruit, which leads to reduced quality and acceptance for commercialization/consumption. Therefore, there may be increased postharvest losses and consequent losses induced by poor storage conditions.

Regarding the cross-sectional diameter, it was observed that there was no interaction between coatings and storage time, but there were individual effects of these factors (Table 3).

Table 3. Mean values for the transverse diameter of the Hawaii papaya, stored in different packages, for 15 days and under environmental conditions

Packages	**Time**					
	3	**6**	**9**	**12**	**15**	**Mean**
			Transverse Diameter (mm)			
Control	79.6a	75.6ab	75.4ab	77.5ab	70.8b	75.8*C*
FP	78.7a	79.1a	77.6a	79.5a	78.6a	78.7*B*
SH	82.9a	82.4a	82.2a	82.2a	80.9a	82.1*A*
SP	80.7a	79.6a	78.5a	79.1a	79.2a	79.4*AB*
Mean	80.4*a*	79.2*ab*	78,4*ab*	79.6*ab*	77.3*b*	
		Packages	**Packages*time (p*)**	**CV (%)**		
		0.049	0.42	10.74		

Plastic film (FP), hermetic-bag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

The transverse diameter ranged from 70.8 to 82.9 mm and was higher than the results found by Alves et al. (2012), in studies of characterization of Hawaii papaya. The best yields were obtained by adopting a hermetic-bag and perforated-bag, possibly due to the efficiency of these treatments on the maintenance of fresh fruit mass, which presents direct relation to its turgidity.

Mean cross-sectional diameters decreased over storage days, especially in unpacked fruits (control) (Table 3). Reis (2014) explains that greater exposure of fruits to the environment (without packaging) increases its dehydration rate, causing wilting and changes in its biometric characteristics.

The longitudinal diameter was not affected by the interaction between treatments and storage time. Only time had a significant effect ($p < 0.05$) on this variable, with a 7.77% reduction in fruit cross-sectional diameter, estimated at 15 days of storage, compared to the first evaluation period (Table 4).

Table 4. Mean values of the longitudinal diameter of Hawaii papaya, stored with different packages, for 15 days and under environmental conditions

Packages	**Time**					
	3	**6**	**9**	**12**	**15**	**Mean**
			Longitudinal Diameter (mm)			
Control	119.3	116.4	115.2	114.2	107.5	114.5A
FP	117.7	122.3	117.2	121.5	103.8	116.5A
SH	120.5	118.1	124.0	121.0	123.8	121.3A
SP	121.7	123.2	124.8	121.2	105.5	119.3A
Mean	119.8*a*	120.0*a*	120.3*a*	119.4*a*	110.5*b*	
		Packages	**Packages*time (p*)**	**CV (%)**		
		0.01	0.18	9.92		

Plastic film (FP), hermetic-bag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

The mean ranged from 105.5 mm to 124.8 mm (Table 4). These values were higher than those found by Alves et al. (2012), for Hawaii papaya, whose treatment averages ranged from 101.68 mm to 108.18 mm. It is important to note, despite the interference of treatments on fresh mass, it does not reflect on the longitudinal diameter, as opposed to obtained for the cross-sectional diameter of the fruit.

Concerning physicochemical characteristics, total titratable acidity (ATT) had a significant effect ($p < 0.05$) on the interaction between packaging and storage time (Table 5).

Table 5. Mean values for total titratable acidity of Hawaii papaya stored in different packages for 15 days under environmental conditions

Packages	**Time**					
	3	**6**	**9**	**12**	**15**	**Mean**
			ATT			
Control	0.16aAB	0.11bA	0.13abA	0.11bA	0.14abA	0.13
FP	0.18aA	0.09bA	0.14abA	0.11bA	0.11bA	0.13
SH	0.17aAB	0.12bA	0.12bA	0.11bA	0.11bA	0.13
SP	0.13aB	0.13aA	0.13aA	0.12aA	0.11aA	0.12
Mean	0.16a	0.11b	0.13ab	0.11b	0.12ab	
		Time	**Packages*time (p*)**	**CV (%)**		
		0.001	0.001	15.00		

Plastic film (FP), hermetic-bag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

The use of the hermetic-bag and perforated-bag culminated in a linear decline of ATT with storage time. According to Chitarra and Chitarra (2005), acidity decreases as a result of the respiratory process and, or its conversion to sugars, because volatile and non-volatile organic acids are among the most metabolize cellular constituents in the ripening process.

However, for control and plastic film, there were ATT peaks on the third and fifth days of analysis. According to Fernandes et al. (2010), the papaya ripening process is maintained by the consumption of organic acids, since the fruit has no starch reserves.Valerio et al. (2017) add that acidity peaks may be linked to galacturonic acid synthesis through pectin hydrolysis by pectinamethylesterase. This suggests the use of hermetic-bag and the perforated-bag was effective in the conservation of Hawaii papaya, by reducing water loss and increasing shelf life

The ATT results did not differ significantly from each other in all storage periods, which shows lower oscillations of treatments by packaging action (Table 5). Similar results were also obtained by Morais et al. (2010) storing “Tainung 1” papaya at 10 °C and 85% RH for 35 days of storage.

Although it had not shown a significant difference, it was possible to observe that fruits packed with SH and SP maintained a more uniform behavior of ATT contents throughout the storage period, not differing statistically in relation to the time. According to Silva et al. (2009), this behavior is interesting because it delays the biochemical transformations responsible for fruit pH changes; in other words, it slows down the ripening.

On table 6 is shown the values for total soluble solids (SST) contents. There were statistical significance and interaction for both factors evaluated.

Table 6. Mean values for total soluble solids of papaya fruits stored in different packages for 15 days

Packages	Time					
	3	6	9	12	15	Mean
			SST			
Control	9,.51bA	11.93abA	11.86abA	13.35aA	13.55aA	12.04*A*
FP	10.71aA	11.48aA	10.26aA	10.72aA	10.64aA	10.76*B*
SH	9.80aA	10.64aA	11.01aA	10.55aA	10.25aB	10.45*B*
SP	11.04aA	11.14aA	11.25aA	11.18aA	11.44aA	11.21*AB*
Mean	10.27*b*	11.30*ab*	11.10*ab*	11.45*ab*	11.47*a*	
		Time	**Packages*time (p*)**	**CV (%)**		
		0,03	0.05	10.22		

Plastic film (FP), hermetic-bag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

It was possible to observe a progressive increase in the SST content during the storage period. The highest averages were estimated for control at 15 days of storage (13.55 °Brix) and the plastic film at 12 days (10.72 °Brix). It is important to note that, although the values of OSH increased during the storage period, this increase was not significant. According to Bron (2007), papaya accumulates little starch, about 0.5% after anthesis, and it decreases until it stabilizes around 0.1% after 75 days of anthesis. As it has minimum starch quantities to be hydrolyzed in the ripening, there is a little variation in the levels of SST during postharvest.

According to Luz et al. (2015), the soluble solids content is a hard precision characteristic, since there may be wide variation according to the management employed in fruit production. Nevertheless, according to Reis et al. (2015), with rare exceptions, the values obtained in this study are within the recommended standard for papayas from the Solo group (9.58 to 11.80 °Brix). The control treatment papayas during storage 12 and 15 presented higher values than those established by Reis et al. (2015). This high degree may be linked to the early ripening of the fruits analyzed in this treatment.

Fruits packed with hermetic-bag and plastic wrap had lower SST mean than the perforated-bag and control (Table 6). It shows the efficiency of these two packages in retarding organic acid degradation since it is a crucial process in ripening. According to Pimentel et al. (2011), total soluble solids (SST) well represent the fruit ripening and generally, a high SST content indicates a higher degree of fruit maturity. Moreover, for Pego et al. (2015), this parameter is used by many authors as a characteristic that reflects the sensory quality of fruits.

Concerning the maturing of the fruit, it was observed that this variable was significantly affected by storage time ($p < 0.05$) (Table 7).

Table 7. Mean values for the maturing rate of Hawaii papaya, stored in different packages, for 15 days and under environmental conditions

Packages	**Time**					**Mean**
	3	**6**	**9**	**12**	**15**	
			Maturing (%)			
Control	7.00c	51.62b	37.50b	82.50a	96.25a	54.97
FP	6.26c	63.25b	86.25a	97.00a	100.00a	70.55
SH	4.37c	10.00c	18.75b	73.75a	73.75a	36.12
SP	12.50c	51.56b	90.62a	100.00a	100.00a	70.94
Mean	7.53c	44.11b	58.28b	88.31a	92.50a	
		Time	**Packages*time (p*)**	**CV (%)**		
		0.00	0.052		13.95	

Plastic film (FP), hermetic-bag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

The lowest percentages occurred for fruits packed with hermetic-bag. This demonstrates that this package was one of the most effective in delaying the ripening of Hawaii papaya during 15 days of storage (Table 7). These results corroborate Martins (2012) and Barbosa (2012), who described the modified atmosphere as an effective technique to reduce the effects of gas exchange on peel color change and fruit ripening.

In relation to the seed mass, the effect of the interaction between the packages and the storage time was observed (Table 8).

Table 8. Mean values for papaya seed mass stored in different packages for 15 days

Packages	**Time**					
	3	**6**	**9**	**12**	**15**	**Mean**
			Seed Massa (g)			
Control	47.8aA	62.1aA	47.8aB	75.9aA	57.5aA	61.8B
FP	47.7bA	61.3abA	61.8abAB	62.5abA	75.9aA	61.8AB
SH	48.9aA	56.7aA	64.9aAB	63.0aA	75.6aA	61.8A
SP	58.5aA	67.9aA	77.6aA	60.4aA	76.9aA	68.2A
Mean	50.8ab	62.0a	62.9a	65.4a	71.5*a*	
		Time	**Packages*time (p*)**	**CV (%)**		
		0.00	0.03	17.19		

Plastic film (FP), hermetic-bag (SH) and perforated-bag (SP); * significant at 5% probability by the F test; CV: coefficient of variation; Uppercase letters do not differ from each other on the same row and lowercase letters in the column.

The increase in storage time culminated in an increase of seed mass. According to Cruz et al. (2016), this may be associated with the fact that seeds continue to develop during fruit ripening until they reach their highest quality. Therefore, these results prove that the fruits were undergoing postharvest metabolization during the study period. And according to the results obtained, the use of Hawaii papaya packaging has delayed seed development, which is possibly associated with the retardation of its maturation.

4. Conclusion

To sum up, at the end of the study, it was found that the hermetic-bag is efficient for maintaining the fresh mass loss, firmness, maturing, total soluble solids content, total titratable acidity and pH of Hawaii papaya, which are important quality attributes for its marketing.

The use of a hermetic-bag is recommended to increase the postharvest shelf life of Hawaii papaya under environmental storage conditions (T = ± 25 °C; RH = 48%) and for at least 15 days of storage.

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References

Alves, A. S. et al. (2012). Produtividade do mamoeiro havaí submetido a dosagens e intervalos de aplicação de biofertilizante bovino. *Engenharia Ambiental, 9*, 100-109.

AOAC - Association of Official Analytical Chemists (1995). *Official methods of analysis of the Association of the Analytical Chemists*. (16th ed.). Washington.

Associação Brasileira De Supermercados – ABRAS. (2015). Avaliação de perdas nos supermercados brasileiros. São Paulo: ABRAS. [Online]. Available: http://www.abrasnet.com.br/economia-e-pesquisa/perdas/pesquisa-2015 (May 13, 2019).

Barbosa. N. C. (2012). *Taxa de respiração do mamão em função das diferentes condições de atmosferas de armazenamento em temperatura ambiente.* Dissertação (Mestrado em Produção Vegetal) - Campos dos Goytacazes – RJ, Universidade Estadual do Norte Fluminense – UENF.

Bron, I. U. (2007). *Amadurecimento de mamão 'Golden': ponto de colheita, bloqueio da ação do etileno e armazenamento refrigerado*. Tese (Doutorado em Agronomia). Escola Superior de Agricultura Luiz de Queiroz.

Chitarra, M. I. F., & Chitarra, A. B. (2005). *Pós-colheita de frutas e hortaliças: fisiologia e manuseio*. (2rd ed.). Lavras-MG: Editora UFLA.

Costa, L. C. et al. (2011). Procedência, qualidade e perdas pós-colheita de mamão 'Havaí' no mercado atacadista da EMPASA de Campina Grande-PB. *Agropecuária Técnica, 32,* 21- 34. https://doi.org/10.25066/agrotec.v32i1.7207

Cruz, M. A. et al. (2016). Grau de amadurecimento do fruta na qualidade fisiológica de sementes de atemóia (*Annona cherimola* Mill. X *Annona squamosa* L.). *Revesta Cultivando o Saber. 9*,283-293.

Damatto Júnior, E. R. et al. (2010). Qualidade de pimentões amarelos colhidos em dois estádios de maturação. *Revista Científica Eletrônica de Agronomia, 17*, 23-30.

Dantas, J. L. L., Junghans, D. T., & Lima, J. F. (2013). *Mamão: o produtor pergunta, a Embrapa responde*. (2rd ed.). Brasília, DF : Embrapa.

Dias, C. T. et al. (2011). Conservação pós-colheita de mamão formosa com filme de FP e refrigeração. *Revista Brasileira de Fruticultura*, *33*, 666-670. https://doi.org/10.1590/S0100-29452011000200040

Embrapa – Empresa Brasileira de Pesquisa Agropecuária (2018). Produção brasileira de mamão em 2017. EMBRAPA Mandioca e Fruticultura. [Online]. Available: http://www.cnpmf.embrapa.br/Base_de_Dados/index_pdf/dados/brasil/mamao/b1_mamao.pdf (September 24, 2019)

Fernandes, P. L. de O. et al. (2010). Qualidade de mamão 'Formosa' produzido no RN e armazenado sob atmosfera passiva. *Revista Ciência Agronômica*, *41*, 599-604. https://doi.org/10.1590/S1806-66902010000400012

Ferreira, L. S. (2019). *Perdas pós-colheita de hortifrútis em sete municípios maranhenses, inseridos em diferentes microrregiões*. Chapadinha, MA, UFMA.

Figueirinha, K. T. (2019). *Levantamento de perdas pós-colheita de hortifrútis em cinco municípios maranhenses, inseridos em diferentes microrregiões*. Chapadinha, MA, UFMA.

Food and Agriculture Organization of the United Nations – FAO. (2014). Perdas e desperdícios de alimentos na América Latina e no Caribe. [Online]. Available: http://www.fao.org/americas/noticias/ver/pt/c/239394/ (July 20, 2019)

Gustavsson, J. et al. **(**2011). Global food losses and food waste: extent, causes and prevention. Rome: Food and Agriculture Organization of the United Nations. [Online]. Available: http://www.fao.org/3/a-i2697e.pdf (September 24, 2019).

Luz, L. N. et al. **(**2015). Novos híbridos de mamoeiro avaliados nas condições de cultivo tradicional e no semiárido brasileiro. *Revista Brasileira de Fruticultura, 37*, 159-171. https://doi.org/10.1590/0100-2945-069/14

Martins, D. R. (2012). *Otimização das condições de estocagem do mamão em atmosfera controlada para preservação da qualidade e extensão da vida útil dos frutas*. Tese (Doutorado em Produção Vegetal) – Campos dos Goytacazes – RJ, Universidade Estadual do Norte Fluminense – UENF.

Melo, E. L. et al. (2013). O desafio do planejamento de demanda no setor hortifrutigranjeiro: um estudo de caso da Empresa Nova Casbri. [Online] Available: www.aedb.br/seget/arquivos/ artigos13/45318548.pdf. (May 19, 2019)

Morais, F. A. (2010). Influência da atmosfera modificada sob a vida útil pós-colheita do mamão "Formosa". *Revista Verde, 5,* 01-09.

Pego, J. N. et al. (2015). Conservação pós-colheita de mamão 'Sunrise Solo' com revestimento comestível a base de fécula de mandioca**.** *Enciclopédia Biosfera, 11,* 628-629. https://doi.org/10.1590/0100-2945-194/13

Pimentel, J. D. R. et al. (2011). Estudo da conservação de mamão Havaí utilizando películas comestíveis a diferentes temperaturas. *Scientia Plena. 7,* 1-6.

Reis, H. F. (2014). Conservação pós-colheita de mamão formosa (*Carica papaya L.*) e controle alternativo *in vitro* e *in vivo* de *Colletotrichum gloeosporioides*. Tese (Doutorado em Agronomia) – Universidade Federal da Grande Dourados. Dourados, MS: UFGD.

Reis, R. C. et al. (2015). Caracterização fisico-quimica de frutas de novos híbridose linhagens de mamoeiro. *Pesquisa Agropecuária Brasileira, 50*, 210-217. https://doi.org/10.1590/S0100-204X2015000300004

Sanches, A. G. et al. (2017). Avaliação da qualidade de alfaces minimamente processadas cultivadas em sistema hidropônico. *Revista Trópica – Ciências Agrárias e Biológicas, 10,* 19-31.

Santos, C. E. M. et al. (2008). Comportamento pós-colheita de mamões formosa 'Tainung 01' acondicionados em diferentes embalagens para o transporte. *Revista Brasileira de Fruticultura, 30,* 315-321. https://doi.org/10.1590/S0100-29452008000200008

Santos, J. S., & Oliveira, M. B. P. P. (2012). Alimentos frescos minimamente processados embalados em atmosfera modificada. *Braz. J. Food Technol., 15*, 1-14. https://doi.org/10.1590/S1981-67232012000100001

Silva, A. V. C. et al. (2009). Uso de embalagens e refrigeração na conservação de atemóia. *Ciênc. Tecnol. Aliment., 29,* 300-304. https://doi.org/10.1590/S0101-20612009000200010

Silva, L. R. et al. (2018). Estimates and causes of fresh fruit post-harvest losses in the Chapadinha Microregion, Maranhão, Brazil. *Revista Agro@mbiente On-line ,12*, 288-299. https://doi.org/10.18227/1982-8470ragro.v12i4.5223

Valerio, D. B. (2017). *Avaliação de diferentes formas de acondicionamento na qualidade pós-colheita de mamão papaia (Carica papaya L)* – Brasília. Monografia - Universidade de Brasília/ Faculdade de Agronomia e Medicina Veterinária.

Glossary

FP: Plastic Film

SH: Hermetic-Bag

SP: Perforated-Bag

SST: Total Soluble Solids

ATT: Total Titratable Acidity