

Waste assessment in distribution and marketing logistics of horticultural products: evidence from Brazil

Evaluación de residuos en logística de distribución y comercialización de productos hortícolas: evidencias en Brasil

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ABSTRACT

Worldwide, one-third of the food produced is unconsumable due to marketable quality losses. Parallely, and given the growing world population, levels of waste have become unacceptable. Supply channels play a fundamental role in establishing strategies for food waste mitigation. The objective of this research was to analyze if good operational practices with different dimensions of distribution and commercialization logistics may contribute to reduce fruit and vegetable waste. The studied dimensions were: logistics, operations, technology, trade and management. Several questionnaires were administered to 83 specialized wholesale merchants from a large supply center in Brazil, for lettuce, potato, orange, papaya and tomato. The results indicated that for papaya and potato, low and high waste generation are associated with a greater number of anti-waste actions ($p = 0.0071$ and $p = 0.0469$ respectively). For tomato, lettuce and orange, no significant differences for high and low waste in relation to the number of actions undertaken in these chains, was found. These results represent a first approach to understanding the reasons for food waste at wholesale centers.

Keywords

food waste • supply chain management • waste minimization • sustainable marketing • fruit surplus • waste prevention

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RESUMEN

A nivel mundial, un tercio de los alimentos producidos no se consume debido a la pérdida de calidad para la comercialización, y con la creciente población mundial, los niveles de desperdicio son inaceptables. Los canales de suministro juegan un papel fundamental en la mitigación del desperdicio de alimentos y en el establecimiento de estrategias para reducirlo. El objetivo de esta investigación fue analizar si las buenas prácticas operativas de diferentes dimensiones de la logística de distribución y comercialización contribuyen a reducir los niveles de desperdicio de frutas y hortalizas. Las dimensiones fueron: logística, operaciones, tecnología, comercio y gestión. Los cuestionarios fueron administrados a 83 comerciantes mayoristas especializados de un gran centro de suministro en Brasil para lechuga, papa, naranja, papaya y tomate. Los resultados indican que, para papaya y papa, bajo y alto desperdicio están asociados con el mayor número de acciones realizadas por los comerciantes ($p = 0,0071$ y $p = 0,0469$ respectivamente). Para tomate, lechuga y naranja, no hay evidencia significativa de diferencias para alto y bajo desperdicio y el número de acciones tomadas en estas cadenas. Los resultados obtenidos en esta investigación representan un primer acercamiento para comprender las razones del desperdicio de alimentos en los centros mayoristas.

Palabras clave

desperdicio de alimentos • gestión de la cadena de suministro • minimización de desperdicios • comercialización sostenible • excedente de frutas • prevención de desperdicios

INTRODUCTION

Food loss and waste generation persist as world essential challenges. Approximately one-third of globally produced food, is not consumed. This is largely due to loss of quality for marketing and/or consumption. Given the relentless growth of the world population, these unacceptable levels cause financial and nutritional losses worldwide (5, 19, 40, 41).

Research on causal agents like management mechanisms and quantification of food loss/waste levels, as well as on efficient actions promoting food loss/waste reduction, should be considered and approached (2). According to Abiad and Meho (2018), information on food loss and waste is still limited to specific investigations, and in many cases, sampling design does not allow results generalization or even comparisons among studies.

Reducing food loss and waste contributes to increasing food supply by reducing the need to complement its availability through public policies or even through commercial imports and donations. Higher food availability contributes to lowering prices, implying, under normal market conditions, lower prices for final consumers (14, 36, 42).

Conceptually, food loss refers to the reduction in the amount of available edible food throughout its production chain. Waste, in turn, constitutes losses in retail and/or caused by the final consumer. Only products intended for human consumption are considered waste, excluding inedible parts and animal feed. Food intended for human consumption but used, for instance, in bioenergy, still constitutes a loss (19). The causes of food loss and waste generation are mainly related to financial, managerial, and technological limitations during harvest, postharvest and storage, packaging systems and marketing infrastructure (22). In the distribution and commercialization logistics, food degradation affects all stages, from production, harvest and postharvest, to processing, distribution and sales (3, 5, 26, 31, 37, 45). According to Cunha (2015), loss is also associated with pathogen attack in cooling chambers and packages, budding in roots and tubers, and advanced maturation. Postharvest losses and quality deterioration of fruit and vegetable crops are mainly caused by pests, microbial infection, natural ripening, and environmental conditions such as heat, drought, moisture, and improper postharvest management (35, 45). Marketing channels, especially short channels, hold importance since they reduce transaction costs by mediating contact between growers and final consumers (24). However, these channels are inherent to intermediary agents and actors involved in product sales (9). A marketing channel allows growers to reach various distribution centers, such as fairs, industries, industrial centers,

cooperatives, events and even to export their products overseas, increasing marketing reach (43). Identifying the distribution/commercialization stages with the highest levels of waste generation, allows a more efficient management of the supply chain, with lower levels of associated loss (5, 34).

In Europe, initiatives for accurately quantifying waste in the main economic sectors, are increasing. In 2012, the European Union, estimated food retail waste at 5 million tons (5, 38). In these countries, the food retail sector accounts for approximately 5% of total food waste in the entire food chain. This sector was responsible for wasting 2% of food in the United Kingdom and about 2 to 4% in Poland, Germany and Sweden (18, 20). In Latin America, initiatives regarding food waste are still modest, failing to quantify food waste among the different food systems. According to FAO (2016), Latin America and the Caribbean are responsible for 6% of global food losses. In these regions, 15% of food for human consumption is wasted each year (21). According to Parfitt *et al.* (2010), small retailers, especially those not connected to other chains, are more likely to generate higher volumes of food waste given their limited resources and inadequate customer demand forecasting. Therefore, management and maintenance of supplier-customer relationships cannot guarantee food delivery and reduced waste in food retailing.

Kummu *et al.* (2012), after assessing waste generation at different stages through the chain for different countries, classified them into two groups: middle- to high-income countries, with more than 50% of waste associated with distribution and consumption, and low-income countries, where the most waste is associated with production and postharvest. These same authors indicated that cereals account for 57% of total losses in the food supply chain, fruit and vegetables, for 39%, and roots and tubers, for 33%. The highest levels of food loss and waste in absolute terms are associated with industrialized Asia and South and Southeast Asia (29). In this sense, Affognon *et al.* (2015), when assessing food waste through meta-analysis, indicated that waste of roots and tubers, and fruit and vegetables in sub-Saharan Africa were estimated at 33 to 60% and 37 to 55%, respectively. In the same sense, Stensgard *et al.* (2016), when assessing food waste during 2010-2015 in Norway, indicated that, considering the volume of wholesale sales, percentages of food waste decreased as a result of increased sales. Among the evaluated groups, fruit and vegetables showed the highest waste generation, resulting, for the analyzed period, in between 1.0 and 1.03% of wholesale sales.

Nonetheless, controlling key physiological aspects that contribute to the loss of quality of fruit and vegetables in the distribution and marketing chains contributes to reducing commercial loss, increasing food supply for human consumption. Thus, the objective of this study was to evaluate how the logistics, operations, technology, trade, and management dimensions may interrelate with each other affecting waste production, given that the analysis of only one dimension cannot properly evaluate food waste in its entirety.

MATERIALS AND METHODS

The chosen methodology was based on a semi-structured questionnaire administrated to wholesale merchants of the Campinas Supply Center - CEASA Campinas (2018). This methodological approach, known as *rapid assessment* or *quick appraisal* (17), Kumar (1993), Dunn (1994) and Beebe (1995) is founded on data obtained from secondary sources along with semi-structured interviews in which more detailed data and/or information is required to understand the dynamics of the sector assessed.

The five chosen products (orange, papaya, lettuce, tomato and potato) and their respective categories, namely (1) fruit, (2) leaf, flower and stem vegetables, and (3) root, bulb, tuber and rhizome, are among the most consumed by the Brazilian population, according to the latest Family Budget Survey - POF 2008 - 2009 (13, 27). According to the POF 2008-2009, orange and papaya consumption is 2.807 and 2.045 kg/capita/year, respectively, second only to watermelon (3.368 kg/per capita/year) (27). Tomato consumption is 4.916 kg/capita/year, first in the fruit group. In the leaf group, lettuce consumption is 0.91 kg/capita/year, behind cabbage with 1.032 kg/capita/year. Finally, ranking first in the tuber vegetables group, consumption of potato is around 4.037 kg/capita/year (27). Twelve wholesale merchants

were interviewed for lettuce, 15 for potato, 14 for orange, 19 for papaya and 23 for tomato, comprising a total of 83 wholesale merchants. To maintain anonymity, merchants were coded by sequential numbers from 1 to 83.

The administrated questionnaires referring to business practices, storage, transport conditions, postharvest treatment and management, provision and delivery of services, marketing and after-sales strategies, were administered during the second half of 2018. During data collection, each wholesale merchant was asked to report the amount of waste associated with each product. Thus, the declared waste depended on each wholesale merchant, functioning as waste estimator during trade and distribution logistics.

Seventeen variables related to marketing and distribution were obtained from the questionnaire, providing a positive (+) or negative (-) relationship with food waste depending on their association with the distribution and commercialization logistics chain (table 1). Values of 1 (yes) or 0 (no) were associated to each variable indicating if wholesale traders carried out such procedure in the logistics chain of the analyzed product.

Table 1. Description of variables collected from CEASA-Campinas wholesale merchants and used for analysis.

Tabla 1. Descripción de las variables recopiladas de los comerciantes mayoristas CEASA-Campinas y utilizadas para el análisis.

Variable	Description	Contribution to or loss
Handling during trade	To identify procedures assessing product quality status. Represented by "tipman".	-
Transshipment operations	To identify transshipment operations. Represented by "oprtrans".	+
Package trading	To identify packaging in product marketing . Represented by "comtpemb".	-
Product quality control	To identify product quality control . Represented by "tipcotr".	-
Supplying package	To identify packaging supply for the producer or buyer. Represented by "fornemb".	-
Classification and reclassification operations of sold products	To identify product classification and/or reclassification procedures. Represented by "clarecla".	-
Cooling chamber	To identify the use of a cold chamber. Represented by "camfria".	-
Postharvest treatment	To identify postharvest treatments such as wax, application of fungicides, or drying, among others. Represented by "tratpos".	-
Transport type	To identify chosen transport Represented by "tiptrns".	-
Provision of service	To identify customer services (consignment of products, exhibitors). Represented by "tipreserv".	-
Promotional pricing	To identify promotional pricing. Represented by "prcprom".	-
Price tracking	To identify if the wholesaler follows price movements. Represented by "acmovpr".	-
Purchase by contract	To identify the sale, such as a contract and contractual requirement. Represented by "comp".	-
Purchase by opportunity	To identify purchase opportunity. Represented by "compop".	+
Alternate destinations	To identify whether unsold products are discarded or donated to institutions such as food bank and charities. Represented by "destcomr".	-
Waste control	To identify waste control. Represented by "cntrdesp".	-
Fixed producer/supplier	To identify whether the products sold are supplied by fixed producers or suppliers. Represented by "pffixo".	-

When defining analyses dimensions such as the representation of a group, to assume that causal relationships for waste analysis are multi-factorial and dynamic, is possible. Thus, in order to evaluate the relationship between variables and practices/conducts on the evaluated fruit and vegetable waste generation, five dimensions were defined (33, 46).

Given this context, these dimensions constituted a form of representation capable of sorting various elements for analysis, considering a complex and multi-factorial intersection between waste, established variables, chain actors, their practices and procedures, and the fruit and vegetable analyzed. The five defined dimensions were: logistics, operations, technology, trade and management (figure 1). Based on a self-declared value of waste and an average value (obtained by the arithmetic mean of all values reported by wholesale merchants), wholesale merchants were grouped into “high” or “low” level of food waste for each product. The database was created considering response frequency and leading to proportions. Descriptive analyses of variables and dimensions were performed for each of the five products evaluated.



Figure 1. Dimensions and associated variables.

Figura 1. Dimensiones y variables asociadas.

Statistical analysis

To test the hypothesis stating that “the distribution of the number of waste preventive actions is the same for groups with low and high waste”, the Wilcoxon-Mann-Whitney non-parametric test was performed for each product.

The analyses were performed with R software version 4.0.2, aided by the coin package (23, 39, 47). A significance level of 5% was considered for all tests.

RESULTS

For high waste and for all evaluated products, the highest averages for declared waste were observed with the smallest number of preventive or anti-waste actions. Among all evaluated products, potato stood as the one with the least actions (49 shares) (table 2, page 212).

Table 2. Frequency for the group of high waste.
Tabla 2. Frecuencia para el grupo de residuos altos.

Dimension/Variables	Papaya	Potato	Lettuce	Orange	Tomato
Logistics	18	12	14	9	21
Tipman	6	1	5	2	5
Oprtrans	5	4	5	2	6
Comtpemb	7	7	4	5	10
Operations	16	3	13	9	18
tipcotr	5	2	5	3	3
fornemb	2	0	4	3	9
clarecla	9	1	4	3	6
Technology	19	6	14	9	13
camfria	6	0	3	1	1
tratpos	6	6	6	4	6
tiptrns	7	0	5	4	6
Trade	40	22	26	23	43
tipreserv	4	3	1	4	6
prcprom	6	4	6	3	10
acmovpr	8	4	5	4	10
comp	7	3	6	4	5
compop	6	3	3	3	2
destcomr	9	5	5	5	10
Management	13	6	9	7	14
cntrdesp	7	4	4	4	7
pffixo	6	2	5	3	7
Average waste	8.4	9.8	27.4	3.3	6.5
Total shares	106	49	76	57	109
Minimum number of shares	9	5	10	9	7
Maximum number of shares	14	11	15	15	13

For low waste and all evaluated products, the highest averages for declared waste were observed when the largest number of anti-waste actions were performed. Tomato and papaya resulted to have the highest number of shares, with 109 and 106 shares, respectively (table 3, page 213).

Orange and papaya wholesalers carried out the largest number of anti-waste actions (80%), with reported low levels of residues of 1.3% and 3.5%, respectively (figure 2, page 213-214). The high waste generation rates for orange (3.3%) and papaya (8.4%) were observed for the fewest waste avoiding actions (60% for orange and 67% for papaya).

Low levels of waste for tomato (0.8%) and lettuce (16.6%) were observed when wholesale traders carried out the most anti-waste actions, with 67% for tomato and 72% for lettuce (figure 2, page 213-214). Wholesale traders with the highest waste of tomato (6.5%) and lettuce (27.4%) were the ones that carried out the fewest anti-waste actions (64%) (figure 2, page 213-214).

Wholesale potato traders with low declared waste (2.4%) and high declared waste (9.8%) carried out 60% and 41% of anti-waste actions, respectively. Among all the considered products, wholesale potato traders were the ones performing the fewest preventive actions (figure 2, page 213-214).

The highest waste generation rate reported by wholesale traders was observed for lettuce (average 22.5%). The lowest level of waste was observed for orange (average of 2.2%). Papaya and potato resulted to have an average level of waste of 5.8%, while tomato showed 3.3% (figure 3, page 214).

For low papaya waste, the lowest frequencies were observed for the variables purchase opportunity and transshipment operation, with 30% and 40%, respectively (figure 4, page 214).

The highest frequencies of the management and trade variables were observed for low lettuce waste, resulting in 100 and 80%, respectively (figure 4, page 214).

Table 3. Frequency for the group of low waste.
Tabla 3. Frecuencia para el grupo de bajo residuo.

Dimension/Variables	Papaya	Potato	Lettuce	Orange	Tomato
Logistics	20	11	11	23	27
tipman	7	3	3	8	12
oprtrans	3	0	2	6	2
comptemb	10	8	6	9	13
Operations	24	8	8	24	26
tipcotr	10	4	4	9	5
fornemb	6	1	4	6	9
clarecla	8	3	0	9	12
Technology	25	16	15	18	20
camfria	10	1	4	6	3
tratpos	7	8	6	9	10
tiptns	8	7	5	3	7
Trade	50	34	30	41	53
tipreserv	8	4	4	2	8
prcprom	10	7	6	8	13
acmovpr	9	7	6	8	13
comp	9	8	5	6	6
compop	4	0	3	8	1
destcomr	10	8	6	9	12
Management	18	12	12	15	21
cntrdesp	10	0	6	6	10
pffixo	8	8	6	9	11
Average waste	3.5	2.4	16.6	1.3	0.7
Total shares	137	81	106	121	147
Minimum number of shares	12	9	11	11	7
Maximum number of shares	15	13	15	14	14

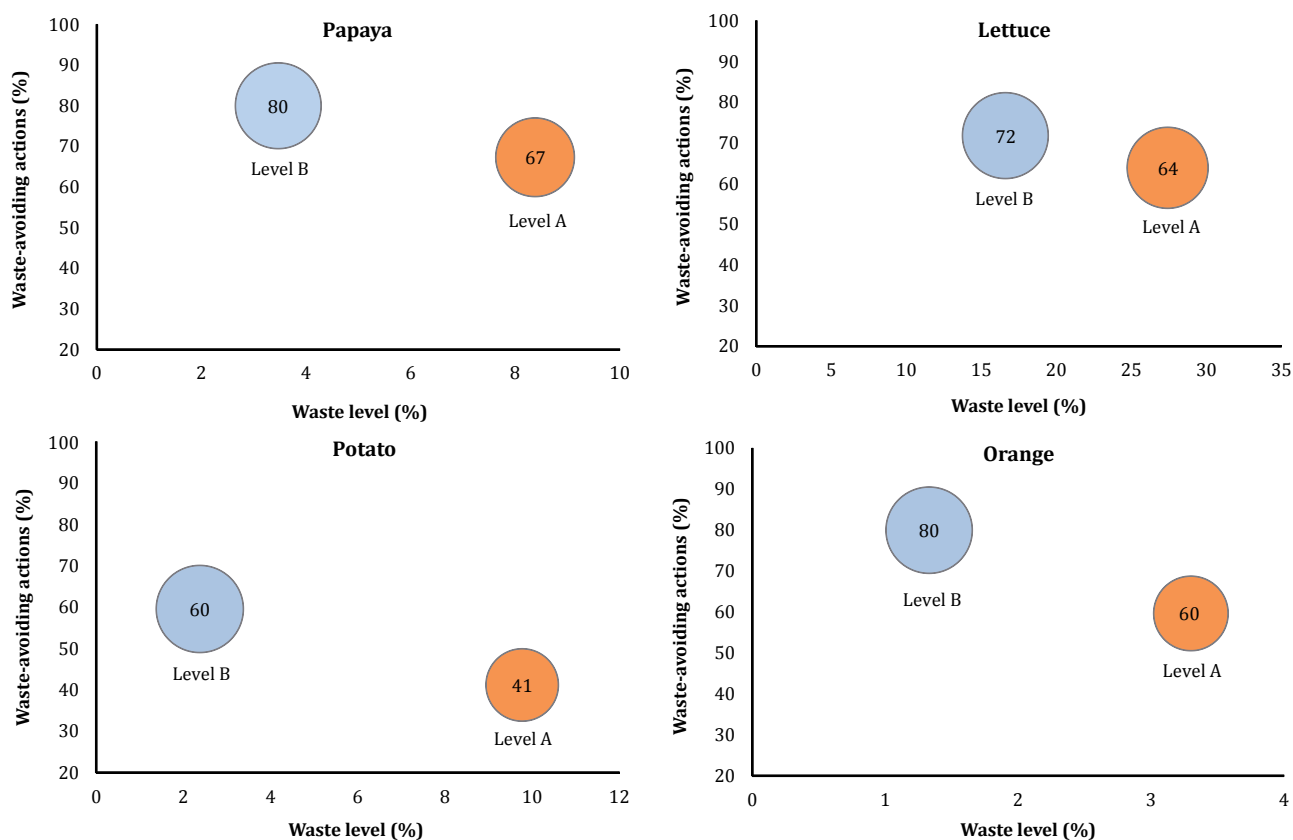


Figure 2. Levels of declared waste and number of anti-waste actions.

Figura 2. Niveles de residuos declarados y número de acciones que evitan los residuos.

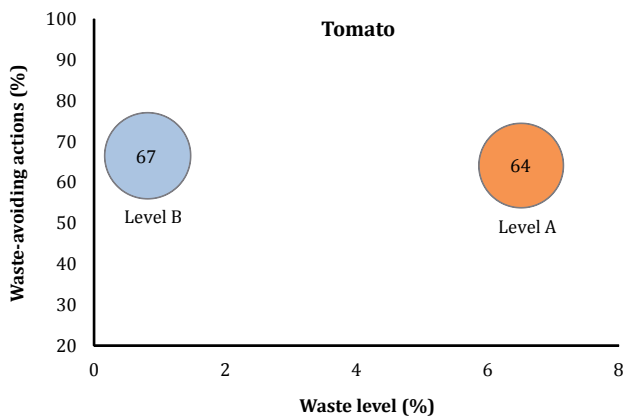


Figure 2 (cont.). Levels of declared waste and number of anti-waste actions.
Figura 2 (cont.). Niveles de residuos declarados y número de acciones que evitan los residuos.

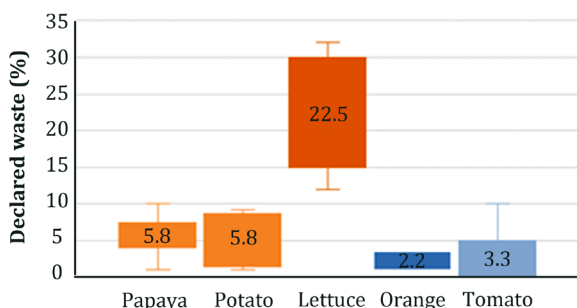
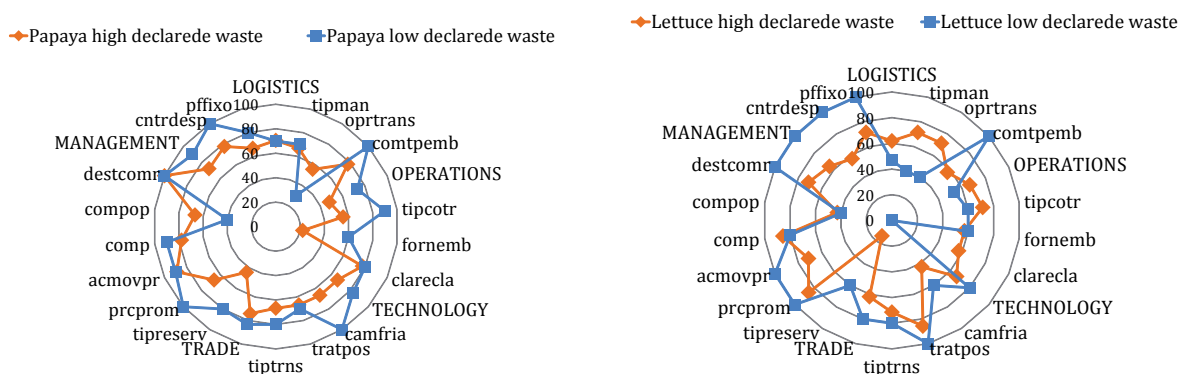


Figure 3. Declared waste of evaluated fruit and vegetables.
Figura 3. Desecho declarado de las frutas y verduras evaluadas.

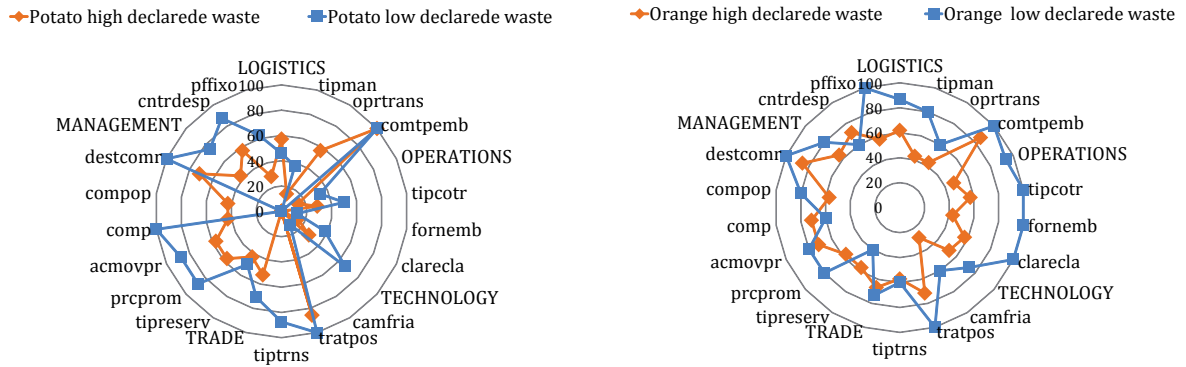


Legend: tipman: trade handling operations, oprtrans: transshipment operations, compsemb: package trading, tipcotr: type of control for traded products, fornemb: supplying package, clarec: classification and reclassification operations of sold products, camfria: cooling chamber, tratpos: postharvest treatment, tiptrns: transport type, tipreserv: provision of services, precprom: promotional pricing, acmovpr: track price changes, comp: purchase by contract, compop: purchase by opportunity, destcomer: unsoldable sent products, contrdesp: waste control, pffixo: fixed producer or supplier.

Leyenda: tipman: operaciones de manipulación comercial, oprtrans: operaciones de transbordo, compsemb: comercio de paquetes, tipcotr: tipo de control para productos comercializados, fornemb: paquete de suministro, clarec: operaciones de clasificación y reclasificación de productos vendidos, camfria: cámara de enfriamiento, tratpos: poscosecha tratamiento, tiptrns: tipo de transporte, tipreserv: prestación de servicios, precprom: precios promocionales, acmovpr: seguimiento de cambios de precio, comp: compra por contrato, compop: compra por oportunidad, destcomer: productos enviados no vendidos, contrdesp: control de residuos, pffixo: fijo productor o proveedor.

Figure 4. Percentage contributions of dimensions and indicators to papaya and lettuce waste levels.
Figura 4. Contribuciones porcentuales de dimensiones e indicadores a los niveles de residuos de papaya y lechuga.

For low potato waste, the highest frequencies were observed for management and trade, 80 and 70%, respectively (figure 5).



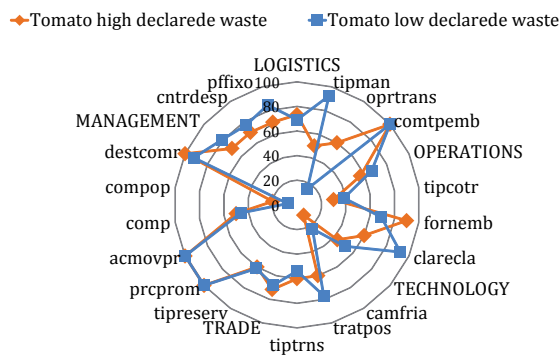
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Figure 5. Percentage contributions of dimensions and indicators to potato and orange waste levels.

Figura 5. Porcentaje de contribuciones de dimensiones e indicadores a los niveles de desechos de papa y naranja.

The highest frequencies of the operations dimension (93.3%) and logistics dimension (86.7%), were observed for orange low waste (figure 5). The highest frequencies in the management dimension were 80.8% for low tomato waste and 70.0% for high tomato waste (figure 6).



Legend: tipman: trade handling operations, oprtrans: transshipment operations, comptemb: package trading, tipcotr: type of control for traded products, fornemb: supplying package, clarec: classification and reclassification operations of sold products, camfria: cooling chamber, tratpos: postharvest treatment, tipttrns: transport type, tipreserv: provision of services, prcprom: promotional pricing, acmovpr: track price changes, comp: purchase by contract, compop: purchase by opportunity, destcomer: unsoldable sent products, cntrdesp: waste control, pffixo: fixed producer or supplier.

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Figure 6. Percentage contributions of dimensions and indicators to tomato waste levels.

Figura 6. Contribuciones porcentuales de dimensiones e indicadores a los niveles de residuos de tomate.

For the supply and marketing logistics of papaya and potato, low and high waste were associated with the greater number of actions taken by wholesalers (figure 7). For the distribution and marketing logistics of tomato, lettuce and orange, no significant differences among high and low waste generation and number of anti-waste actions, could be found (figure 7).

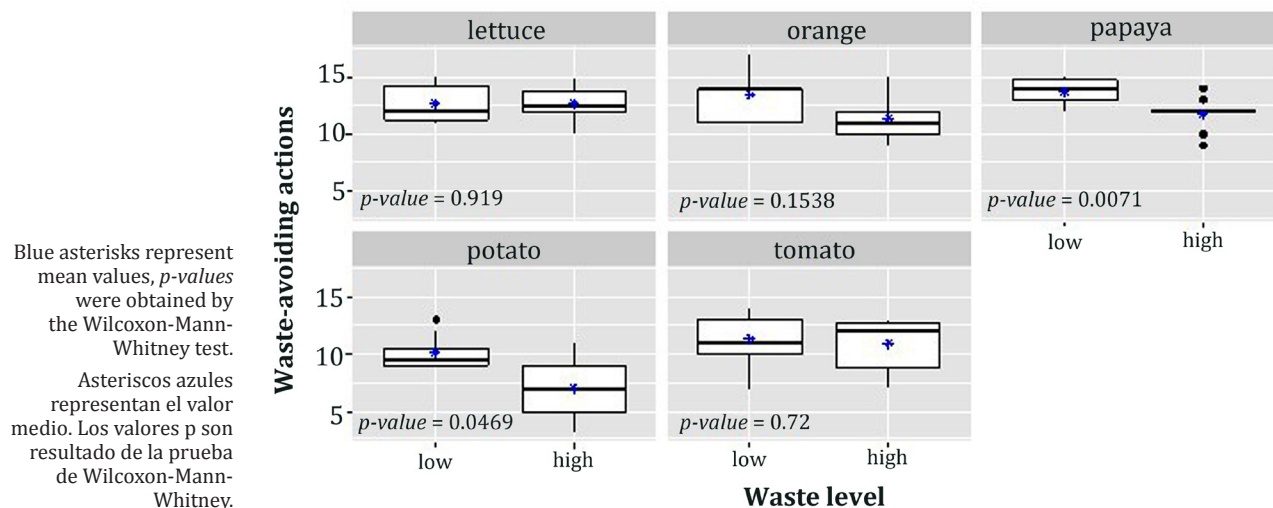


Figure 7. Boxplot of the number of anti-waste actions by level of waste, for each product.
Figura 7. Boxplot del número de acciones anti-desperdicio por nivel de desperdicio, por producto. Asteriscos azules representan el valor medio.

DISCUSSION

For papaya, the low content of declared waste resulted to be associated with the use of cardboard boxes, plastics and other types of packaging, as well as the use of cooling chambers that contribute to a slower cellular metabolism and longer storage. On the other hand, some practices such as transshipment operations, open truck transport (often covered with canvas) and the use of “K” type packaging (wood), were associated with higher waste levels.

Potato, with the same declared waste level as papaya, also shares inadequate storage and commercialization. Load stacking and the volume of potato packages (20 kg) contribute to accelerating tuber metabolism and its consequent deterioration.

The low frequency of operation and management variables contributed to higher waste production for all the evaluated products. Levels of waste in the distribution and supply chains varied according to the product considered and were related to procedures in the distribution and marketing logistics chains. A complex intersection between declared waste, defined variables, wholesalers, and established procedures in the distribution and marketing logistics determine that the highest levels of waste are related to inadequate commercial and logistics practices, technical limitations and inappropriate storage, commerce and transportation infrastructure (11, 19). According to Abiad and Meho (2018), equipment, low quality techniques and inadequate handling in the fruit and vegetable chain cause mechanical, physiological and pathological damage. Fruit and vegetable waste is associated, to a greater or lesser extent, with specific conditions of the distribution and marketing logistics, such as: storage, processing, packaging, transportation and marketing (8, 23, 32). According to Kasso and Bekele (2018), maintaining relative humidity provides longer shelf-life and quality, reducing postharvest losses and deterioration. Other factors such as the use of cooling chambers, plastic or cardboard packaging, storage, adequate transport and shorter distances are also associated with lower levels of waste. The main factors causing postharvest loss and quality deterioration are also related to improper handling, cargo handling operations, inadequate packaging, inappropriate transport, storage, processing and display for sale (28, 38). In addition, shared fruit and vegetable transport, or combining different stages of ripeness, may negatively impact quality, accelerating maturation (6).

CONCLUSION

The larger the expanded area of the radar chart formed (figure 4, page 214; figure 5, page 215 and figure 6, page 216) the lower the level of waste declared for papaya and potato. For these products, high and low frequencies of all dimensions are associated with high and low waste, respectively.

For the distribution and marketing logistics of tomato, lettuce and orange, no significant differences for high and low waste in relation to the number of anti-waste actions was found.

Papaya and potato waste generation at CEASA Campinas involve multiple factors and depend on the practices established in the distribution and marketing chains.

Due to the physiology of the fruits and vegetables analyzed, and given post-harvest conditions, some level of food waste is expected. However, to establish good practices aimed at minimizing waste in these chains, is necessary.

Considering the characteristics of each product and the practices established in each distribution and marketing logistics, to compare different products does not lead to an assertive assessment of facts. Since each product demands different and specific conditions of transport, packaging, cooling and storage, a careful analysis of the various dimensions and variables, must be approached.

This work does not represent a definite assessment of waste from the perspective of the CEASA Campinas distribution and marketing logistics. However, it stresses the need to create instruments capable of reliably quantifying food waste, with demands to be met by local public authorities and the industry, in order to minimize fruit and vegetable losses in wholesale markets.

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