Research contributions to estimation of tomato postharvest losses in Brazil[1]

Augusto Hauber Gameiro, José Vicente Caixeta-Filho, Thiago Guilherme Péra.

Group of Research and Extension in Agro-industrial Logistics (ESALQ-LOG), University of Sao Paulo, Brazil.

Introduction

The supply of tomatoes for consumption or processing is a relatively complex activity, especially given the perishability of the fruit. Large-scale plants require large volumes of raw material. Evidence confirms that there are significant logistics losses (Gameiro et al., 2007). In 2013 the Brazilian production of tomatoes was 4.187 million tons, in an area of 62,690 hectares, generating a gross value of agricultural production estimated at R$ 5.220 billion or US$ 2.420 billion (IBGE, 2015). Part of that volume is destined for industrial processing of foods such as sauce, extracts, pulps, catchups, juices etc. The proper management of the raw material is a key point for the competitiveness in the sector.

It is known that the tomato fruits are highly perishable with a very thin peel, becoming a fragile material for handling and transporting. The fruit has in its composition approximately 93% to 95% water. Empirical evidence report high values of existing losses in supply, therefore efforts to optimize the supply logistics are required.

Objectives

The objective of this paper is to present some progress made in recent years related to methods of estimation of post-harvest losses of tomato for both fresh consumption and for industrial processing in Brazil.

Methods

We will discuss three research results developed by ESALQ-LOG Group: Costa & Caixeta-Filho (1996), Gameiro et al. (2007) and Gameiro et al. (2008). Henceforth we refer to these results as P1 (from "paper 1"), P2 and P3, respectively. We will highlight the progress and discuss the difficulties and limitations met. Thus, we aim to contribute to the discussion of a research and development agenda regarding the tomato PHL issue for the coming years.

P1 intended to analyze the economic effects of post-harvesting losses for tomato for fresh consumption, specifically during its transport and commercialization, since the producing area of Apiaí city to the "Mercado Municipal of Piracicaba", in Piracicaba city (both in Sao Paulo State). Three agents were identified in this commercialization channel: the producer, the middle-man and the retailer. It was analyzed, through non-linear programming techniques, the variations of prices, quantities, revenues and margins in relation to the increase of the transportation and retail market losses, as well the changes in the supply and demand price elasticities.

In P2 and P3 we followed closely the whole process of harvesting and industrial supply of tomatoes in a facility located in the Brazilian Midwest region. In P2, the data collected in the field were harvest fruit weights, waiting times, load disposal on trucks and losses involved. For the estimation of tomato PHL, we carried out an experiment in which we measured the weight difference of samples arranged in loads of 8 trucks that had waiting times properly controlled. The fruit waiting times inside the boxes in the field after manual harvest were found (waiting to load the trucks) and the fruit waiting time in the truck body (during traveling and waiting to unload at the facility). We obtained the weights by appropriate scales both in the field and in factory. Samples of 30 kg fruits were prepared, placed in polypropylene bags and placed at three different heights in the buckets. For each time two samples were prepared. Thus, in total,

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we outlined an experiment with 48 samples obtained from eight trucks in three heights and two samples per time. We used the data of percentage weight loss to adjust econometric models (multiple linear regression models) of losses for different waiting times (in the box and bucket) and load height inside the truck. The model considers manual harvest.

In P3 a deterministic simulation mathematical model was developed with the objective of allow better knowledge of the whole process of tomato harvest, from the field to the facility, and to estimate possibilities of optimization. The simulation using the model generated different scenarios that, when compared with the real performance in field, show the importance of the accurate management, with evident potential of expressive financial gains in the supply chain process due the reduction of time, losses and costs.

Results

Through P1 we surprisingly noticed that any kind of losses in post-harvest channel was beneficial for the producer, because there was an increase of prices followed by an increase in the demanded quantity. On the other hand, the middle-men were indifferent to increases in losses, either at the retail or at the middle-man level, because they sell in volume (number of boxes) and the losses are accounted in weight (kg). For the retailers, the losses in any market level were not interesting, because they buy in volume and sell in weight, incorporating their own losses as well the middle-men's ones. It was also confirmed that the consumer was always in prejudice with the increase of losses, because there is an increase in price related to a reduction in the quantity demanded.

The experiment for measuring losses described in P2 generated the data that we used to estimate the loss equations. We tested different models with and without constant, with simple variables, square and cross ones. The models showed regression coefficients (R2) between 56.9% and 66.6%. In most of them, the estimated coefficients were significant for the "t" test at 5% significance. As expected, the signs of the variables related to time (time in the boxes and time in the back of trucks) showed positive signs indicating that the higher this time, higher product losses. For the height variable, the signal found (in models 1 and 2) were negative, also going to meet expectations. Thus, the greater portion of the height of the product is determined, the lower the weight pressure on the fruit and thus the losses are smaller. Comparing the seven tested models, we elected the #6. In addition to submitting the highest regression coefficient, t-tests were significant for two of the three variables and the signs are consistent with the expected from the literature. Thus, the model indicates that losses are influenced by the waiting time in the boxes and in trucks (where the pressure on the fruit is higher), and this has its effect on losses potentiated by the time the fruits were inside the boxes, in the field, waiting for the loading (cross variable). If we consider, for example, that the product has to wait 12 hours in the boxes at the field before being loaded into the truck and another 12 hours between the trip and the wait for unloading at the factory (these times were fairly representative of the Brazilian reality), the weight loss would be of the order 2.39%. Two assumptions and limitations should be considered from P2: i) due to the expansion of mechanical harvesting, new models should be proposed for this technology; and ii) new experiments should consider the variety of fruits, since it is known that some are more resistant than others.

The simulation model of supply logistics developed in P3 allowed us to conclude that the losses of product could be reduced from the current more than 2% for less than 1%. The reduction of production capacity idleness could be reduced to lower opportunity cost and higher total revenue. To a factory with a processing volume of more than 330 thousand tons per season, the improvements of the supply process by PHL could result in gains estimated of approximately of US$ 2.3 million/season.

Conclusions

Our general conclusions are that the developed researches - both for tomatoes for fresh consumption and for processing - with a focus on detailed mapping of the supply chain contributed to a better understanding and measuring of product losses. We conclude that the proposed methods for the estimation of tomato PHL are suitable, allowing quantifying the losses and thus signaling the importance of proper management of the process.

The main limitations - that consequently motivate new ideas - are: the need to consider different varieties of tomatoes; to develop similar research considering mechanical harvesting (whose use has increased significantly in recent years in Brazil); to develop new supply chain optimization models and, not only deterministic simulation ones.

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