Assessment of Fruit and Vegetable Waste at Wholesale Markets in Nepal for Vermicomposting

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ABSTRACT

An appraisal of the current post harvest practices and losses of horticultural produces in the major fruit and vegetable wholesale markets of Nepal was conducted to quantify the amount of fruits and vegetable wastage. This study was conducted with the view to generate useful information about the causes of loss of horticultural produce and also quantify the amount of fruit and vegetable wastage being accumulated in the market centers so that such organic wastes could be reused as resource for vermicomposting. Shelf life of different vegetable species and the nutrient content of the wastage samples of different species of vegetables were also evaluated. Survey of the three major market centers namely; Narayangadh, Pokhara, and Kalimati fruit and vegetable wholesale market and series of laboratory experiments were conducted. Forty five wholesalers and 90 retailers were selected for the study. Data were collected using structured questionnaires. The results indicate that among 45 wholesalers no one has cold storage facility which is the major cause of loss of produce. From regression analysis it was concluded that lack of cold storage facility and inappropriate packaging facility had significant effect on the loss of the produce. Regarding the wastage accumulation, maximum wastage was accumulated during the months of July to October, up to 20 tons per day in Kalimati wholesale market, Kathmandu. Total of 80% of the wastage was simply discarded as garbage, 10-15% used as animal feed and about 5% used as source for composting and vermicomposting. Leafy vegetables contributed the most in wastage accumulation. The shelf life of leafy vegetables was significantly (at p = 0.05) the lowest (1 day) at the ambient storage condition as compared to other vegetable types. Regarding the nitrogen content of the wastage samples, the leafy vegetable wastes (5.25%) and legume vegetable wastes (4.48%) were statistically at par and significantly (p = 0.05) higher than other treatments. Except the wastage sample of root vegetables (0.37%), other four treatments were not statistically different (0.69%- 0.78%) in phosphorus content. Potassium content of the wastage sample of leafy vegetables were significantly the highest (1.32%) (at p = 0.05) and statistically not different with wastage sample of legume vegetables (1.12%) and composite wastage sample (1.18%).

Keywords:

Fruit and Vegetable Waste, Wholesale Markets in Nepal, Vermicomposting, market centers, composting and vermicomposting

INTRODUCTION

Post-harvest loss of fruit and vegetable is a matter of great economic concern in Nepalese agriculture. A considerable proportion of the harvested produce never reaches the consumers, mainly because of post-harvest losses. The estimated post-harvest loss of fruit and vegetable in Nepal lies in the range of 20-50 percent (Gautam and Bhattarai, 2006). A 15-35 percent loss has been reported earlier in horticultural produce at different stages along the chain from harvesting to marketing (Kaini, 2000). In their fresh form fruit and vegetable are rich in water content and hence liable to deterioration; microbial, physiological as well as mechanical. Harvested fruit and vegetables are living entities and hence respiration and other physiological functions is a natural and common phenomenon in which absorption and release of gases and other materials from and to the environment takes place. All these ongoing physiological activities of fruit and vegetables make produce susceptible to deterioration during transportation and storage and the deterioration process is accentuated by high temperature and humidity conditions. According to Marangoni *et al.* (1996), temperature plays a vital role in the metabolism of fruits and vegetables. Metabolic activity in fresh fruit and vegetables continues even after harvest and energy for this process comes from respiration and so storage of harvested produce is to be done in appropriate temperature and humidity controlled environment to retard the rate of metabolic activities (Mannapperuma, 1991).

Marketing of horticultural commodities in Nepal is still a big challenge. For local markets use of tractors and vans is a common practice. Various horticultural produces are brought to the market in the same carriage, stacking one upon another haphazardly and without proper packaging practices. Common load carrying trucks and tops of passenger buses are the major and only modes of transportation being used for long distance transportation. During the transportation of fruits and vegetables from the production site to the consumption site i.e. city areas, a huge percentage of damage is inevitable. Massive losses are reported to occur during the post-harvest chain due to the lack of proper temperature and humidity controlled storage facility and improper and rough handling (Kaini, 2000). About half of the losses are due to physical injuries and improper handling during storage, and distribution (Cortez, Honório and Moretti, 2002). Various factors responsible for losses could be management inexperience, harvesting practices, packaging methods and handling at the retailers (Resende, 1979). Neder (1992) focused on the influence of physical damage responsible for the biological deterioration of fruit and vegetables. Lack of know-how associated with poor post-harvest facilities and poor management are the major causes of post-harvest loss. Lack of proper temperature controlled storage conditions is a matter of great concern, and so availability of such storage facilities is a must to avoid such loss in horticulture produce. In the lack of proper storage facilities the shelf life of the perishables is minimized and so a large amount of wastage is generated in the market centers. Those fruit and vegetable species with minimum shelf life under the ordinary/ambient storage conditions in the market centers are maximum contributors to the waste generation at the market centers. Buyukbay *et al.* (2010) reported inadequate post-harvest handling, lack of appropriate storage facilities, poor infrastructure and poor marketing system as the principal causes of damage and loss of horticultural produces.

Proper disposal of vegetable and fruit wastage being generated in the fruit and vegetable collection centers and wholesale markets is a headache for the concerned authority as well as the wholesalers and retailers. This waste can be used as cheap and easily available resources for composting and bio-fertilizer production and vermicomposting which could be a best alternatives to the current disposal system at dumping sites. Organic-based agriculture production is an emerging technology in the present context which not only solves the waste disposal problem through the conversion of bio-degradable waste into organic fertilizers but also ensures the year round availability of organic fertilizers for crop production. This study aims to assess fruit and vegetable waste as potential feedstock for vermicomposting with the following specific objectives.

- To assess post-harvest handling practices and loss of fruit and vegetable at major wholesale markets in Nepal so as to assess the total fruit and vegetable wastage collection in the respective markets.
- To assess the shelf life of different vegetables species under ambient storage conditions.
- To quantify the proportion of different components of wastage and their nutrient content.

METHODOLOGY

Methodology of the research consists of two parts; the first part comprises a survey with marketers and second part a series of laboratory experiments.

The first part of the research is descriptive in nature. Surveys were carried out in the fruit and vegetable wholesale markets at three densely populated cities namely; Kathmandu, Pokhara and Narayangadh where almost all types of fruits and vegetables are being marketed. Forty five wholesalers and 90 retailers were selected for the study. Data were collected using structured questionnaires. All the available data were transferred to analytical software, SPSS and analyzed. With the use of SPSS, frequency of variable, ranking of the variables, regression and weighted averages were analyzed. Weighted average analysis was calculated to value the overall wastage and regression analysis was performed to identify the determinants of overall losses.

A series of laboratory experiments were conducted in order to accomplish the following defined objectives.

Shelf life of different vegetable species under ambient storage condition

An experiment was conducted to analyze the storability of the seasonal vegetables under ambient storage condition.

Freshly arrived seasonal vegetable samples were purchased in the morning from the Narayangadh wholesale market and brought to the horticultural lab for the study. Treatments were fixed so as to include various categories of vegetables viz., leafy vegetables, root vegetables, legume vegetables and fruit vegetables based on the availability. The brought vegetable species were kept in a flat tray and placed inside the horticulture laboratory in ambient condition. There were 9 treatments.

Treatment details

T1: Coriander (100 gm)
T2: Broad leaf Mustard (100 gm),
T3: Carrot (500 gm)
T4: Radish (500 gm)
T5: Cowpea (500 gm)
T6: French bean (500 gm)
T7: Okra (250 gm)
T8: Tomato (500 gm)
T9: Sponge gourd (500 gm)

Design: Completely Randomized Design (CRD) with 3 replications.

Observation

Shelf life of the commodities: Daily observation was taken on the physical appearance of the treatments. When about half of the amounts of the commodities of each treatment were damaged / decayed and considered unmarketable, this was considered as the end of the shelf life of the commodities.

Nutrient content of the wastage sample of different vegetable species

Composite sample of vegetable wastes (fruit waste was minimal) was taken from the heap of wastage. The waste was segregated into individual components to define various treatments. The samples were oven-dried and taken to the Soil Science Department of NARC (Nepal Agriculture Research Council) for analysis of nitrogen, phosphorus and potassium. There were 5 treatments.

Treatment details

T1: Leafy wastes (including leafy vegetables and leaves of cole crops)
T2: Underground/Root vegetables waste
T3: Leguminous vegetables waste
T4: Fruit vegetables waste
T5: Composite waste sample

Replication= 4 (The samples were collected on four alternate days)

Design: Completely Randomized Design (CRD)

Data analysis

Data entry was carried out to develop ANOVA table, and DMRT was applied for mean separation of nutrient content of the wastage samples and shelf life of the vegetable species under ambient storage condition.

RESULTS AND DISCUSSION

Availability of cold storage

During the survey it was found that the cold storage facility was completely lacking (Table 3) in the wholesale market periphery and thus according to the traders some portion of fruits and vegetables that arrives at wholesale markets in the country is discarded as waste due to the lack of proper temperature and humidity controlled storage facilities.

Table 1. Availability of cold-storage among wholesalers in three major fruit and vegetable markets in Nepal, 2012

Response	Narayangadh	Pokhara	Kalimati	Total
Yes	-	-	-	-
No	15(100)	15(100)	15(100)	45(100)
Total	15(100)	15(100)	15(100)	45(100)

One of the most important known methods to retain the freshness and quality of fresh fruits and vegetables is the utilization of cold-storage i.e. refrigeration. A temperature controlled supply chain during the marketing of produce is a must. An uninterrupted series of storage and distribution activities maintained at a given temperature range reduces the losses of perishable horticultural produce. Such reduction in loss due to uninterrupted cold-chain was reported by Ilic and Vukosavljevic (2010).

Number of distribution channels

A total of 90 retailers were interviewed during the survey and it was observed that by the time the produce reaches the hand of the retailers, 4-5 distribution channels were involved (75.6 percent) followed by ≤3 channels (14.4 percent) or >5 channels (10 percent). More steps in distribution channels i.e. more intermediaries between producer and consumers, leads to increased losses of the produce, because produce is loaded and unloaded each time the ownership changes. During loading and unloading, rough handling of the produce leads to mechanical damage to the produce which acts as an avenue for microbial attack and finally leads to decay and rotting of the produce. To reduce these losses different measures are recommended, careful and gentler handling of the produce, faster transportation and proper storage during each loading and unloading (Rolle, 2006).

Table 2. Number of distribution channels involved during the marketing of the produce at three major wholesale markets in Nepal, 2012

No. of distribution channels	Narayangadh	Pokhara	Kathmandu	Total
≤3	6 (20)	5 (16.7)	2 (6.7)	13 (14.4)
4-5	20 (66.7)	22 (73.3)	26 (86.7)	68 (75.6)
>5	4 (13.3)	3 (10)	2 (6.7)	9 (10)
Total	30 (100)	30 (100)	30 (100)	90 (100)

Figures in the parenthesis indicates percentage

The distribution channels involved were:

Channel-1: Farmer - Pre-harvest contractors – Wholesalers – Retailers - Consumers

Channel-2: Farmer – Wholesalers – Retailers - Consumers

Channel-3: Farmer – Wholesalers - Consumers

Channel-4: Farmer -Farmer's co-operative society - Consumers

Channel-5: Farmer - Pre-harvest contractor - Commission agents – Wholesaler – Retailer - Consumer

Packaging materials used by wholesalers

Out of 45 respondents it was seen that all the respondents (100 percent) use plastic bags and sacks as packaging material (Fig. 1). Similar practices of packaging of produce were seen prevailing in all the three markets. The use of plastic bags and sacks do not protect the fruits and vegetables from mechanical damage as they cause fruit and vegetable loss by crushing and mechanical injury. El Assi (2004) reported that large congestion of fruits and vegetables creates high heat in sacks due to physiological change by metabolic reactions which in turn accelerate mechanical damage and microbial attack.

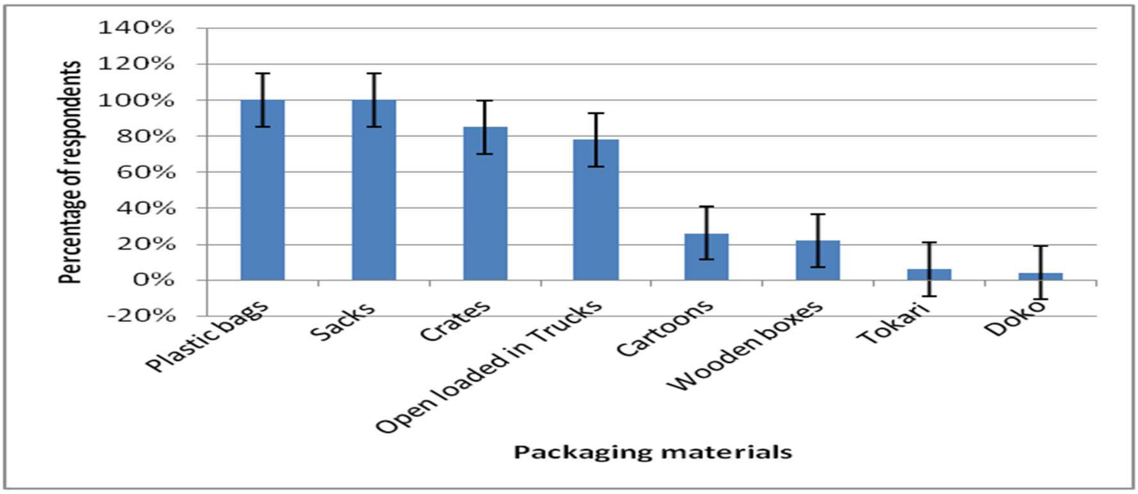

Figure 1. Distribution of average multiple responses about the packaging materials being used by wholesalers at the three major wholesale markets in Nepal, 2012

Weighted average analysis

In order to calculate the total value loss of the horticultural produce, weighted average of the overall loss of produce has been calculated by considering the percentage value as weights and mid value of the wastage range as average loss. This loss gives the value of overall wastage of horticultural produce from harvest point to the market centers at different stages. The weighted average analysis suggests that 25 per cent of the total produce harvested is simply thrown as wastage. This clarifies that 25 percent of the total investment on the production of fruit and vegetable is a complete loss due to inappropriate post-harvest facilities and simply discarded as garbage. Veena *et al.* (2011) reported that close to 30 percent of harvested fruits and vegetables is going to waste every day.

Regarding the percentage of loss in horticultural produce similar responses were obtained from the three markets. Maximum losses (35-40 percent) were reported by the respondents in leafy vegetables during the rainy seasons. All the respondents from the three markets responded that during rainy season horticultural produce are liable to maximum loss even up to 35 percent.

Table 3. Weighted average of overall wastage at the major wholesale markets in Nepal, 2012

Wastage range	Frequency (No. of respondents)	Percentage of respondents	Average wastage (mid-value of wastage range)	Weighted average of overall losses
15-20 percent	16	17.8	17.5	WA={(17.8×17.5)+(33.3 ×22.5)+(28.9×27.5)+(13.3×32.5)+(6.7×37.5) } /100
20-25 percent	30	33.3	22.5	= 311.5+749.25+794.75+432.25+251.25/100
25-30 percent	26	28.9	27.5	= 2539/100
30-35 percent	12	13.3	32.5	= 25.39
35-40 percent	6	6.7	37.5	= 25 percent

Wastage accumulation

Figure 5 shows the wastage accumulation in the three major wholesale market centers in Nepal during three seasons. Frequent observation of the market centers was done during various seasons i.e. rainy season (July-Oct), winter season (Nov-Feb) and dry season (Mar-June) to quantify the amount of wastage. During the months of July – October 20 Mt/day wastage generation occurs in Kalimati market, Kathmandu followed by 9 Mt/day in Pokhara wholesale market and 3 Mt/day in Narayangadh wholesale market on fresh weight basis.

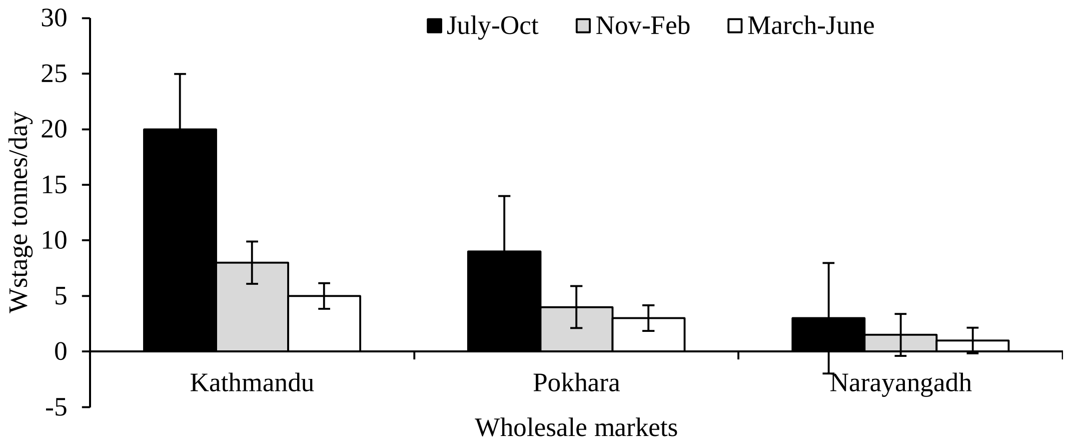

Figure 2. Wastage accumulation per day at three major wholesale market centers in Nepal, 2012

Since fruit and vegetables are the major market arrivals, so they are the major wastage contributors, though other materials as packaging materials such as plastic, Styrofoam's (apple covering) also contribute to wastage generation. The observation made in the fruit and vegetable wholesale market of Narayangadh is presented in Figure 3, which clarifies that 95 percent by weight of the wastage is bio-degradable.

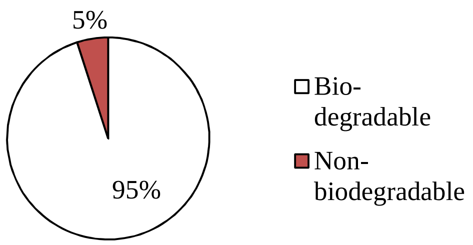

Figure 3. Observation of percentage of Biodegradable and Non-biodegradable waste by weight at Narayangadh fruit and vegetable wholesale market, Nepal, 2012

Disposal of accumulated wastage at market centers

During the survey among three wholesale markets it was concluded that almost 80 percent of the accumulated wastage was simply disposed as garbage. Such accumulated wastage is disposed by the municipality in the dumping sites/ landfill sites. The remaining 20 percent of the wastage is being used in some useful manner as cattle feed and hog feed and composting. Farmers visit wholesale markets every day to collect the wastage to feed their animals and as animal farms these days are increasing in the urban and peri-urban areas, consumption of such wastage as animal feed is also increasing. However for the purpose of composting of such wastage, people come to market once in 15-20 days with their mini trucks and take away the wastage. Only a few persons are involved in such business so not much wastage is used in composting and vermicomposting.

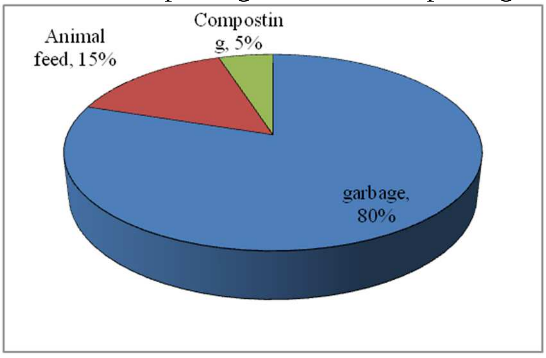

Figure 4. Disposal of accumulated wastage at the major wholesale market centers

Shelf life of the commodities under ambient storage condition

The experiment was carried out to ascertain which type of vegetables was prone to maximum loss during storage in ambient condition, as the wholesale markets of Nepal are devoid of cold storage facility. Almost all the respondents during the survey had the opinion that the leafy vegetables were prone to the maximum loss and so the experiment was conducted to confirm or otherwise this result.

Table 4. Shelf life of vegetable species at ambient (29±2˚C) storage condition at IAAS Rampur, 2012 August

Treatment	Shelf life (Days)
T1 (coriander)	1.00d
T2 (BLM)	1.00d
T3 (Carrot)	3.33c
T4 (Radish)	3.67bc
T5 (Cowpea)	3.00c
T6 (French bean)	4.33b
T7 (okra)	3.67bc
T8 (Tomato)	11.33a
T9 (Sponge gourd)	3.33c
Mean	3.85
LSD (0.05)	0.81
CV (percent)	12.24

The shelf life of leafy vegetable (Coriander and BLM) was significantly (p=0.05) lower than other vegetables. However, the shelf life of coriander and BLM were statistically at par. Tomato had the significantly (p=0.05) highest shelf life The minimal shelf life of leafy vegetables might be due to the factors as surface area-to- volume ratios, maturity stages and surface injuries during handling. Leafy vegetables being harvested and marketed at their young and tender stage have high metabolic activities which lead to a shorter shelf life than other vegetables. The maximum shelf life seen with tomato might be due to the presence of a natural protective surface layer which helps to retard the water loss from the fruit. Similar results for shelf life of tomatoes were reported by Rahman *et al.* (2010) and Subburamu *et al.* (1990) in their studies.

The result signifies that the leafy vegetables with their minimum shelf life in ambient storage condition are likely to deteriorate faster than other species and so it is not uncommon to see heaps of leafy vegetable wastage being accumulated at the market centers more than other vegetable species.

Nutrient content of wastage samples

This experiment was conducted to determine the nutrient content of the waste samples, to conclude whether the wastage could be utilized for vermicomposting or not.

Table 5. Nutrient content of different wastage samples detected at Narayangadh market in August, 2012

Treatments	N%	P%	K%
T1 (Leafy wastes)	5.25a	0.78a	1.32a
T2 (Root vegetable wastes)	1.20c	0.37b	0.89b
T3 (Legume vegetable wastes)	4.48a	0.73a	1.12ab
T4 (Fruit vegetable wastes)	2.84b	0.75a	0.99b
T5 (Composite waste sample)	3.12 b	0.69a	1.18ab
Mean	3.43	0.66	1.10
LSD(0.05)	0.65	0.24	0.27
CV (percent)	12.62	15.91	16.13
SEm(±)	0.22	0.08	0.09

The Nitrogen content of leafy vegetable wastage samples (T1) and leguminous vegetable wastage sample (T3) was significantly (p=0.05) superior to other treatments. The phosphorus content was statistically (p=0.05) similar within all the treatments other than treatment 2. Regarding the potassium content of the wastage samples, treatment 1 was significantly (p=0.05) superior than T2 and T4 and treatment 3 (T3) and treatment 5 (T5) were statistically at par with treatment 1 (T1). With such nutrient content of the wastage samples it would be a right decision to use such wastage as resources for vermicomposting, rather than simply discarding and disposing as garbage.

CONCLUSION

Lack of proper post-harvest facilities at the fruit and vegetable wholesale markets huge amount of fruit and vegetables is wasted every day. Ninety five percent of the accumulated wastage at the fruit and vegetable wholesale market centers being biodegradable is easily recyclable. This is a cheap and easily available resource which can be recycled through various methods of vermicomposting and composting, and the final product reused as bio-fertilizers such as vermicompost and compost. In fact, it could be a close nutrient cycle starting from farmers' field through market centers to again in farmers' field as vermicompost.

NPK content of the composite waste sample from the pile of fruit and vegetable wastes being 3.12 %, 0.69% and 1.18% respectively the nutrients could be recovered through vermicomposting rather than disposing as garbage. Thirty two tonnes of fruit and vegetable wastes (95 percent being bio-degradable) collected per day during the months of July-October in three major market centers can supply 0.9 tonnes of nitrogen, 0.2 tonnes of phosphorus and 0.4 tonnes of potassium per day. This amount of nitrogen, phosphorus and potassium if recovered through vermicomposting will save Rs78, 260 for urea, Rs 62,500 for SSP and Rs 40,000 for MoP per day. Through the use of new and innovative technology of vermicomposting such organic wastes can be converted into organic fertilizers rich in nutrient content. In fact, vermicomposting is a 'win-win' solution to deal with the problem of safe disposal of wastage because of the increasing rate of waste generation and high collection and disposal costs associated with it. Such an approach could lead to sustainable development with an efficient utilization of available resources. Nepalese farmers are facing the problem of timely unavailability of fertilizers which is a major constraint for their high productivity. This technology may partially substitute the import of expensive chemical fertilizers creating new employment opportunities which ultimately leads to income generation and poverty reduction. Moreover, farmers these days are aware about organic agriculture and ill-effects of chemical fertilizers on soil health which has led to the high demand of organic fertilizers. Thus, this technology not only solves the problem of disposal of garbage from the fruit and vegetable market centers but also helps in fulfilling the fertilizer demand of our farmers which is a major constraint of Nepalese agriculture.

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