Food and Agriculture Organization of the United Nations

# Analysis of food loss in the cucumber, zucchini and table grapes value chains in the West Bank, Palestine

## Causes and Solutions

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Cairo, 2023

Required citation:
FAO. 2023. *Analysis of food loss in the cucumber, zucchini and table grapes value chains in the West Bank, Palestine – Causes and Solutions.* Cairo. https://doi.org/10.4060/cc7787en



ISBN 978-92-5-138177-9


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# Acknowledgements

This report was prepared by the Palestine Economic Policy Research Institute (MAS), under the coordination of Raja Khalidi, Research Coordinator, and supported by the following team of experts: Jamil Harb (Team leader); Nahed Samara; Tareq Sadeq; Mohammad Omari; Amena Jaber; Dalia Abu Thaher; Manal Shuaib and Mohammad Al Wawi. Hala Chahine, Associate Professor, Post-harvest Specialist, Lebanese University, Beirut carried out the technical review. At all stages of research and drafting, activities were conducted with the guidance of the FAO Office for Palestine, under the responsibility of Pirro-Tomaso Perri, former Policy Officer at the FAO–European Union Partnership Programme – FIRST. He worked in close collaboration with Azzam Saleh, Head of Programme, and under the overall supervision of Ciro Fiorillo, Head of Office. Technical supervision was conducted by Jozimo Santos Rocha, former Agro-Industry Officer, and Jennifer Smolak, Value Chain Specialist, FAO Regional Office for the Near East and North Africa.

FAO and MAS wish to thank the Ministry of Agriculture of the Government of Palestine for facilitating the investigation. They especially appreciate the feedback provided by practitioners and inhabitants of the study areas, the representatives of various non-governmental organizations, rural associations, women's groups and local businesses who dedicated their time to taking part in interviews, focus group meetings and otherwise sharing their experience for this study. Design and layout by Shereen Najjar.

# Abbreviations

## Glossary

| | |
|---|---|
| **CG** | cucumbers consumed fresh and mostly cultivated in greenhouses |
| **CLP** | critical loss points |
| **CP** | cucumbers designated for pickling |
| **du** | dunum (=0.1 hectare) |
| **FSC** | food supply chain |
| **GHG** | greenhouse gases |
| **IrrSDTG** | irrigated seeded table grapes |
| **LLP** | low loss point |
| **MAP** | modified atmosphere packaging |
| **MAS** | Palestine Economic Policy Research Institute |
| **n.d.** | no date |
| **PAL** | Palestine |
| **RfSDTG** | rainfed seeded table grapes |
| **SLTG** | seedless table grapes |
| **WB** | West Bank |

## Governorates

| | |
|---|---|
| **BET** | Bethlehem |
| **GS** | Gaza Strip |
| **HEB** | Hebron |
| **JEN** | Jenin |
| **JER** | Jericho |
| **NAB** | Nablus |
| **QAL** | Qalqilya |
| **TUB** | Tubas |
| **TUL** | Tulkarem |

## Ministries

| | |
|---|---|
| **MoH** | Ministry of Health |
| **MoA** | Ministry of Agriculture |

# Executive summary

Estimates of food loss and waste (FLW) in Palestine suggest that around 11 percent occurs during post-harvest handling and storage, with another 11 percent occurring during distribution. This study was undertaken to analyse the extent and causes of, and potential solutions to, food losses in three food subsectors that constitute important products in terms of income, food security and nutrition in Palestine; table grapes, cucumber and zucchini. It covered six food supply chains (FSCs).

The analysis for cucumber and zucchini FSCs took place during the main season, April 2020–June 2020. The assessment of the table grape FSCs was divided into two time slots, May–June 2020 for irrigated grapes, and September–October 2020 for rainfed grapes. The study followed the prescribed FAO methodology entitled, Food Loss Analysis: Causes and Solutions Case studies in the Small-scale Agriculture and Fisheries subsectors (FAO, 2016). This includes four phases; screening of available information and data; survey of farms, wholesale markets and retailer shops; sampling including collection and analysis of samples obtained from farms, wholesale markets and retailer shops and synthesis of results and recommendations. Primary data was collected from samples, assessed for all possible defects and injuries, and categorized for all classes of qualitative and quantitative losses (physiological, mechanical, and pathological). In addition, a load tracking 'trial' was performed to evaluate a potential solution for table grapes loss; cold storage coupled with modified atmosphere packaging (MAP). The results are presented in the Annex.

The COVID-19 pandemic occurred after the study was planned and obstructed the investigation. The pandemic also disrupted the agrifood sector and distorted the critical points along FSCs where losses were more likely to happen. Results show that retailer shops become a critical loss point for most FSCs given the ramifications of the COVID-19 crisis on household purchasing power.

An estimated 162 500 tonnes/year of cucumbers are produced for fresh consumption and 54 000 tonnes/year for processing. The major marketing channel for fresh cucumbers is through wholesale markets and retailer shops. The major actors in the cucumber FSCs for the Israeli market are farmers, owners of collection centres, and traders. For local markets, wholesalers and retailers are the major actors. Women play a significant role in family farming and harvesting.

Sixty cucumber farms, six retailer shops, and six wholesale markets were surveyed in this study. A major loss point for cucumber was identified as being at farm-level. Around 20 percent of processing cucumbers and around 5 percent of the greenhouse cucumbers are left unharvested or discarded if larger or smaller than the size demanded. Sampling results show that postharvest quantitative losses amount to 13.1 percent and 12.6 percent for processing cucumbers and fresh cucumbers from greenhouses, respectively. Losses are mostly related to mineral nutrition deficiency in cultivated plants and injury/damage sustained as a result of harvesting techniques, even if these manifest themselves further along the supply chain.

Potential loss-reduction measures for cucumbers include replacing the current rough harvesting containers with smooth containers and placing containers in ventilated areas to avoid heat build-up while waiting for transfer to the market.

Zucchinis are among the most commonly cultivated and consumed plants in Palestine. They are mostly produced in irrigated open fields and marketed through wholesale markets and retailer shops. Over 90 percent of zucchini products are marketed in the domestic market, which tolerates most defects caused by handling, particularly the slightly scratched fruits. Profits from zucchini production are more equally shared among the three main FSC actors (farmers, wholesalers, and retailers).

Forty zucchini farms, six retailer shops, and six wholesale markets were surveyed. The most significant critical losses happen at the production phase. Harvest time and harvesting practices lead to mechanical injuries of 10–15 percent of fruits. Quantitative losses for zucchini were 22.5 percent, with the major causes being pre-harvest factors, high temperature stress and transport. Potential loss reduction measures for zucchini are ensuring careful harvesting and handling, proper cultural management, and optimization in both fertilization and irrigation.

Table grapes produced under rainfed conditions principally originate from the Hebron and Bethlehem governorates. They are marketed as fresh in the local domestic market and processed into malban, dibs and jam. Farmers struggle to create profits, and many are forced to abandon their plots or shift to other cultures with more stable prices and less labour effort. Irrigated seeded table grape cultivation is concentrated in the northern West Bank. They are a cash crop with over 60 percent marketed in Israel. 100 percent of the product is consumed fresh, and the vine leaves productivity rate is estimated at around 400 kg per Du. Seedless grape production is highly industrialized and is concentrated in the Nablus and Jordan Valley governorates. It relies on Israeli traders and food companies for marketing, bypassing the local wholesalers and retailers.

Thirty grape farms, six retailer shops, and six wholesale markets were surveyed. The production phase also proved to be the main loss point, driven by market factors. Price fluctuations and supply gluts drive farmers to harvest grape clusters at the improper stage, a practice associated with various causes of losses. Results show that quantitative losses for irrigated grapes (seedless and seeded) and rainfed table grapes are 13.5 and 18 percent respectively. The major causes of losses are the lack of cold chain and dynamics in the markets. These factors became particularly evident during the COVID-19 pandemic. Extending the marketing window for table grapes through cold chain and proper packaging material can be a means to add value and prevent economic and food loss.

A major conclusion from this study is that qualitative losses deserve attention, particularly with the FSCs for zucchini and for table grapes from rainfed agriculture. Taking into consideration the high unemployment rate in Palestine, the social impact of reducing losses is significant, as more profits will enable farmers to expand their farms and hire more skilled resources. On the other hand, reducing the use of agrochemicals by at least a quarter will benefit the environment without necessarily increasing losses.

Finally, with the overall aim of reducing food losses in Palestine, other recommendations include: training programmes to improve extension services; regulatory enhancements to the marketability of fresh FSCs; improved regulation of the handling of agrochemicals, and a national multistakeholder initiative to develop FLW-focused reduction measures, policies and strategies.

# Introduction
# The cucumber, zucchini, and table grapes subsectors

## 1) Overview and importance of the subsectors

The total land area in both the West Bank (WB) and Gaza Strip (GS) is around 6 million dunums (du),[1] of which an estimated 1.4 million dunums is agricultural land (unpublished data from the Palestinian MoA in 2017). There are over 100 000 agricultural holdings, These are dominated by smallholders (State of Palestine, 2019b). Over two-thirds of the landholdings occupy less than three dunums. Large farms of over 10 dunum are rare in Palestine. The agricultural sectors in both WB and GS share the same problems, water scarcity being the main constraint for sustainable development. However, Gaza's agriculture is believed to be more advanced, due to high investment in the greenhouse sector during the 1970s to produce cut flowers and strawberries.

Over 950 000 dunum are devoted to fruit tree cultivation (see Table 1), of which olive trees make up the major portion. The area dedicated to vegetable production in West Bank is around 175 000 dunum. In various regions, vegetables are cultivated under irrigation and a significant portion in greenhouses.

**Table 1 Areas (in du) cultivated with fruits trees, vegetables, and field crops in the WB and GS, 2017**

| Region | Vegetables | Fruits trees | Field crops | Total |
|---|---|---|---|---|
| West Bank | 175 138 | 951 750 | 291 351 | 1 418 239 |
| Gaza Strip | 12 749 | 22 593 | 3 622 | 38 964 |

**Source:** Ministry of Agriculture, unpublished data

Despite the significant expansion of the agricultural sector in the last 15 years, major issues remain that require improvement. The positive developments discussed later in the specific food supply chain (FSC) chapters, particularly regarding seedless grapes and pickling cucumbers, cannot hide the problems and threats associated with their expansion. Among the major problems are four threats that render these subsectors vulnerable: (1) the severe shortage in water resources; (2) lack of skilled workers; (3) the lack of effective marketing systems and (4) the weak social structure among rural women and men.

Estimates of food loss and waste (FLW) in Palestine suggest around 11 percent occur during post-harvest handling and storage, and another 11 percent during distribution (State of Palestine, 2019). Food losses are mostly attributed to the lack of knowledge surrounding post-harvest treatments and lack of proper infrastructure, such as cold storage and transportation. These impact both consumers

[1] 10 dunums = 1 hectare = 10 000$m^2$.

and producers in terms of prices, availability, and quality. Consequently, they threaten national food security, waste resources, increase existing stress on ecosystems and cause environmental damage through greenhouse gas emissions. The national food security and nutrition strategy views FLW reduction as a strategic objective and calls on all actors to engage in reducing losses, reusing, recycling and promoting more sustainable consumption patterns.

This study aims to analyse the magnitude, causes of, and solutions to FLW in three selected food subsectors in Palestine. It builds upon similar studies conducted in recent years into tomato, avocado and sweet pepper value chains. The methodology used is sourced from, Food Loss Analysis: Causes and Solutions Case studies in the Small-scale Agriculture and Fisheries Subsectors (FAO, 2016).

The cucumber, zucchini and table grapes subsectors were selected for food loss analysis in this study, and each is discussed in greater detail in Chapter 3. Overall, Tables 2 and 3 reveal the significance of the selected subsectors in Palestine. Table 2 presents the total area, production volume, and productivity of the cucumber, zucchini, and table grape FSCs in Palestine in 2010 and 2017. Table 3 presents the average importance of each subsector against key indicators, rated by the study team from 1 (low), 2 (medium) to 3 (high). The economic importance, the generation of foreign exchange, the contribution to national food consumption, the contribution to national nutrition, and the impacts on environment and climate change of FSCs will be further detailed by region in the respective chapters for each FSC.

**Table 2 Area, production, and productivity (tonnes per dunum) of the three FSCs in Palestine (2010 and 2017)**

| FSC | Area (du) 2010 | Area (du) 2017 | Production (tonne) 2017 | Productivity 2017 (tonnes /du) |
|---|---|---|---|---|
| Cucumber | 19 224 | 31 201 | 154 005* | 5.75 |
| Zucchini | 17 529 | 20 921 | 56 074* | 2.45 |
| Table Grapes | 37 487 | 78 962 | 63 440 | 1.23 |

**Source:** for 2010: PCBS. 2023. Percentage Distribution of Agricultural Holdings in Palestine by Sex of Holder and Governorate, 2010/2011. In: Palestinian Central Bureau of Statistics. Ramallah, Palestine. Cited 6 April 2023. https://www.pcbs.gov.ps/Portals/_Rainbow/Documents/Agri.2010-2011,5E.htm; for 2017: Palestine Ministry of Agriculture, unpublished data.

*Recent estimations (2019) by the study team suggest total production of cucumber and zucchini are much higher; up to 216,500 tonnes of cucumber and 100,000 tonnes of zucchini.

**Table 3 Average importance of the subsectors at national level**

| Subsector/ All regions | Economic Importance | Generation of foreign exchange | Contribution to national food consumption | Contribution to national nutrition | Impacts on environment and climate change |
|---|---|---|---|---|---|
| Cucumbers | 2.5 | 1.6 | 1 | 1 | 2.6 |
| Zucchinis | 2.3 | 1 | 2.6 | 1.3 | 1 |
| Table Grapes | 2.2 | 1.6 | 2.3 | 1.7 | 2.4 |

**Source:** Authors' estimations.

* 1 (low), 2 (medium) or 3 (high)

# 2) The current policy framework

The National Food and Nutrition Security Policy in Palestine (2019–2030), operationalized by the National Investment Plan for food and nutrition security and sustainable agriculture (NIP 2020–2022), is a strategic policy consisting of a comprehensive and coordinated set of measures needed to ensure food and nutrition security in Palestine (State of Palestine, 2019a and 2019b). This policy connects FLW with food and nutrition security through food availability, and as a means to ensure sustainable food production systems and resilient agricultural practices. Under "Sectoral result 4.2. Food loss and waste reduced, and use of renewable energy resources promoted", proposed interventions include: knowledge and technology transfer to improve post-harvest activities; nutrition education and shift to safe diets with lower environmental footprint and energy use; incentivizing resilient and sustainable production and consumption; and promoting domestic renewable energy resources to reduce the energy footprint of food production and consumption (State of Palestine, 2019b).

For many food subsectors in Palestine there are two channels; products for the domestic market and those for export, including products destined for the Israeli market. In the domestic market, the extent of adherence to regulation and standards is very low. Local consumers do not ask for sorted highly uniform fresh products. Accordingly, farmers are not incentivized to make any investment to grade and sort products. This significantly reduces post-harvest handling and contributes to FLW, but it may also result in lower prices, making most produce affordable for almost all consumers.

The National Food Safety Strategy provides the framework for food safety compliance throughout the FSC, another challenge requiring improvement. The implementation of this strategy is needed to avoid food safety issues harming local consumers in the long term. In this respect, there is no need to enforce any regulation that requires highly uniform products, or for products that are free from external defects or healed injuries, unless such defects impose a health risk to consumers.

# 3) Relevant institutions and their roles

The public institutions involved in agricultural activities, and their respective responsibilities are as follows:

- The Ministry of Agriculture (MoA) is the umbrella entity that supervises the governmental, civil society (NGOs) and private institutions' activities related to agriculture production and marketing;
- The Ministry of Health has the partial mandate, together with the MoA, of overseeing food safety;
- The Ministry of Labour is responsible for the supervision of agricultural cooperatives and promoting the training of skilled workers.

Other governmental institutions are also active in the food sector. These include the Palestinian Standards Institution, Palestinian Water Authority, and Environment Quality Authority.

Non-state actors involved in agricultural activities include:

- The Palestinian Agricultural Relief Committee (PARC);
- The Applied Research Institute of Jerusalem (ARIJ);
- The Arab Studies Society Land Research Centre; and
- The Union of Agricultural Work Committees (UAWC).

These organizations have a long history of working with farmers and other stakeholders active in the agricultural sector. Their major contributions are to the rehabilitation of new agricultural lands, supporting small scale farmers and documenting Israeli violations in rural areas. However, their contribution to both applied research and marketing of agricultural products is marginal.

In addition to non-state actors, the academic institutions that have Faculties of Agriculture are also involved, although their impact is minimal. The budgets allocated for academics to undertake applied research and agricultural extension are insufficient to effectively support any programmes to reduce food losses. Key institutions include An-Najah National University, Hebron University and Al-Azhar University.

Despite the aforementioned activities, efforts and institutional contributions, significant levels of food losses persist. This may be mainly due to the absence of a national applied research programme and effective regulations that address these losses. Further, the absence of national monitoring and traceability system for agricultural products makes it difficult to secure the safety of all FSCs.

# 4) Food safety

Food safety is still a major concern for consumers in Palestine as agrochemicals are widely used and there is little effective monitoring of pesticide residues. The increased consumption of grape leaves is highly welcomed by health professionals (Harb and Murrar 2022; in press), but these leaves receive a lot of pesticides, particularly contact insecticides. The tendency of farmers to apply pesticides without observing the safety times before picking is alarming. Additionally, and given the quick development of both cucumber and zucchini fruits, efforts are needed to control the use of pesticides as a food safety measure.

The food safety management mechanism in the area of study is summarized in Table 4 below.

**Table 4 Food safety management mechanisms**

| Controller (Regulations) | Control | Actual situation | | Responsible agent |
|---|---|---|---|---|
| Government regulation and requirements (Public Health Law, Agriculture Law, the Palestinian Standards and Measurements Law, and the Consumer Protection Law). | National food safety/ quality standards | Exists and applies to the whole FSC | | |
| | | Exists but not rigorous | X | MOH; MOA |
| | | Doesn't exist | | |
| | Frequency stage of checking (none, low, medium, high) | Harvest | None | MOA |
| | | Transport | Zucchini: Low<br>Cucumber designated for pickling: medium<br>Seedless grapes: medium | MOA |
| | | Storage | None | |
| | | Processing | Zucchini: No<br>Cucumber: medium<br>Grapes: No | |
| | | Market | Low | MOH |
| | Obligatory registration of the food processing/ preparation unit | Exists | X | MOH; MOA |
| | | Doesn't exist | | |

| Controller (Regulations) | Control | Actual situation | | Responsible agent |
|---|---|---|---|---|
| FSC actors' food safety management system | GHP/ GAP/ HACCP/ voluntary standards | HACCP | Yes | MOH; MOA |
| | Identification of potential hazards | Exists | For seedless grapes and processed cucumber in the export markets | MOA and export market |
| | | Doesn't exist | For zucchini, fresh cucumber and seeded grapes | |

**Source:** Authors' estimations according to observations and informants' interviews.

# 5) Selection of FSC for investigation

The screening revealed that the zucchini, cucumber, and table grape subsectors fit the criteria for food loss analysis. The main reasons for this selection are:

- all three are produced by smallholders, specifically rain-fed table grapes for the grape subsector, and fresh cucumbers for the cucumber subsector (although seedless grapes and cucumber designated for pickling are produced mainly by medium-sized and large farms);
- a significant portion of the selected subsector fruit is exported (seedless grapes and cucumber for processing);
- the selected subsectors are economically important as shown in Table 5, 6, and 7.

The selected subsectors for this study constitute major products in Palestine. It is worth noting that most farmers, particularly smallholders, cultivate more than one crop to diversify production. Our interviews with farmers reveal that any product suitable for marketing in Israel or in Arab countries can be profitable to farmers due to the low cost of transport through informal channels and to higher prices in the export markets where consumer income is much higher.

The cucumber subsector produced over 150 000 tonnes in 2017 (Table 10) of which cucumbers consumed fresh were mostly cultivated in greenhouses (CG), or cucumbers designated for pickling (CP) were mainly cultivated in open fields. CP are mostly produced in medium-sized farms that are family-owned and managed by men. Women are active in picking, but not in cultivation and marketing. Cucumbers are mainly produced in Jenin, Tubas, Gaza Strip, Nablus and Hebron. However, quantitative data on the number, age, and gender of smallholder producers in each subsector is lacking for the cucumber subsector, as well as for zucchinis and grapes.

Over 50 000 tonnes of zucchinis were produced in 2017 (Table 25), mainly in Gaza Strip, Tubas, Jericho, Jenin and Hebron. Based on study observations, most zucchini farms are small-sized and over 90 percent of smallholders are male. Zucchinis are destined entirely for the local market and an important crop in the local diet.

The table grapes subsector producers produced over 150 000 tonnes in 2017 (Table 37). There are three main FSCs: seedless table grapes (SLTG); rainfed seeded table grapes (RfSDTG) and irrigated seeded table grapes (IrrSDTG). Table grapes are mostly consumed fresh, although a significant portion of seeded grape is diverted for processing in the Hebron governorate into molasses, malban, and to a lesser extent, raisins. Seeded grape farms are small, whereas seedless grapes are produced mainly by medium-sized and large farms. Table Grapes are mainly produced in Hebron, Bethlehem, Jericho and Nablus.

# The food supply chains – Situation analysis

## Description of the marketing systems of the selected subsector FSCs

The marketing systems for the selected subsectors are highly diverse. CP and SLTG FSCs are highly industrialized; GC, zucchini, and IrSDTG FSCs are run as enterprises with high inputs of agrochemicals. In contrast, the RfSDTG FSC is the traditional form of extensive agriculture that entails low inputs but with lower productivity.

The highly industrialized FSCs (CP and SLTG) rely heavily on sales to Israeli traders and food companies, and completely bypass the local wholesalers and retailers. Agreements with Israeli traders and processing plants require that farmers adhere to strict regulations concerning food safety and quality, therefore products are strictly sorted for export or diverted to local markets if not up to standard for the Israeli market where they are sold for lower prices. Farmers producing CP and SLTG have access to resources that are not readily available to small farmers; accessing inputs and marketing their produce is easy and well-organized. They sell to the Israeli market through regular channels, as well as by smuggling in significant quantities.

For the GC, zucchini and IrSDTG, the major marketing channel is through wholesale markets and retailer shops. The wholesalers trade the fresh product and charge farmers 10 percent of the final price. Retailers get the needed fresh produce directly from wholesale markets, and most of the time bring the products to their shops using their own regular vehicles. These are not designed for transporting fruits and vegetables. Hardly any vehicles are cooled, and most retailers and traders move products uncovered and unprotected. Furthermore, it is common practice to mix products together in the vehicles. This is significant for table grapes as certain fresh products (such as ripe banana) emit large quantities of the ripening hormone ethylene which has adverse effects on the quality of grape clusters. Rachis browning is severe upon exposure to ethylene.

A major issue for marketing is the lack of functional agricultural cooperatives. There are large numbers of agricultural cooperatives in all regions, however, they face issues of inefficiency, lack of vision, lack of expertise, and corruption. The issue of cooperatives remains a live issue, for all stakeholders, but mostly for farmers who expressed their wishes for better marketing cooperatives. At the same time, most farmers firmly believe that the current cooperatives system has no future.

The infrastructure that supports FSCs is inferior. Most farms are not connected with paved roads, and a significant percentage of unpaved roads are not levelled. This increases the levels of mechanical injuries. Further, most farms are not connected to electricity. Consequently, the prospect of farms having proper post-harvest handling facilities is almost unattainable, in particular, features such as cold rooms and precooling units. In addition, transport of fresh products is conducted primarily by farmers using vehicles that are not designed for the transportation of fresh produce. Most retailers and traders use similar vehicles.

The main actors in the FSC in the local market are the farmers, wholesalers, and retailers. However, for the FSCs for export, the main actors are farmers, intermediaries, processing plants (for open-field

produced cucumber), and traders and retailers at export markets (for seedless grapes). Table 5 shows the economic importance of the three subsectors and their FSCs, the participation of women and smallholders, and contribution to income generation for each type of actor.

**Table 5 Economic importance of food supply chains for smallholder actors.**

| Subsector | FSC | Gender | Percentage of produce by | | Contribution to income generation (Percentage share of total annual income) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Small holders | Others | Farmers | Middlemen | Wholesalers | Retailers |
| Cucumber | CG | M/Family enterprise | > 90 | < 10 | 60 | 10 | 10 | 5 |
| | CP | M | < 20 | > 80 | 30 | 25 | 5 | 5 |
| | Baby cucumber | M/Family enterprise | > 90 | < 10 | 15 | 5 | 2 | 2 |
| Zucchini | Domestic Market | M | > 80% | 10% | < 15% | < 5% | < 5% | < 5% |
| Table Grapes | Seeded grapes | M | > 95% | < 1% | 85% | 20% | 10% | 20% |
| | | F | < 5% | 0% | | | | |
| | SLTG | M | > 75% | < 25% | 40% | 30% | 5% | 5% |
| | | F | 0% | < 5% | | | | |

**Source:** Authors' estimations according to observations and informants' interviews.

## FSC actors' involvement and their benefit: social and environmental issues

The Palestinian economy suffers structural distortions and challenges that affect all sectors, including agriculture. Agriculture has gradually lost its capability to absorb the workforce. Agricultural investment in large-scale production and urban expansion has significantly affected poor farmers, resulting in many challenges that are further complicated by the occupation. The field visits and interviews with farming families show the negative impact of large companies on their profitability.

Workers do not have any kind of protection. They lack union representation, and generally lack the security provided by contracts or agreements. Farms employ day or seasonal agricultural workers via informal networks. Workers are not paid directly, but through a middle person who manages them, making the information about their daily wage unclear and potentially unfair. Farmers mentioned that wages for men and for women were similar within these types of arrangements.

The agricultural sector is one of the main employers for women. However, women are less likely to own agricultural holdings or hold positions of authority (PCBS, 2023). Activities carried out by women are mainly limited to picking and packaging, while men are responsible for everything else. The creation of large agricultural companies has aggravated the exclusion of women, reducing them to their traditional and reproductive roles and limiting them to informal agricultural work. Data from the Palestinian Central Bureau of Statistics Labour Force Report 2019, indicate a decline in women's participation

rates in agriculture and industry over the past 20 years, from 35 percent of the agriculture workforce in 2000 to 7 percent in 2019. The prevailing cultural context limits female employment in many sectors. During field visits, some farmers explained they would rather reduce production than employ women, because "women are not suitable for this type of work", believing that "women can't do the same work men do, whether physical labour or staying late". On a visit to a cucumber farm, the owner responded to a question concerning the involvement of women, "housework is sufficient for her and working on the farm is not suitable". At the same time, it was observed that many farmers deal with brokers who in turn employ women.

Women who are employed in the agrifood sector face a division in labour roles and discrimination in terms of wages, work hours and conditions, and rights. Women are prevented from participating in activities such as transportation and marketing but are entrusted with activities such as picking grape-vine leaves and processing of grape products such as molasses. Women perform most of these tasks within a seasonal system, or the family system, on a day-to-day or quota labour system. In most of these agreements, women receive little return or compensation. Where they are compensated, it is for less than their male counterparts while doing the same work under the pretext that women are less productive. They are often obliged to remain in the job due to family circumstances or due to family pressure. Women do not have the opportunity to take breaks or attend to personal needs within the present infrastructure of farms.

Women do not tend to perform jobs with high financial returns or that require advanced skill. This stifles economic, cultural, and social progress. Importantly, women do not own farms or assets such as transportation trucks. The lack of financial return limits the level of personal self-development whether in terms of skills, training opportunities, or ownership. The work also tends to be performed under harsh conditions. Women interviewed in Jenin described hard work that extends for long hours under the sun, in addition to housework. In the same visit, a woman and her husband confirmed the poor working conditions, and when asked about sharing wages with her husband, she replied, "he makes the decisions; we have the same financial commitment".

Other risks come with agricultural labour, with implications on health and livelihoods. Farmers reported that any damage to the crop affects the workers' wages, since seasonal workers work for a percentage of the output. Health risks include: working in extreme heat leading to heatstroke; reptile and insect bites, and other injuries. There are also dangers associated with the use of agrochemicals and the absence of protective equipment in most cases. In addition, the absence of toilets has forced women either to use unsafe places, or wait until they get home, putting their health at risk. Furthermore, chil-dren may participate in the agriculture work. During field visits, male children were observed accom-panying their family to the seedless grape farms in the Al-Jiftlik region, while their sisters stayed home.

## Environment-related inputs and factors in subsectors

The major inputs for the selected subsectors and their FSCs are water, land, agrochemicals, plant materials, and energy sources. It is typical for Palestinian agriculture that water and land are the scarcest natural resources. In addition, labour became a fifth major limiting factor, as most farmers who adopted an intensive cultural approach complained about the lack of both skilled and unskilled workers. This issue will be discussed in the social part of this study.

Concerning the water issue, it is known that each dunum needs around 300–400 $m^3$ water for irrigation in one production cycle. A production cycle is less than three months for cucumber and zucchini in most farms. In certain regions such as Qalqylia and Ateel, water of good quality is available for the current farms but might be limited in the event of further significant expansion. However, in other regions, like Jericho and Gaza Strip, water supply has become too limited for any expansion. Furthermore, water quality has greatly deteriorated in the last decade. In other regions, including the Hebron, Bethlehem, Jerusalem and Ramallah governorates, the water resources are very limited to the point that cultivation of grapes, cucumber and zucchini under irrigation is out of reach in most regions. Exceptions are farms near natural springs (such as Wadi Fukin near Bethlehem and Dura near Hebron) and a limited number of farmers who secure water by storing it in their wells during wintertime.

As for land resources, the illegal confiscation of land for Israeli settlements and the urbanization in most regions, particularly near Jenin, Qalqylia, Tulkram, Jericho, and Tubas cities, have displaced Palestinians from fertile soils that were historically used for agriculture. Another obvious development is in Al-Nassariya, near Nablus, which has an urbanization problem so severe that there might not be any land available for agricultural activities in less than 10 years. Farmers in that area benefit from the available water resources and warm spring conditions to produce large quantities of fresh fruits and vegetables that are very profitable in that time.

The third factor that has great environmental impact is the excessive use of agrochemicals in five out of six FSCs investigated in this study, namely CP and CG, zucchini, and SLTG and IrSDTG. Previous studies show that the excessive use of chemical fertilizers leads to salinization of the soil and economic losses for farmers (Harb *et al.*, 2019). Losses are often tightly coupled to the improper fertilization of cultivated plants.

Concerning soils and soil fertility, and referring to FSCs produced under irrigation, farmers tend to apply sufficient, and occasionally very high, amounts of manure, either on an annual or biannual basis. In contrast to this good practice, most farmers are used to applying large amounts of fertilizers directly before planting, the so-called foundation. Previous studies, as well as current observations, indicate that the practice is environmentally unsound, and even harmful. The application of huge amounts of phosphorus is of particular concern (Harb *et al.*, 2019).

In addition to the aforementioned factors, livestock is almost absent in farms that adopt intensive culture. It is also notable that Palestinian farmers who have worked in Israeli farms have more specialized skills.

The environmental impact of intensive cultures is significant due to the excessive use of agrochemicals and plastics (such as in cucumber cultivation in greenhouses). Furthermore, the energy used to pump water and move products within farms, and from farms to other points of the chain is also significant. In contrast, energy demand in grape farms in rainfed regions is much lower, but at the cost of much lower productivity.

# The Food Losses – Study findings and results

This chapter presents the study findings and results segregated by the three subsectors included in this study, and six FSCs therein. Sixty cucumber farms, 40 zucchini farms, and 30 grape farms were surveyed. In addition, six wholesale markets: Beita; Nablus; Hebron; Jericho; Tulkarem; and Halhul, and 6 retailer shops for each subsector were also surveyed. The assessments for the cucumber and zucchini FSCs took place during the main season (April 2020 – June 2020). However, the assessment of the table grape FSCs was divided into two-time slots: May – June 2020 for irrigated grapes, and September– October 2020 for rainfed grapes.

Samples, in triplicate, were assessed for all possible defects and injuries, and categorized for all classes of losses (physiological, mechanical, and pathological). Qualitative and quantitative losses were both quantified.

## Expected food losses in the selected FSC

The disruptions caused by the COVID-19 pandemic changed everything known about the critical loss points (CLP). These are the points in the FSC where food losses have the highest magnitude, impact on food security, and economic impact. In this sense, results show that retailer shops have become a critical loss point for most FSCs. The affordability of fresh fruits and vegetables for most consumers became much lower than in 'normal' years, as consumers focused on purchasing basic commodities such as rice and bread. The main reasons for loss of purchasing power are, skyrocketing unemployment rates and the inability of the Palestinian Authority to pay salaries to their employees.

Farmers and traders do not follow any standard system for products that are designated for the domestic market (Harb *et al.*, 2019). Farmers discard only decayed and severely injured products, and market their products without sorting. This approach is benefits both farmers and consumers, as it decreases the amount discarded as waste by farmers. The situation is totally different for CP and SDTG that are marketed to the Israeli market. Farmers are forced to be selective and discard products that are bigger than a specific diameter (for cucumber) and smaller than specific size (for grape clusters). The products extracted as result of sorting are marketed in the domestic market, but fetch much lower prices.

The major factor in the presumed food losses is the target market. These dictate the extent and nature of losses. As a clear example, cucumbers produced in large open fields are discarded in the collection centres, since the recipients in this FSC (pickling processing units in Israel) follow their own standards. These dictate specific sizes for the production process. At their farms, farmers discard the very large fruits that are sound and taste good, but which are considered as losses. A very limited number of farmers collect these fruits and market them with few restrictions in the local market at lower prices.

Losses vary among subsectors and FSCs. Consequently, the causes of losses and potential measures to mitigate them are described separately. The lack of studies addressing losses makes it very difficult for experts to elucidate the real evidence-based reasons for losses. It is of vital importance to start a large research programme to determine the real reasons for losses. This programme must investigate the current fertilization programmes and irrigation scheduling and correlate the findings with losses. Further, it must address the timing of production cycles.

## Quality scoring

The produce quality of every FSC in the respective chapters is evaluated according to Table 6. When the produce is completely unfit for consumption it will be scored zero to one; then depending on the level of defects the quality score will be two to six; and a perfect produce will be graded seven to ten.

**Table 6 Quality scoring of FSCs**

| Quality score | Category |
|---|---|
| 0–1 | Completely unfit for consumption (to be discarded) |
| 2–6 | Medium defects |
| 7–10 | In perfect shape |

**Source:** FAO. 2016. Food Loss Analysis: Causes and Solutions Case studies in the Small-scale Agriculture and Fisheries Subsectors. Rome. http://www.fao.org/3/a-az568e.pdf

## Low loss points and good practices leading to low food losses

With the exception of zucchini, the major low loss point (LLP) is the transport stage. The cucumbers and table grapes FSCs tolerate transport, even with improper vehicles and roads of inferior quality. Despite that, quantitative losses of up to 5 percent were recorded by farmers and traders. This study's trial with table grapes found quantitative loss of around 1 percent only. The second major LLP is related to pest management. Farmers adopting intensive culture use a lot of pesticides. These reduce the pathogens load to very low levels. That creates a safety problem, but with respect to pathological losses, the current practices greatly reduce such losses. This is evident for all farms as regards rainfed table grapes, particularly during the 2020 season, which was exceptional with its very low prices. The third LLP is the wholesale markets because the product remains in these markets for a very short period.

# 1) The cucumbers subsector

Cucumber is among the major cultivated plants in Palestine with a production volume of almost 160 000 tonnes in 2017. As shown in Table 7, the top producing governorates are Jenin, followed by Tubas, Nablus, Hebron, Khan Yunis, Jericho and Jordan Valley. Recent estimations by the study team quantifies the total production of cucumber to around 216 500 tonnes in 2019 based on information from private companies who know the number of seeds/transplants for each FSC. Table 8 evaluates the importance of cucumber in the different governorates from 1 (low) through to 3 (high) based on secondary data analysis and discussions with informants.

**Table 7 Area, production, and productivity of cucumber supply chain in Palestine (2010 and 2017)**

| Governorate | Area (Du) 2010 | Area (Du) 2017 | Production (tonnes) 2017 | Productivity (tonnes per Du) |
|---|---|---|---|---|
| Jenin | 4 109 | 6 135 | 30 369 | 5 |
| Tubas | 4 054 | 4 720 | 29 000 | 6.1 |
| Tulkarm | 2 260 | 2 967 | 6 729 | 2.3 |
| Nablus | 3 837 | 5 280 | 18 385 | 3.5 |
| Qalqilya | 451 | 901 | 6 258 | 6.9 |
| Salfit | 25 | 35 | 134 | 3.8 |
| Ramallah and Al-Bireh | 105 | 177 | 760 | 4.3 |
| Jericho and Jordan Valley | 1 103 | 1 365 | 11 115 | 8.1 |
| Jerusalem | 30 | 97 | 322 | 3.3 |
| Bethlehem | 117 | 222 | 2 454 | 11.1 |
| Hebron | 686 | 2 029 | 20 389 | 10 |
| Gaza | 44 | 1 045 | 2 236 | 2.1 |
| North Gaza | 275 | 1 138 | 3 855 | 3.4 |
| Rafah | 952 | 930 | 7 188 | 7.7 |
| Khan Yunis | 106 | 1 525 | 11 286 | 7.4 |
| Deir Al Balah | 176 | 505 | 3 525 | 7 |
| **Total** | **19 224** | **31 201** | **154 005** | **5.75** |

**Source:** for 2010: PCBS. 2023. Percentage Distribution of Agricultural Holdings in Palestine by Sex of Holder and Governorate, 2010/2011. In: Palestinian Central Bureau of Statistics. Ramallah, Palestine. Cited 6 April 2023. https://www.pcbs.gov.ps/Portals/_Rainbow/Documents/Agri.2010-2011,5E.htm; for 2017: Palestine Ministry of Agriculture, unpublished data.

**Table 8 Evaluation of the importance of the cucumber subsector**

| Cucumber in regions | Economic Importance | Generation of foreign exchange | Contribution to national food consumption | Contribution to national nutrition | Impacts on environment and climate change |
|---|---|---|---|---|---|
| WB and GS | 3* | 1 | 1 | 1 | 3 |
| JEN | 3 | 2 | 1 | 1 | 3 |
| GS | 3 | 1 | 1 | 1 | 3 |
| TUB | 3 | 3 | 1 | 1 | 3 |
| HEB | 1 | 1 | 1 | 1 | 1 |

**Source:** Authors' elaboration.

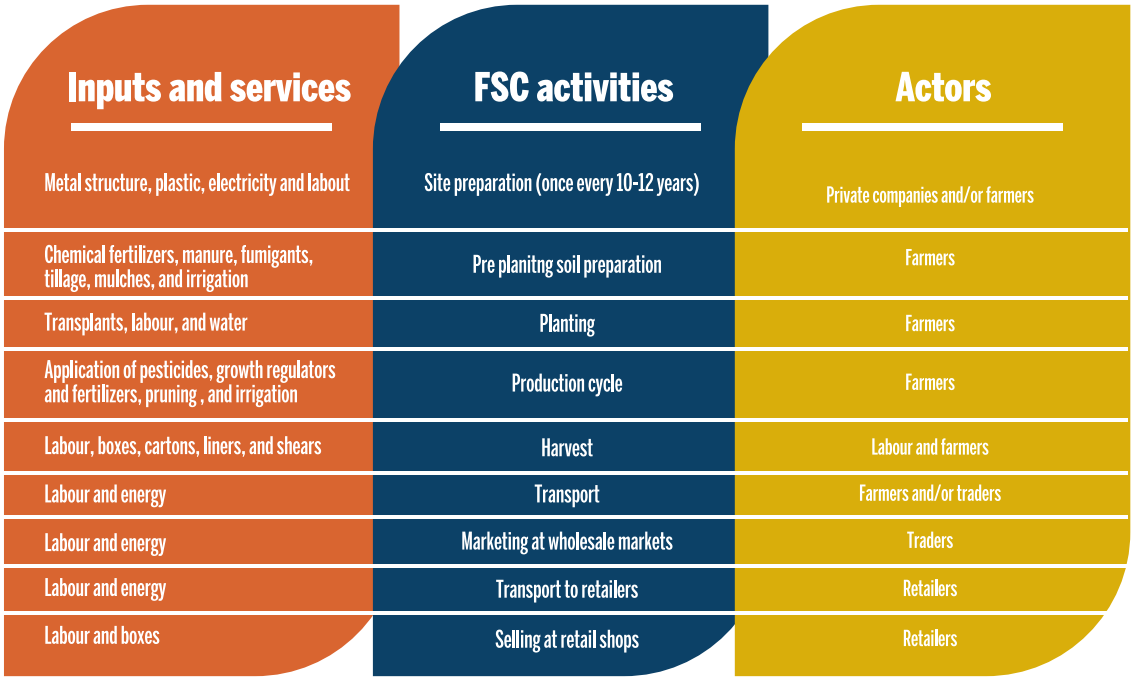
* 1 (low), 2 (medium) or 3 (high)

CP is a major FSC in the cucumber subsector. CP is cultivated in open fields under irrigation and the major market is pickling plants in Israel. Conversely, cucumber produced in greenhouses is marketed predominantly locally and consumed in salads. It is worth noting that in certain regions such as Gaza Strip, cucumber is produced in two cycles per year. The farms producing cucumber in Hebron and Bethlehem governorates are close to consumers in the highly populated governorate of Hebron, which helps limit food loss in transportation and distribution. Around Hebron city, such as in the Dura and Fawar regions, cucumber is cultivated in greenhouses twice per year between April and June over 100 days and between July and October over 120 days. In Bethlehem governorate, cucumber is cultivated in Irtas, Wadi Fukin, and Eastern Bethlehem. As regards health benefits, the nutritional quality of cucumber is relatively low.

Cucumber cultivation faces major obstacles for expansion that are related to limited water resources and an underdeveloped marketing system. The main cause of water scarcity is political in nature, as Israel still dominates the allocation and management of water resources and controls about 82 percent of the groundwater (The International Bank for Reconstruction and Development/The World Bank, 2009).

Nonetheless, a significant increase in production is evident for open-field cultivated cucumber destined for Israel. An expansion in greenhouse cultivation was also observed in the southern governorates of the West Bank. This development is highly welcome, due to the proximity to Hebron, Dura, Yatta, Dahrieh and Bethlehem, reaching over one million consumers. Figure 1 shows the product flow of cucumber produced in small farms in both open fields and greenhouses.

**Figure 1 Cucumbers – product flow**



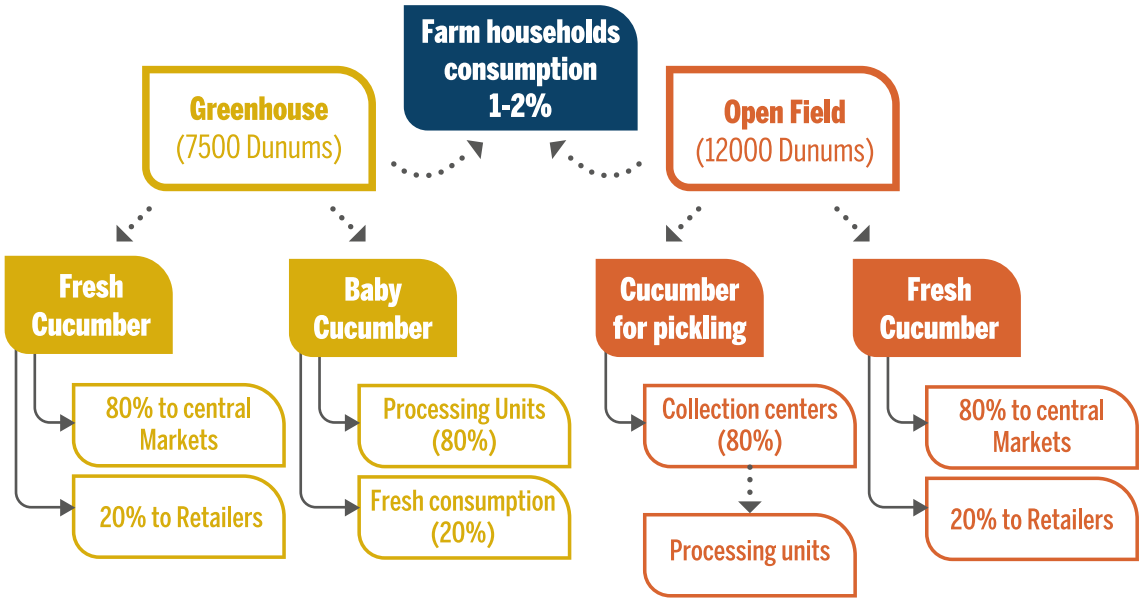

**Source:** Authors' elaboration.

## a) Cucumber subsector actors' involvement and their benefits

The major actors in the CP FSC are farmers, owners of collection centres, and traders to the Israeli market. The local traders receive a major part of the profit, followed by farmers. Prices are relatively high, and farmers consider it as a profitable FSC.

Prices of CG fluctuate significantly during the season. This occasionally results in financial losses for farmers. Wholesalers, retailers, and traders do not suffer any losses in such times. However, if farmers were to consistently record profits, their household income would not be enough unless they manage more than 5.0 dunums. Whereas CG cultivation creates many jobs, farmers report difficulties in obtaining both skilled and unskilled workers. Figure 2 illustrates the actors within the cucumbers FSC and their activities in addition to the services and inputs used.

**Figure 2 Actors, activities and inputs and services in the cucumber FSC**




**Source:** Authors' elaboration

## b) Detailed description of the cucumber FSCs

The FSC cucumber for fresh consumption (CG) starts at the farm, where plants are cultivated in green-houses. Farmers reported much higher productivity than if cultivating cucumbers in open fields. The parthenocarpic fruits are always picked at an immature stage and delivered the same day to wholesale markets. Intermediaries and traders occasionally purchase the fresh product directly from farms, but this is not the major channel. Retailers purchase produce from the wholesale markets and transport it using regular vehicles which are not designed to carry fruits and vegetables.

CP is highly industrialized and profitable, and traders direct the major proportion to Israeli pickling companies. Most farms are medium to large in size. Plants are grown in irrigated open fields where farmers or workers apply excessive chemical fertilizers and pesticides. CP farmers have access to resources that are not readily available to small farmers, namely inputs and marketing channels. As mentioned earlier, there is a regular channel to the Israeli market, but also a significant smuggling market.

Following the harvesting of immature fruits, fruits are pre-sorted, and extra-large fruits are discarded. The fresh marketable product is moved to collection centres where they are sorted for a second time. Sorting at farms and at collection centres eliminates around 10 to 15 percent of the product. A significant proportion of these extra-large fruits are left in the field, with a small amount sold to restaurants. During the 2020 season however, most restaurants were closed due to COVID-19 and the losses were higher.

Tables 9 and 10 provide a basic description of the CP and CG FSCs. Each phase of the FSC is detailed in terms of geographical location and the production schedule in each location, the main product and by-product, quantities produced, and duration of the production cycle. For CP, the only by-product is the 15 percent of production that goes for fresh consumption. Food safety and quality controls are applied at the primary production level only when the produce is being exported. For CG, there are no by-products and food safety measures are not applied at all.

Table 11 and 12 describe the level of involvement of women and men, the organization level of the actors in the FSC and additional information about the social structures for both CP and CG.

**Table 9 Detailed description of the cucumber for processing FSC: basic information**

| Phase | Geographical Location | Months of the year (day. month) | | Quantity (tonnes 2020) | By-products | Duration/ Distance | Services |
|---|---|---|---|---|---|---|---|
| | | From | To | | | | |
| **Primary production** | Tubas | Late 01 | 25.05 | 20 000 | 15% for fresh consumption | 4 months | Irrigation/ fertigation, pest control |
| | Jenin | 05.03 | 30.06 | | | 3 months | |
| | Maithalon (minor) | 01.05 | 01.07 | | | 2.5 months | |
| **Harvest** | Tubas | 20.03 | 25.05 | 17 000 (- losses) | None | Early hours of the day | Picking, discarding oversized and damaged |
| | Jenin | 20.04 | 30.06 | | | | |
| | Maithalon | 01.06 | 15.07 | | | | |
| **Post-harvest handling/ sorting** | Tubas | 20.03 | 25.05 | 17 000 (- losses) | None | Same day of harvest | Sorting |
| | Jenin | 20.04 | 30.06 | | | | |
| | Maithalon | 01.06 | 15.07 | | | | |
| **Transportation** | Tubas | 20.03 | 25.05 | 17 000 (- losses) | None | 3–8 hours | Moving product to collection centres |
| | Jenin | 20.04 | 30.06 | | | | |
| | Maithalon | 01.06 | 15.07 | | | | |
| **Collection centres** | Tubas | 20.03 | 25.05 | 17 000 (- losses) | None | Less than 12 hours | Moving product to processing plants |
| | Jenin | 20.04 | 30.06 | | | | |
| | Maithalon | 01.06 | 15.07 | | | | |

**Source:** Authors' estimations according to observations, informants' interviews, and secondary data.

**Table 10 Detailed description of the CG FSC – basic information**

| Phase | Geographical Location | Months of the year (day/month) | | Quant (tonnes)* | Duration/ Distance | Services |
|---|---|---|---|---|---|---|
| | | From | To | | | |
| **Primary production** | Jenin | 01.02 | 01.07 | 194 000 | 5 months | Irrigation/ fertilisation, pest control<br>Training<br>Pruning<br>Shading |
| | | 15.07 | 01.10 | | 2.5 months | |
| | | 15.10 | 15.02 | | 4 months | |
| | Northern Jordan Valley | 20.08 | 15.11 | | 3 months | |
| | | 20.12 | 15.04 | | 4 months | |
| | Tulkarem | 01.02 | 01.07 | | 5 months | |
| | | 15.07 | 01.10 | | 2.5 months | |
| | | 15.10 | 15.02 | | 4 months | |
| **Harvest** | Jenin | 20.03 | 01.07 | 194 000 (- losses) | Early hours of the day | Picking, discarding of damaged and oversized fruits, and packing |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |
| | Northern Jordan Valley | 15.09 | 15.11 | | | |
| | | 30.01 | 15.04 | | | |
| | Tulkarem | 20.03 | 01.07 | | | |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |
| **Post-harvest handling** | Jenin | 20.03 | 01.07 | 194 000 (- losses) | Same day of harvest | Packing of fresh fruits |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |
| | Northern Jordan Valley | 15.09 | 15.11 | | | |
| | | 30.01 | 15.04 | | | |
| | Tulkarem | 20.03 | 01.07 | | | |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |
| **Transportation** | Jenin | 20.03 | 01.07 | 194 000 (- losses) | 2–24 hours | Moving fruits to whole-sale markets |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |
| | Northern Jordan Valley | 15.09 | 15.11 | | | |
| | | 30.01 | 15.04 | | | |
| | Tulkarem | 20.03 | 01.07 | | | |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |
| **Wholesale Market** | Jenin | 20.03 | 01.07 | 194 000 (- losses) | Less than 12 hours; rarely 24 hours | Purchasing and selling of the product |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |
| | Northern Jordan Valley | 15.09 | 15.11 | | | |
| | | 30.01 | 15.04 | | | |
| | Tulkarem | 20.03 | 01.07 | | | |
| | | 10.08 | 01.10 | | | |
| | | 20.11 | 15.02 | | | |

| Phase | Geographical Location | Months of the year (day/month) | | Quant (tonnes)* | Duration/ Distance | Services |
|---|---|---|---|---|---|---|
| | | From | To | | | |
| **Retailers** | All governorates | 30.01 | 15.04 | NA | 1–2 days | Selling the product to consumers |
| | | 20.03 | 01.07 | | | |
| | | 10.08 | 01.10 | | | |
| | | 15.09 | 15.11 | | | |
| | | 20.11 | 15.02 | | | |

**Source:** Authors' estimations according to observations, informants' interviews, and primary data.

* Productivity for the year 2020

### Table 11 Detailed description of the cucumber for processing FSC– Social structures

| FSC/ STEPS | Involvement of women | | Involvement of men | | Who is mainly involved | Organization level of FSC actors* | Gender / social patterns |
|---|---|---|---|---|---|---|---|
| | Girls | Women | Boys | Men | | | |
| **Primary production** | 1** | 1 | 1 | 3 | Mainly men | Families and private companies | In most cases, men within the family handle this process. Women are occasionally involved but do not have same access to equipment as men due to their traditional gender roles in agriculture. |
| **Harvest** | 1 | 3 | 1 | 2 | Men and women | Family and occasional day laborers | Women typically involved both on family farms and as day laborers when need be. |
| **Post-harvest handling** | 0 | 1 | 0 | 3 | Men | Family and small companies | Women have less skills and experiences due to the division of labour (communication with male traders and wholesalers). |
| **Transport** | 0 | 0 | 0 | 4 | Product picked and taken to market by traders | Family and traders (small companies) | • Transport typically taken care of by men (farmers, traders).<br>• Total absence of women due to the horizontal separation. |
| **Market sales** | 0 | 0 | 0 | 4 | Men deal with traders who take the product to market | Small companies | • Little bargaining power for farmers<br>• Absence of women illustrating the traditional and cultural obstacles they face |

**Source:** Authors' elaboration.
* Individual/Household level/Cooperative
** Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad, 0: does not exist.

**Table 12 Detailed description of the cucumber from the greenhouse FSC– Social structures**

| FSC/ STEPS | Involvement of Women | | Involvement of Men | | Who is mainly involved | Organization level of FSC actors* | Gender / social patterns |
|---|---|---|---|---|---|---|---|
| | Girls | Women | Boys | Men | | | |
| **Primary production** | 1** | 2 | 1 | 4 | Mainly men. Occasionally women in select areas. | Family | In this stage, there is equality between men and women. |
| **Harvest** | 1 | 3 | 1 | 4 | Men and women | Family and occasional day labourers | Women work both within family and as day laborers. |
| **Post-harvest handling** | 0 | 3 | 0 | 4 | Women | Family or day labourers | • Women in sorting by size before transport.<br>• Sorting only required for the export or "Israeli" market. |
| **Transport** | 0 | 0 | 0 | 4 | Produce is picked up by traders for the market | Families | • Farmers and occasionally traders.<br>• Absence of women due to horizontal separation |
| **Market sales** | 0 | 0 | 0 | 4 | Men deal with traders who then take the produce to markets | Private companies and families | • Little bargaining power for farmers.<br>• Absence of women in markets; traditional/ cultural obstacles.<br>• Related to agricultural tenure. Men are dominant in all the cycle. |

**Source:** Authors' elaboration.

* Individual/Household level/Cooperative
** Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad, 0: does not exist.

## c) Economics of the cucumbers FSCs

The production of CG consists of three main levels in the supply chain (farmers, wholesalers, and retailers). The average cost for farmers is 0.40 USD/kg. At the pre-harvest level, farmers bear the costs of ploughing, fertilizer, irrigation, labour, greenhouses, fumigation, seedlings, pesticides, spraying and farm management. At the harvest and packing levels, farmers bear the costs of harvesting, packaging, and transportation to markets. In Table 13, the farm-gate price, which represents the price that farmers charge to wholesalers, is 0.45 USD/kg, leaving 0.05 USD/kg as profit to farmers. The average profit to wholesalers is also 0.05 USD/kg. It is worth noting that the profit is higher for retailers (0.55 USD/kg) than for farmers since they pay lower average costs than farmers. Values given in the tables are based on the prices for the period from May to July 2020.

**Table 13 Detailed description of the CG FSC– economics**

| FSC stage | Cost of operation USD/kg | Cumulative Cost USD/kg | Value USD/ kg final product | Value-added / Margins USD/ kg | Remarks |
|---|---|---|---|---|---|
| **Pre-harvest** | 0.31 | 0.31 | | | Costs of ploughing, fertilizers, irrigation, labour, greenhouse management, fumigation, seedlings, pesticides, spraying and farm management |
| **Harvest and packing** | 0.09 | 0.40 | 0.45[a] | 0.05 | Manual harvesting, packaging, and transportation to markets |
| **Wholesale** | 0.05 | 0.45 | 0.50[b] | 0.05 | Municipality fee, labour, and equipment |
| **Retail** | 0.06 | 0.51 | 1.06[c] | 0.55 | Transportation, labour, equipment, and electricity |

**Source:** Authors' estimations according to observations and informants' interviews.

a price at farm gate (May – July 2020); b price at wholesale market gate; c consumer price.

The production of CP is different. It consists of three main levels of the supply chain (farmers, collection centres, and processing units). The average cost for farmers is 0.41 USD/kg which is close to the average cost for CG (Table 14). The farm-gate price, which represents the price that farmers charge to processors, is 0.66 USD/kg, leaving a higher average profit of 0.25 USD/kg to farmers. The second stage is sorting and packing in collection centres. The average profit for collection centres is 0.31 USD/kg. The value of the final processed product is 2.82 USD/kg. The final processing stage, consisting of pickling, pasteurization, storage and transportation, costs 0.15 USD/kg. leaving the largest profit share with an average profit of 2.23 USD/kg to processors.

**Table 14 Detailed description of the CP FSC – economics**

| FSC stage | Cost of operation USD/kg | Cumulative Cost USD/kg | Value USD/kg final product | Value-added / Margins USD/kg | Remarks |
|---|---|---|---|---|---|
| **Pre-harvest** | 0.36 | 0.36 | | | Costs of soil preparation, fertilizers, irrigation, labour, seedlings, pesticides, spraying and farm management |
| **Harvest and packing** | 0.05 | 0.41 | 0.66[a] | 0.25 | Manual harvesting, packing and transportation to collection centres |
| **Collection centres** | 0.03 | 0.44 | 0.75[b] | 0.31 | Sorting and packing |
| **Processing units** | 0.15 | 0.59 | 2.82[c] | 2.23 | Pickling, pasteurization, storage, and transportation |
| **Wholesale markets*** | 0.08 | 0.67 | 0.9[d] | 0.23 | |

**Source:** Authors' estimations according to observations and informants' interviews.

a price at farm gate; b price at collection centre gate; c price of the final processed product; d price at the wholesale market.
* Minor quantities are marketed locally, which is consumed fresh or for pickling at home.

## d) Environment-related inputs and factors in the cucumber subsector

In addition to the environment-related inputs and factors mentioned in earlier sections, such as water, land, agrochemicals, and energy sources, another factor requiring consideration is plant material. For almost all cucumber farms, transplants of hybrid seeds are used, and the use of local 'baladi' seeds is very limited. Hybrid transplants are very productive, but highly susceptible to pests. To secure high productivity, farmers use large quantities of pesticides. This raises the problem of food safety related to pesticides residues. Indigenous plant material (baladi seed) is potentially more tolerant to a wide range of pests, however local study is needed to confirm this assumption.

Tables 15 and 16 describe the factors that affect the environment in both cucumber FSCs. For CP, which are cultivated under irrigation in open fields, the process starts with soil preparation. This includes tillage, application of manure, and the pre-plant application of chemical fertilizers. After that, plant material is purchased from certified sources (private companies) and planted in relatively wet soil. Cultivated plants are heavily fertilized during the short growing season. In addition, pesticides are also used widely and frequently, although the amounts differ between seasons. In the case of CG, the plant density is higher, and more agrochemicals and plastics are used, therefore the environmental impact is high. As regards water usage, each dunum needs from 300 to 400 m3 water for irrigation in one production cycle (less than three months for cucumber in most farms). Table 17 describes different factors relevant to an environmental assessment of the cucumber subsector.

**Table 15 Detailed description of the cucumber for processing FSC: environment**

| Cucumber PRODUCTION | | Quantity | Unit for 1 Du* |
|---|---|---|---|
| Tools, Equipment, Facilities | **Harvesting equipment** | | |
| | - Gloves | 4 | No |
| | - Plastic (20 litre) containers for harvest | 10 | No. |
| | **Packing bags** | 160 each bag 30kg | No. |
| | **Irrigation system** | | |
| | - Pipes | 650 | metres |
| | - Drippers | 1 625 | No. |
| | - Fertigation unit | 1 | No. |
| | **Manual and motorized sprayers for pesticides** | | |
| | Tractor | 1 (for every 40 dunums). Otherwise, one tractor for a mixed farm. Small farms may rent a tractor for limited time | No. |
| Materials, Chemicals | Manure | 6–8 annually | $m^3$ |
| | Fertilizers | 450 (150 kg nitrogen fertilizers and 300 kg complete fertilizers) | Kilogramme |
| | Pesticide | 2 | Litre |
| Energy | Fossil fuel (diesel or gasoline) | 120 | Litre |
| Water | Groundwater | 400 | $m^3$ |

| Cucumber PRODUCTION | | Quantity | Unit for 1 Du* |
|---|---|---|---|
| | TRANSPORTATION | | |
| **Tools, Equipment, Facilities** | Rented pickup truck | 1 (owned or rented) | No. |
| | Tractor | 1 | No. |
| | WHOLESALE, RETAIL | | |
| **Tools, Equipment, Facilities** | Forklift | 15- 20 for each market | No |
| | Keeping rooms (few with cold units) | Less than 5 in each wholesale market | No |
| | Refrigerated unit | 2–3 by each retailer | No |

**Source:** Authors' estimations according to observations and informants' interviews.

**Table 16 Detailed description of the fresh cucumber FSC– environment**

| PRODUCTION | | Quantity | Unit for 1 DU* |
|---|---|---|---|
| **Tools, Equipment, Facilities** | **Harvesting equipment** | | |
| | -Pruning shears | 3 | No. |
| | -Plastic (20 litres) containers for harvest | 3 | No. |
| | **Packaging equipment** | | |
| | - Plastic boxes. Few cardboard | 50 | No. |
| | **Production phase** | | |
| | -String thread | 1 600 | No. |
| | **Irrigation system** | | |
| | - Pipes | 650 | metres |
| | -drippers | 1 600 | No. |
| | - Fertigation unit | 1 for each dunum | No. |
| | **Manual and motorized sprayers for pesticides** | | |
| | Tractor | 1 for 3–5 dunums | No. |
| **Materials, Chemicals** | Manure | 15 each year | $m^3$ |
| | Fertilizers | 190 (70 kg nitrogen fertilizers and 120 kg complete fertilizers) | Kilogramme |
| | Pesticide | 3 | Kilogramme |
| | **Materials for greenhouses** | | |
| | - Plastic film | 150 (once time every three years) | $m^2$ |
| | - Mulch (ground cover) in Jordan Valley | 650 | No. |
| | - Yellow and blue insect sticky traps | 16 | No. |
| **Energy** | Fossil fuel (diesel or gasoline) | 6 | Litre/hour |
| **Water** | Groundwater | 400 | $m^3$ |

| PRODUCTION | | Quantity | Unit for 1 DU* |
|---|---|---|---|
| TRANSPORTATION | | | |
| **Tools, Equipment, Facilities** | Rented pickup truck | 1 (owned or rented) | No. |
| | Tractor | 1 | No. |
| | Car | 1 | No. |
| WHOLESALE, RETAIL | | | |
| **Tools, Equipment, Facilities** | Forklift | 15–20 for each market | No. |
| | Keeping rooms (few with cold units) | Less than 5 in each wholesale market | No. |
| | Refrigerated unit | 2–3 by each retailer | No. |

**Source:** Authors' estimations according to observations and informants' interviews.

**Table 17 Factors for the environmental assessment of the cucumber subsector**

| Factors | FSC | Description | Details |
|---|---|---|---|
| **Type of production system** | Processing | Intensive, in open fields. | • Hybrid seeds<br>• Heavy use of agrochemicals and energy<br>• Short production cycle |
| | Fresh | Intensive, in greenhouses | |
| **Land preparation practices** | Processing | Soil preparation and application of manure and chemical fertilizers | • Removal of previous crop residues<br>• Tillage, fumigation, and application of chemical fertilizers (foundation ration) and manure |
| | Fresh | Soil preparation and placing mulches | • Mulches are placed for fresh cucumbers<br>• Distribution of irrigation pipes and system |
| **Soil quality and land degradation** | Processing | Soils have enough various nutrients, mainly *P and Mg | • P and Mg accumulated over the years leading to nutritional imbalances<br>• Previous study shows that soils, before planting, have high levels of both *N and P already, applied during the previous production cycle. No soil analysis. |
| | Fresh | | • Farmers apply chemical fertilizers recommended by manufacturers of these chemicals, and agriculture extension officers. |
| **Water regime** | Processing | Drip irrigation with fertigation unit | • Water is scarce in Palestine.<br>• Water applied in moderate amounts.<br>• Water scheduling and application is relatively efficient. |
| | Fresh | Drip irrigation | • Efforts to optimize water consumption by the cultivated plants are highly needed. |
| **Ecosystem impacts** | Processing | Culturing these FSCs is intensive. It is profitable but has negative impact on the ecosystem due to excessive use of fertilizers and pesticides. | • Excessive agrochemicals use (fertilizers and pesticides), water pumping, and transport have a negative impact on the ecosystem and the agrobiodiversity.<br>• Salinization of soil due to application of fertilizers and use of low-quality water is a problem in certain regions, including Gaza Strip and Jordan Valley.<br>• Efforts are needed to optimize the application of chemicals |
| | Fresh | | |

| Factors | FSC | Description | Details |
|---|---|---|---|
| **Sources of GHG emissions** | Processing | GHG emissions due to soil preparation and transport, agrochemicals and fuel | • Preparation of soil, production of agrochemicals and transport are energy intensive<br>• Machinery emits excessive amounts of GHG<br>• There is a need to optimize their use |
| | Fresh | | |
| **Climatic factors** | Processing cucumber | Quant. and qual. losses due to climate | • Planting dates are early in the season<br>• Temperature and rainfall fluctuations cause losses |
| | Fresh | Abiotic stress inside greenhouse | • High temperatures and high light irradiance cause frequent quantitative and qualitative losses<br>• Increased water needs to compensate for high transpiration rates |
| **Utilization of residues in the supply chain** | Processing | Residues of previous crops are rarely used as valuable resources. They are rather discarded | • Farmers discard residues of previous crops to reduce pathogens load on the new crop not knowing their value as plant nutrients and soil amendments.<br>• Composting is not a common practice<br>• The agriculture extension officers knowledge and advice needed |
| | Fresh | | |
| **Re-use of food losses** | Processing | Fruits with mild defects are used, whereas those with severe defects are discarded | • Fruits with minor defects are marketed to restaurants<br>• Fruits with severe damages and extra-large fruits are discarded<br>• Farmers of processing cucumbers discard large fruits<br>• Farmers recorded that the reuse of injured extra-large cucumbers is not profitable |
| | Fresh | | |

**Source:** Authors' elaboration.

*P, Mg, N: Phosphorus, Magnesium, Nitrogen respectively

## e) Expected food loss in the cucumber subsector

The expected critical loss points for cucumber, according to the opinion of respondents, are mainly of physiological and pathological nature during production. The quick growth of fruits and the negligence of workers in picking a significant part of fruit at the requested sizes leads to a situation with fruits that are too large for the processing plants. The very large fruits from open-field cultivated cucumbers are discarded. Despite being edible, it is not economically feasible for farmers to harvest and/or market these fruits. These losses amount to around 25 percent of cucumbers. The second major category is attributed to losses due to diseases and insects. These losses are around 5–7 percent. Informants also mentioned mechanical losses, but they stressed that such losses are minor. Table 18 mentions the causes of losses in the cucumber subsector identified in the preliminary screening.

**Table 18 Preliminary screening of food losses in the cucumber subsector**

| Step in the FSC | Expected Critical Loss Points | | Comments/ Remarks Losses might be due to: |
|---|---|---|---|
| | Quantitative | Qualitative | |
| **Preharvest** (Production phase) | 5–10% | 0% | • Improper fertilization programmes (high N*application)<br>• Temperature fluctuations inside greenhouses<br>• Pest infestations and pathogens<br>• Irregular irrigation |
| **Harvest**** | 20–25% | 10% | • Negligence of workers in harvest timing<br>• High N*application that slows growth of fruits |
| **Transportation** | 2% | 5% | • Dirty crates<br>• Overloading of crates<br>• Exposure to direct sunlight that causes wilting |
| **Collection centre**** | 5–10 % | 10% | • Sorting of oversized fruits<br>• Lack of cold chain |
| **Wholesale markets** | 1–2 % | 5% | • Low quality crates<br>• Overloading of crates<br>• Lack of cold chain<br>• Delay in marketing |
| **Retailer shops** | 5–10 % | 10–15 % | • Lack of cold chain<br>• Overloading boxes<br>• Exposure to sunlight<br>• Delay in marketing |

**Source:** Authors' estimations according to observations and informants' interviews.

*N= Nitrogen
** Applicable only for open-field cultivated CP

Farmers and agriculture extension officers have reported in previous case studies that they rely heavily on plant nutrition programmes designed by the manufacturers of commercial chemical fertilizers. This study observed imbalanced programmes, noting that farmers apply nitrogen and phosphorus fertilizers at much higher levels than needed. This applies also for cucumbers and the other subsectors.

The major risk factors for cucumbers varies greatly between the two FSCs. For CP, the major risk factor relates to the need to harvest the cucumbers at a certain size; everything that is larger or smaller is discarded. Such losses may reach 15-20 percent. Most farmers reported that it is not economically feasible to collect, pack, transport, and market the extra-large fruits; almost all consumers prefer only small and medium sized fruits.

For CG, the major risk factor is the improper application of fertilizers. This problem is common to almost all cultivated vegetables in Palestine. Excessive application of N fertilizers leads to losses, both physiological and pathological. Extra-large fruits and more decay infections are due to excessive vegetative growth. Fluctuations in temperature inside greenhouses is a major cause for physiological losses in fresh cucumbers, such as weight loss and shrivelling.

As for post-harvest handling, the overloading of cartons and packing containers is widespread and accompanied by mechanical injuries. In addition, the lack of cold chain is an issue, although CG are marketed within two to three days after picking, so establishing a cold chain for cucumber might not be economically feasible.

Other risk factors of minor importance are related to the transport of fresh products, temperature stress, and pest management causing mechanical, physiological, and pathological injuries. However, most injuries do not impair the marketability of fresh cucumber in the local market. Another factor that is important is the role of wholesalers and traders, particularly when the production volume for cucumber is too high and prices became too low to support effective cultivation. This results in drastic increases in all types of losses. In this regard, farmers believe there is a significant power imbalance between them and the wholesalers and traders and see functional cooperatives as a solution.

## f) The food losses in cucumbers – Study findings and results

Sixty cucumber farms, six retailer shops, and six wholesale markets were surveyed. Samples, in triplicates, were assessed for all possible defects and injuries, and categorized for all classes of losses (physiological, mechanical, and pathological) and both qualitative and quantitative losses were quantified. Table 22 presents the quality scoring according to categories of damages, and Table 23 analyses the quality of the sampled cucumbers units showing the type of damage and the causes of the symptoms in the sample.

A major CLP for CP or CG are the production and harvest. As mentioned above, around 20 percent of processing cucumbers produced in open fields and around 5 percent of the greenhouse cucumbers are left unharvested or discarded if larger or smaller than the size demanded. A second major CLP is the wholesaler markets, where losses doubled. The main reason is that fruits are not protected from the external environment and are placed in spaces that are not temperature-controlled. Accordingly, pathological, mechanical, and physiological losses increased significantly. Among these losses are shrivelling and decay (see Table 20).

The matrix in Table 24 summarizes the results of cucumber food losses analysis. Measurements were taken one day after harvest and after three days at room temperature. Suggested solutions to reduce food loss in cucumbers include: improve picking and packing of fresh produce by replacing the current rough picking containers with smooth variants; and keeping the containers in a ventilated area to avoid heat build-up while waiting to transfer them to the market within two days.

**Table 19 Quality scoring of cucumber at different stages of the FSC**

| Quality score | Category | Description of the quality (Open field) | % Reduction of market value | Description of the quality (Greenhouses) | % Reduction of market value | Description of the quality (Wholesale markets) | % Reduction of market value | Description of the quality (Retailer shops) | % Reduction of market value |
|---|---|---|---|---|---|---|---|---|---|
| 0–1 | Completely unfit for consumption (to be discarded) | *Mechanical, pathological, then physiological | 100 | Mechanical, pathological, then physiological | 100 | Pathological, mechanical, then physiological | 100 | Physiological disorders | 100 |
| 2–6 | Medium defects | Mechanical, pathological, then physiological | 20–30 | Pathological, mechanical, then physiological | 5–10 | Pathological, mechanical, then physiological | 5–10 | Pathological then mechanical | 15–20 |
| 7–10 | In perfect shape | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 |

**Source:** Authors' elaboration.

*The causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and followed by pathological disorders)

**Table 20 Quality analysis of sampled units of cucumbers**

| Unit evaluated | Overall quality score | *Type of damage (deterioration) if any | Potential cause and symptoms |
|---|---|---|---|
| **Open-field** | 7.05 | Mechanical, pathological then physiological damage | • Quick growth of cucumbers necessitates daily harvesting<br>• Delays and improper harvesting and overloading cause severe mechanical injuries in many farms |
| **Greenhouses** | 6.70 | Mechanical, pathological then physiological damage | • Physical damage due to delayed and improper harvesting<br>• Overloading leads to infections causing qualitative losses |
| **Wholesalers** | 6.70 | Pathological followed by mechanical damages | • Warm climate in central markets is suitable for pathogens. Luckily, cucumbers are sold the same day.<br>• Dirty facilities make food safety impossible in fresh cucumber |
| **Retailer shops** | 6.55 | Physiological damage | • Warm climate in retail shops results in mild qualitative losses due to pathogens<br>• Consumers do not notice such mild infections, but waste at home is high and fast |
| **Average score:** | 6.75 | | |

**Source:** Authors' estimations according to primary data collection.

*The causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and followed by pathological disorders)

**Table 21 Summary result matrix of food losses in cucumber**

| FSC stage/ process | Type of loss Qt./Ql. | Percentage of the product that incurred quantity loss in this process (Informal local standards) | | Percentage of the product that incurred quality loss in this process | | Percentage of product that goes through this stage | Percentage loss in the FSC | Cause of loss/ Reason for low loss** | Reduced market value (%) | CLP / LLP | Destination of food loss | Impacts on environment/ climate change / natural resources | Impact/ FSC actors affected (men / women) | Loss perception of FSC actors (men / women) | Suggested solutions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *T1 | T2 | T1 | T2 | T1; T2 | | | | | | | | | |
| **Pre-harvest** | Qt | 10 | | | | | | | | | | | | | |
| **Production / harvest ***GH, IR** | Qt/Ql | 4.7 | 3.8 | 37.8 | 39 | 95.3; 96.2 | 4.2 | T1: Mechanical, pathological<br>T2: Mechanical, pathological physiological | 15 | CLP | Waste; animal feed | Waste of resources mainly labour, water, and agrochemicals | Mainly men; lower impact on women | Medium | Improving picking and packing of fresh produce<br>Use of smooth plastic picking containers |
| **Production / harvest ***OF, IR** | Qt/Ql | 3.3 (shelf-life not applicable to CP) | n/a | 24.3 | - | 96.8 | 3.3 | T1: Mechanical Pathological, physiological | 10 | CLP | | | Both men and women | Medium | Replacing current rough containers with smooth ones |
| **Wholesale markets** | Qt/Ql | | 5.15 | 34.2 | 43.3 | 87.6; 94.9 | 8.7 | T1: Pathological, mechanical, physiological<br>T2: Pathological, mechanical, physiological | 5 | CLP | Waste | | Men | High | Place cucumber in ventilated cool rooms to avoiding heat buildup |
| **Retailers** | Qt/Ql | 0.6 | - | 46.1 | - | 99.4 | 0.6 | T1: Physiological<br>T2: Pathological mechanical | 10 | LLP | Waste | Waste of resources; labour, water, and agrochemicals | Men | Low | None; the shelf-life of cucumber in retailer shops is 2 days. Losses are cumulative and reflect damages incurred in the whole chain |

**Source:** Authors' estimations according to primary data collection.

* T1: one day after harvest; T2: after a shelf-life of three days at room temperature
** the causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and followed by diseases)
***GH: greenhouse, IR: irrigated, OF: open field

# 2) The zucchini subsector

Zucchini is among the major cultivated and consumed plants in Palestine. This crop is of high economic importance and contributes to healthy diets. Production volume was over 55 000 tonnes in 2017, however estimations by the study team suggest that by 2019 the total production reached close to 100 000 tonnes. As shown in Table 22, Tubas, followed by Jericho, Jordan Valley and Jenin, are the top producing governorates for zucchinis. Table 23 evaluates the importance of zucchinis in the different governorates from 1 to 3 with 1 (low), 2 (medium) or 3 (high) based on secondary data analysis and discussions with informants.

**Table 22 Area, production, and productivity of zucchini FSC in Palestine (2010 and 2017)**

| Governorate | Area (Du) 2010 | Area (Du) 2017 | Production (tonne) 2017 | Productivity 2017 (tonne per Du) |
|---|---|---|---|---|
| Jenin | 2 438 | 2 304 | 7 726 | 3.4 |
| Tubas | 3 234 | 4 950 | 14 650 | 3 |
| Tulkarm | 229 | 207 | 434 | 2.1 |
| Nablus | 483 | 824 | 1 680 | 2 |
| Qalqilya | 140 | 89 | 167 | 1.9 |
| Salfit | 2 | 78 | 46 | 0.6 |
| Ramallah & Al-Bireh | 357 | 460 | 565 | 1.2 |
| Jericho/Jordan Valley | 7 603 | 5 196 | 10 412 | 2 |
| Jerusalem | 110 | 138 | 84 | 0.6 |
| Bethlehem | 218 | 509 | 362 | 0.7 |
| Hebron | 1 215 | 2 179 | 3 573 | 1.6 |
| Gaza | 93 | 1 000 | 4 135 | 4.1 |
| North Gaza | 152 | 41 | 164 | 4 |
| Rafah | 140 | 431 | 1 588 | 3.7 |
| Khan Yunis | 729 | 1 485 | 5 942 | 4 |
| Deir Al Balah | 386 | 1 030 | 4 546 | 4.4 |
| **Totals** | **17 529** | **20 921** | **56 074** | **2.45** |

**Source:** for 2010: PCBS. 2023. Percentage Distribution of Agricultural Holdings in Palestine by Sex of Holder and Governorate, 2010/2011. In: Palestinian Central Bureau of Statistics. Ramallah, Palestine. Cited 6 April 2023. https://www.pcbs.gov.ps/Portals/_Rainbow/Documents/Agri.2010-2011,5E.htm; for 2017: Palestine Ministry of Agriculture, unpublished data.

**Table 23 Evaluation of the importance of the zucchini subsector**

| Zucchini / regions | Economic Importance | Generation of foreign exchange | Contribution to national food consumption | Contribution to national nutrition | Impacts on environment and climate change |
|---|---|---|---|---|---|
| WB and GS | 3* | 1 | 3 | 1 | 1 |
| JER | 3 | 1 | 3 | 1 | 1 |
| JEN | 3 | 1 | 3 | 1 | 1 |
| GS | 3 | 1 | 3 | 1 | 1 |
| HEB | 2 | 1 | 2 | 2 | 1 |
| HEB/BET | | 1 | 2 | 2 | 1 |

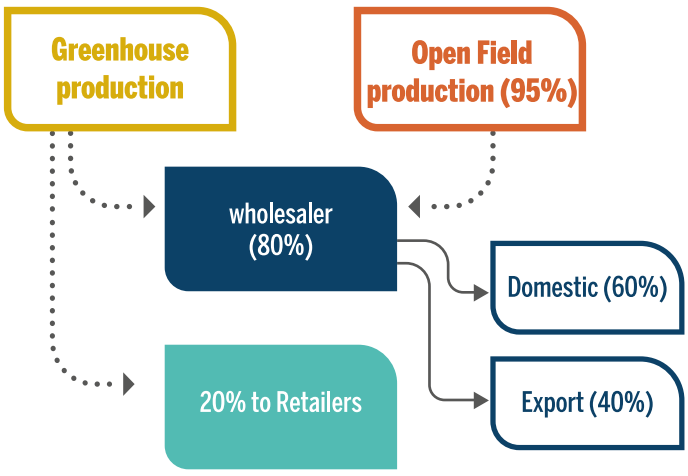
**Source:** Author's elaboration.

*1 (low), 2 (medium) or 3 (high)

Zucchini is a cash crop requiring a significant input of agrochemicals. In most governorates, it is produced in open fields under irrigation, however, in the southern governorates of the West Bank, the 'baladi' variety is produced mostly as rainfed. The productivity of the baladi variety is much lower than commercial varieties. Some farmers have started cultivating zucchini in greenhouses, however data is scarce about this new trend and the economic feasibility is unclear.

Zucchini is available year-round in West Bank and Gaza Strip and the cultivated acreage is stable. Like cucumber, zucchini faces major obstacles to expansion. Water resources and an underdeveloped marketing system are the main limiting factors. The major marketing channel for zucchini is through wholesale markets and to retailer shops. Wholesalers trade the fresh product and charge farmers 10 percent of the final price. Figure 3 below shows the product flow for zucchinis produced in small farms that is marketed fresh via wholesale markets for domestic consumption. Almost all zucchini is consumed cooked, as zucchini is not consumed fresh in Palestine.

**Figure 3 Zucchini product flow**

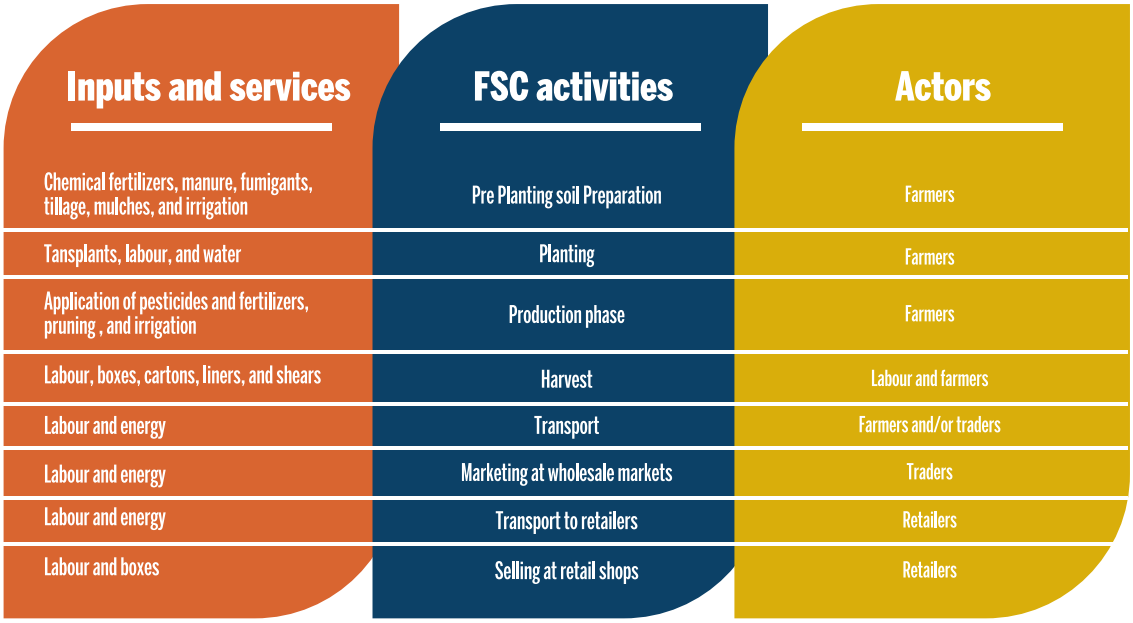



**Source:** Authors' elaboration.

## a) Zucchini subsector actors' involvement and their benefits

Zucchini prices fluctuate significantly during the season, with farmers, rather than wholesalers retailers or traders suffering losses in such times. Furthermore, profits from zucchini cultivation are not high enough to support a normal standard of living for farmers' families unless they have more than 5 dunums. The subsector has been a source of job creation in recent years, however, farmers reported difficulties finding skilled and unskilled workers. Figure 4 below illustrates the actors, their activities, and services and inputs used in the Zucchini FSC.

**Figure 4 Actors, activities and inputs and services in the zucchini FSC**




**Source:** Authors' elaboration.

## b) Detailed description of the Zucchinis FSCs

The FSC zucchini is very similar to fresh cucumber, the major difference being that it is still mostly cultivated in open fields. Table 24 provides a basic description of the Zucchini FSC. Given that there are no by-products of zucchini and that there are no food safety and quality controls applied throughout the chain, these columns were deleted from the table to simplify the presentation of the information. Table 25 describes in detail the social structures of the zucchini FSC and level of involvement of women and men, the organization level of the actors in the FSC, and additional information about the social structures.

**Table 24 Detailed description of the fresh zucchini FSC – basics**

| Phase for Zucchini | Geographical Location | Months of the year | | Quantity (tonnes, 2020)* | Duration/ Distance | Services |
|---|---|---|---|---|---|---|
| | | From | To | | | |
| Primary production | Jenin | 20.01 | 15.05* | 2 700 | 4 months | Irrigation/ fertigation, pest control.<br>Mesh for the second, third and fourth cycles |
| | | 15.04 | 10.07** | 7 425 | 3 months | |
| | | 10.07 | 20.09 | 4 125 | 2.5 months | |
| | | 20.08 | 01.12 | 6 187 | 3.5 months | |
| | Maithlon, Al Farah (Tubas) | 25.04 | 10.07 | 3 300 | 2.5 month | |
| | | 25.07 | 01.11 | 3 300 | 3.5 months | |
| | Jordan Valley | 20.07 | 01.10 | 675 | 2.5 month | |
| | | 01.10 | 01.02 | 8 250 | 4 months | |
| | | 20.01 | 01.05 | 8 250 | 3.5 months | |
| | Hebron | 01.04 | 30.07 | 4 125 | 4 months | |
| | | 15.07 | 15.11 | 4 125 | 4 months | |
| Harvest | Jenin | 01.04 | 15.05 | The amounts listed above minus the losses occurred before harvest | Early hours of the day. | Picking and packing of fruits. Discarding damaged fruits |
| | | 20.05 | 10.07 | | | |
| | | 10.08 | 20.09 | | | |
| | | 01.10 | 01.12 | | | |
| | Maithlon, Al Farah (Tubas) | 25.06 | 10.07 | | | |
| | | 15.09 | 01.11 | | | |
| | Jordan Valley | 20.08 | 01.10 | | | |
| | | 10.11 | 01.02 | | | |
| | | 01.03 | 01.05 | | | |
| | Hebron | 10.05 | 30.07 | | | |
| | | 15.08 | 15.11 | | | |
| Post-harvest handling | Jenin | 01.04 | 15.05 | The amounts listed above minus losses at harvest | During the same day of harvest, rarely for more than 12 hours. | Packing. |
| | | 20.05 | 10.07 | | | |
| | | 10.08 | 20.09 | | | |
| | | 01.10 | 01.12 | | | |
| | Maithlon, Al Farah (Tubas) | 25.06 | 10.07 | | | |
| | | 15.09 | 01.11 | | | |
| | | 20.08 | 01.10 | | | |
| | Jordan Valley | 10.11 | 01.02 | | | |
| | | 01.03 | 01.05 | | | |
| | Hebron | 10.05 | 30.07 | | | |
| | | 15.08 | 15.11 | | | |

| Phase for Zucchini | Geographical Location | Months of the year | | Quantity (tonnes, 2020)* | Duration/ Distance | Services |
|---|---|---|---|---|---|---|
| | | From | To | | | |
| **Transportation** | Jenin | 01.04 | 15.05 | The amounts listed above minus losses at harvest and during post-harvest handling | 2–6 hours | Moving product to wholesale markets; rarely directly to retailers |
| | | 20.05 | 10.07 | | | |
| | | 10.08 | 20.09 | | | |
| | | 01.10 | 01.12 | | | |
| | Maithlon, Al Farah (Tubas) | 25.06 | 10.07 | | | |
| | | 15.09 | 01.11 | | | |
| | Jordan Valley | 20.08 | 01.10 | | | |
| | | 10.11 | 01.02 | | | |
| | | 01.03 | 01.05 | | | |
| | Hebron | 10.05 | 30.07 | | | |
| | | 15.08 | 15.11 | | | |
| **Wholesale Market** | Jenin | 01.04 | 15.05 | The amounts listed above minus losses at harvest, during post-harvest handling, and during transport | Less than 12 hours | Purchasing and selling of the product |
| | | 20.05 | 10.07 | | | |
| | | 10.08 | 20.09 | | | |
| | | 01.10 | 01.12 | | | |
| | Maithlon, Al Farah (Tubas) | 25.06 | 10.07 | | | |
| | | 15.09 | 01.11 | | | |
| | Jordan Valley | 20.08 | 01.10 | | | |
| | | 10.11 | 01.02 | | | |
| | | 01.03 | 01.05 | | | |
| | Hebron | 10.05 | 30.07 | | | |
| | | 15.08 | 15.11 | | | |
| **Retailers** | All governorates throughout the year | Jan | Dec | The amounts listed above minus losses at harvest, during post-harvest handling and transport, and in wholesale markets | 1–2 days | Selling of product |

**Source:** Authors' estimations according to observations and informants' interviews.

* rainfed, ** irrigated

**Table 25 Detailed description of the zucchini FSC– Social structures**

| Zucchini FSC steps | Involvement of Women | | Involvement of Men | | Who is mainly involved | Organization level of FSC actors* | Gender / social patterns |
|---|---|---|---|---|---|---|---|
| | Girls | Women | Boys | Men | | | |
| **Primary production** | 1** | 2 | 1 | 3 | Mainly men, occasionally also women in select areas. | Family and private companies | • Women occasionally involved. They do not have the same access to equipment as men.<br>• In most cases, men handle this process. |
| **Harvest** | 1 | 4 | 1 | 3 | Men and women | Family and occasional day laborers | • Women involved in family farms and as day labourers.<br>• Women work as day labourers on their own, through a mediator/driver, or for longer intervals alongside the families.<br>• At times, older children worked with families. |
| **Post-harvest handling** | 0 | 0 | 0 | 4 | Women | Family or day labourers | • Women are involved in sorting by size, but only when export or transfer to Israeli market takes place. |
| **Transport** | 0 | 0 | 0 | 4 | Male traders | Families and traders | • Transport was typically taken care of by farmers, and occasionally traders.<br>• Absence of women in this stage due to the horizontal separation |
| **Market sales** | 0 | 0 | 0 | 4 | Men deal with traders who then take the produce to market | Traders | • Farmers sell through intermediaries, with little bargaining power<br>• Absence of women in markets, illustrating the traditional and cultural barriers women face<br>• Related to the agricultural tenure, men dominate the whole cycle |

**Source:** Authors' elaboration according to observations and informants' interviews.

* Individual/Household level/Cooperative
** Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad, 0: does not exist.

## c) Economics of the Zucchinis FSC

Unlike cucumbers, the profit from zucchini production is more equally shared among the FSC actors. The average profit margins are 0.65 USD/kg for farmers, 0.61 USD/kg for wholesalers, and 0.70 USD/kg for retailers (Table 29). At the pre-harvest level, farmers bear the costs of ploughing, fertilizers, pesticides, irrigation, labour, seedlings, spraying and farm management. At the harvest and packing levels, farmers bear the costs of manual harvesting, packaging, and transportation to markets. The economics of the zucchini FSC are detailed in Table 26, including costs and value added at each stage. Values given are based on the prices for the period from May to July 2020.

**Table 26 Detailed description of the zucchini FSC– economics**

| Zucchini FSC stage | Cost of operation USD/kg | Cumulative Cost USD/kg | Value USD/kg final product | Value-added / Margins USD/kg | Remarks |
|---|---|---|---|---|---|
| **Pre-harvest** | 0.27 | 0.27 | | | Costs of ploughing, fertilizers, irrigation, labour, seedlings, pesticides, spraying and farm management |
| **Harvest and packing** | 0.11 | 0.38 | 1.03[a] | 0.65 | Manual harvesting, packaging, transportation to market sales |
| **Wholesale** | 0.10 | 0.48 | 1.09[b] | 0.61 | Municipality fee, labour, and equipment |
| **Retail** | 0.06 | 0.54 | 1.24[c] | 0.70 | Transportation, labour, equipment, and electricity |

**Source:** Authors' estimations according to observations and informants' interviews.

[a] price at farm gate; [b] price at wholesale market gate; [c] consumer price.

## d) Environment-related inputs and factors in Zucchini.

Most zucchini farms use transplants of hybrid seeds rather than the indigenous, lower-productivity 'baladi' seeds. Plant material as transplants is very productive but highly susceptible to pests, so farmers use large quantities of pesticides. This raises the problem of food safety due to pesticides residues.

The production cycle of zucchini cultivated in open fields under irrigation starts with soil preparation that includes tillage, application of manure, and pre-plant application of chemical fertilizers. Next, plant material is purchased from certified sources (private companies) and planted in relatively wet soil. Cultivated plants are heavily fertilized during the short growing season. Pesticides are used widely and frequently, although the amounts differ between seasons. As regards water usage, each dunum needs 300 – 400 m3 of water for irrigation in one production cycle (less than three months for zucchini in most farms). It is worth noting that zucchini farmers are highly specialized and hold valuable experience. Table 27 describes the factors in the Zucchini FSC that affect the environment and Table 28 describes environmental factors affecting the zucchini FSC.

**Table 27 Detailed description of the zucchini FSC – environment**

| Zucchini PRODUCTION | | Quantity | Unit for 1 Dunum |
|---|---|---|---|
| **Tools, Equipment, Facilities** | **Harvesting equipment** | | |
| | - Gloves | 10 | No. |
| | - Harvest plastic (20 litres) container | 50 | No. |
| | **Irrigation system** | | |
| | - Pipes | 650 (w: 1.55cm) | metres |
| | Fertigation unit | 1 | |
| | **Manual and motorized sprayers for pesticides** | 1 | No. |
| | Tractor | n/a | No. |

| Zucchini PRODUCTION | | Quantity | Unit for 1 Dunum |
|---|---|---|---|
| Materials, Chemicals | Manure | 3 | $m^3$ |
| | Fertilizers | 90 (50 kg nitrogen fertilizers and 70 kg complete fertilizers) | Kg |
| | Mulch (ground cover) | 45 | m |
| | Yellow insect sticky traps | 10–12 | No. |
| | Pesticides | 1–1.5 litres (wintertime); 3–4 litres (summertime) | Litre |
| Energy | Fossil fuel (diesel or gasoline) | 6 | Litre/hour |
| Water | Groundwater | 250–300 | $m^3$ |
| TRANSPORTATION | | | |
| Tools, Equipment, Facilities | Rented pickup truck | 1 (owned or rented) | No. |
| | Tractor | 1 (owned or rented) | No. |
| WHOLESALE, RETAIL | | | |
| Tools, Equipment, Facilities | Forklift | 15–20 for each market | No. |
| | Keeping rooms (few with cold units) | Less than 5 in each wholesale market | No. |
| | Refrigerated unit | 2–3 by each retailer | No. |

**Source:** Authors' elaboration.

NA: not available

**Table 28 Factors for the environmental assessment of the zucchinis FSC**

| Factors in Zucchini FSC | Description | Details |
|---|---|---|
| **Type of production system** | Intensive culture in open fields | • Hybrid seeds are used<br>• Heavy use of agrochemicals and energy<br>• Production cycle is short |
| **Land preparation practices** | Soil preparation, tillage and application of manure and chemical fertilizers | • Zucchini are cultivated in open fields and need support for growth<br>• After complete removal of the previous crop residues, farmers start with tillage and application of chemical fertilizers (foundation ration) and manure<br>• Farmers distribute irrigation pipes and system |
| **Soil quality and land degradation** | Soils have enough diverse nutrients but excessive amounts of fertilizers are still applied | • Farmers apply large amounts of chemical fertilizers before planting as recommended by the manufacturers and agriculture extension officers, without analyzing the soil<br>• In most farms, the application of certain nutrients, particularly phosphorus leads to nutritional imbalances. Previous study shows that soils already have high levels of both N and P, which were applied during the production cycle of the previous crops<br>• Large amounts of plant nutrients accumulate over the years (P and Mg) |
| **Ecosystem impacts** | Negative impact on the ecosystem due to excessive use of fertilizers and pesticides | • The excessive use of agrochemicals, pumping of water, and transport have a negative impact on the ecosystem and biodiversity<br>• Salinization of soil due to application of fertilizers and the use of water of inferior quality is a problem in certain regions, including Gaza Strip and Jordan Valley<br>• Efforts are needed to optimize the application of fertilizers |
| **Sources of GHG emissions** | GHG emissions due to agrochemicals and fuel for soil preparation and transport | • Production of agrochemicals and soil preparation are energy-intensive, using mostly diesel to power the machines<br>• Transport uses energy that emit excessive amounts of GHG<br>• There is a need to optimize energy use |
| **Climatic factors** | Adverse climatic factors during production cause losses | • Fluctuations of temperature and rainfall lead to quantitative and qualitative losses |
| **Utilization of residues in the supply chain** | Residues are discarded and rarely used | • Residues are valuable resources for plant nutrients and are considered as soil amendments to improve its physical properties<br>• Farmers discard residues to reduce pathogen load on the new crop<br>• Composting is not a common practice |
| **Re-use of food losses** | Damaged and injured fruits are discarded. | • Most fruits with minor defects are marketed to restaurants<br>• Fruits with severe damages and extra-large fruits are discarded |

**Source:** Authors' elaboration.

*P, Mg: Phosphorus, Magnesium, respectively.

## e) Expected food loss in the zucchini FSC

Over 90 percent of zucchini produced are marketed in the domestic market, which tolerates most defects, particularly the deformed and slightly scratched fruits. However, very large fruits are occasionally discarded by farmers, since consumers here prefer small and very small fruits. Most informants explained that very large fruits are sold to restaurants at much lower prices. Results of the preliminary screening of food losses in the zucchini FSC are presented in Table 29.

**Table 29 Preliminary screening of food losses in the zucchini FSC.**

| Step in the FSC | Expected Critical Loss Points | | Comments / Remarks Losses might be due to: |
|---|---|---|---|
| | Quantitative | Qualitative | |
| **Preharvest** (Production phase) | 5 –10% | 0% | • Abortion of small fruits<br>• Improper fertilizers programmes (plant nutrition programmes)<br>• Infections and infestation<br>• Irregular irrigation<br>• Fluctuations in temperature |
| **Harvest** | 10% | 15% | • Mechanical injuries due to breaking of fruit stalk<br>• Decay of petals |
| **Transportation** | 2% | 5% | • Overloading of boxes and cartoons<br>• Mechanical injuries due to compaction<br>• Dirty boxes |
| **Wholesaler** | 1–2% | 5% | • Overloading of boxes<br>• Lack of cold chain |
| **Retailers** | 5–10% | 15% – 20% | • Lack of cold chain<br>• Delay in marketing<br>• Overloading of boxes |

**Source:** Authors' elaboration.

Zucchini are sensitive fruits that need unhurried and careful harvest, handling, and transport practices, which is not the norm for farmers. The major risk factor for zucchini, which is predominantly cultivated in open fields, is the abortion of fruits after fruit set. This problem causes severe losses, as these fruits are very small to market and of very bad quality. The type of loss is closely related to temperature, with farmers noticing that it occurs at specific times early in the season. Another risk factor is the whitening of fruits, where fruits do not get their typical colour. The consumers do not purchase "white" fruits, and accordingly these are considered as losses. Research work is needed to elucidate the reasons for this phenomenon that causes severe losses. Other risk factors observed during this study are the viral infections that affect the shape of fruits in addition to the excessive application of fertilizers.

Harvest and post-harvest handling including transport are factors of high importance. Losses due to overloading of boxes and the use of dirty containers add to the risk of food loss in zucchinis. The scale of physical losses of these combined factors is high, mainly causing qualitative losses due to mechanical injuries (scratches). These fruits are marketable in the local market, but a substantial part is discarded by retailers or consumers. As with the CG FSC, the negative impact of powerful wholesalers and lack of cold chain affects the zucchini FSC.

## f) The food losses in zucchinis – Study findings and results

Forty zucchini farms, six retailer shops, and six wholesale markets were surveyed. Samples, in triplicates, were assessed for all possible defects and injuries, and categorized for all classes of qualitative and quantitative losses (physiological, mechanical, and pathological). Table 30 presents the quality scoring according to categories of damages, and Table 31 analyses the quality of the sampled zucchinis units showing the type of damage and the causes of the symptoms.

The principal CLP for zucchinis relates to harvest time and harvesting practices that led to severe mechanical injuries for up to 10–15 percent of fruits. In addition, the rapid decay of petals (corollas) was observed, although retailers tend to remove them. A second CLP relates to overloading of cartons which leads to a high degree of mechanical injuries that are mostly tolerated by wholesalers, retailers, and consumers. A third CLP is the rapid wilting of fruits within days after picking, especially those already injured. Although quantitative losses at the wholesale markets are high, our assessment reveals that these losses originate from farms and not the markets themselves. Zucchinis are marketed within hours in the wholesale markets, a narrow timeframe in which to incur quantitative losses of around 10 percent.

Tables 32 and 33 summarize the result of the zucchini food loss analysis. Measurements were taken one day after harvest and after a shelf-life of three days at room temperature. Some suggested solutions to reduce food loss in zucchinis include searching for varieties adapted to a hot environment to avoid abortion of fruits due to high temperature stress and protecting fruits from the external environment after harvest. Wrapping fruits in plastic liners then placing them in relatively cold rooms would increase their shelf-life and maintain their turgid quality.

**Table 30 Quality scoring of zucchini**

| Quality score | Category | Description of the quality (Farms) | Percent reduction of market value | Description of the quality (Wholesale markets) | Percent reduction of market value | Description of the quality (Retailer shops) | Percent Reduction of market value |
|---|---|---|---|---|---|---|---|
| 0–1 | Completely unfit for consumption (to be discarded) | *Mechanical, pathological, then physiological | 100% | Mechanical, pathological, then physiological | 100% | Mechanical, then pathological | 100% |
| 2–6 | Medium defects | Mechanical, pathological, then physiological | 20–30% | Mechanical, pathological, then physiological | 5–10% | Mechanical, pathological, then physiological | 25–30% |
| 7–10 | In perfect shape | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 |

**Source:** Authors' estimations according to primary data collection.

* The causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and then pathological disorder)

**Table 31 Quality analysis of sampled units of zucchinis**

| Unit evaluated | Overall quality score | Type of damage (deterioration) if any* | Potential cause and symptoms |
|---|---|---|---|
| Farmers | 6.90 | Physical and mild biological damages | • Fruits are sensitive to improper harvest techniques and rough packing |
| Wholesaler | 6.66 | Physical and mild biological damages | |
| Retailer shops | 6.56 | Physical and mild biological damages | • Most fruits have scratches and mild mechanical injuries. These are marketable at lower prices |
| Average score: | 6.70 | | |

**Source:** Authors' estimations according to primary data collection.

*The causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and followed by diseases).

### Table 32 Summary result matrix of food losses in zucchini

| FSC stage/ process | Type of loss Qt./Ql | Percentage of the product that incurred quantity loss in this process | | Percentage of the product that incurred quality loss in this process | | Percentage of product that goes through this stage | Percentage loss in the FSC |
|---|---|---|---|---|---|---|---|
| | | *T1 | T2 | T1 | T2 | T1; T2 | |
| **Preharvest** | Qt | 20% | ? | | | | |
| **Production and harvest – irrigated** | Qt/Ql | 14.1 | 6.6 | 74.0 | 85.1 | 85.9; 93.4 | 10.3 |
| **Wholesale markets** | Qt/Ql | 9.6 | 7.0 | 67.4 | 54.8 | 90.4; 93.0 | 8.3 |
| **Retail** | Qt/Ql | 7.7 | - | 65.0 | - | 92.3 | 7.7 |

**Source:** Authors' estimations according to primary data collection.

* T1: one day after harvest; T2: after a shelf-life of three days at room temperature.

### Table 33 Summary result matrix of food losses in zucchini (cont'd)

| FSC stage/ process | Cause of loss/ Reason for low loss** | Reduced market value (percent) | CLP / LLP | Destination of food loss | Impacts on the environment / climate change / natural resources | Impact/ FSC actors affected (men / women) | Loss perception of FSC actors (men / women) | Suggested solutions |
|---|---|---|---|---|---|---|---|---|
| **Preharvest** | Whitening of fruits. damages due to fungal decay and insects' infestation | | | | | | | |
| **Production and harvest-irrigated** | T1: Mechanical, pathological physiological<br>T2: Mechanical, pathological physiological | 10 | CLP | Waste | Waste of resources mainly labour, water, and agrochemicals | men/ women | high | Varieties adapted to hot weather; current varieties encounter fruit abortion due to heat stress |
| **Wholesale markets** | T1: Mechanical Pathological<br>T2: Mechanical Pathological physiological | 8 | CLP | Waste | Waste of resources mainly labour, water, and agrochemicals | men | low | None. Fruits stand for less than 24 hours at wholesale markets |
| **Retailers** | T1: Mechanical Pathological | 8 | LLP | Waste | Waste of resources mainly labour, water, and agrochemicals | men | medium | Wrapping fruits in plastic liners and storing in cold rooms might increase shelf life |

**Source:** Authors' estimations according to primary data collection.

** the causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and followed by diseases).

# 3) The table grapes subsector

Palestinian farmers produced over 100 000 tonnes of table grapes in 2020. Hebron and Bethlehem are the top producing governorates of table grapes in Palestine. There are three main FSCs for table grapes covered in this study, SLTG, IrSDTG and RfSDTG. The productivity of irrigated table grapes is high. More than 3 tonnes per dunum in 2020 were observed in the study, and productivity under rainfed conditions in Hebron and Bethlehem governorates is much lower (less than 1 tonne per dunum). Table 34 presents the area of production, tonnage, and productivity of the whole table grapes subsector. Table 35 evaluates the importance of table grapes in the different governorates from 1 to 3 with 1 (low), 2 (medium) or 3 (high) based on secondary data analysis and discussions with informants.

**Table 34 Area, production, and productivity of table grapes supply chain in Palestine (2010 and 2017)**

| Governorate | Area (Du) 2010 | Area (Du) 2017 | Production (tonne) 2017 | Productivity 2017 (tonne per Du) |
|---|---|---|---|---|
| Jenin | 464 | 2 095 | 2 323 | 1.1 |
| Tubas | 78 | 750 | 1 088 | 1.5 |
| Tulkarm | 9 | 32 | 47 | 1.5 |
| Nablus | 324 | 1 230 | 1 630 | 1.3 |
| Qalqilya | 18 | 165 | 34 | 0.2 |
| Salfit | 18 | 723 | 504 | 0.7 |
| Ramallah & Al-Bireh | 225 | 935 | 1 269 | 1.4 |
| Jericho/Jordan Valley | 212 | 328 | 363 | 1.1 |
| Jerusalem | 477 | 3 036 | 8 259 | 2.7 |
| Bethlehem | 5 344 | 14 264 | 12 121 | 0.8 |
| Hebron | 9 853 | 27 248 | 26 725 | 1 |
| Gaza | 2 305 | 4 621 | 5 549 | 1.2 |
| North Gaza | 71 | 497 | 621 | 1.2 |
| Rafah | 155 | 993 | 1 459 | 1.5 |
| Khan Yunis | 73 | 529 | 771 | 1.5 |
| Deir Al Balah | 332 | 595 | 677 | 1.1 |
| **Totals** | **37 487** | **78 962** | **63 440** | **1.23** |

**Source:** for 2010: PCBS. 2023. Percentage Distribution of Agricultural Holdings in Palestine by Sex of Holder and Governorate, 2010/2011. In: Palestinian Central Bureau of Statistics. Ramallah, Palestine. Cited 6 April 2023. https://www.pcbs.gov.ps/Portals/_Rainbow/Documents/Agri.2010-2011,5E.htm; for 2017: Palestine Ministry of Agriculture, unpublished data.

**Table 35 Evaluation of the importance of the table grapes subsector**

| Table Grapes / regions | Economic Importance | Generation of foreign exchange | Contribution to national food consumption | Contribution to national nutrition | Impacts on environment and climate change |
|---|---|---|---|---|---|
| WB and GS | 2* | 1 | 3 | 2 | 2 |
| HEB | 3 | 1 | 3 | 3 | 2 |
| BET | 2 | 2 | 2 | 2 | 2 |
| TUB | 2 | 1 | 2 | 1 | 2 |
| NAB | 2 | 2 | 2 | 2 | 2 |
| JEN | 2 | 2 | 2 | 2 | 2 |
| JER | 2 | 2 | 2 | 1 | 2 |

**Source:** Authors' elaboration.

* 1 (low), 2 (medium) or 3 (high).

The table grapes subsector has seen dramatic changes in the last fifteen years. A major change is the introduction of seedless grapes to northern governorates of the West Bank, driven by wealthy farmers in areas like Al-Nassariya (Nablus governorate). Furthermore, a significant expansion is also evident by smallholders in areas like Qabatiya (Jenin governorate) cultivating IrSDTG.

RfSDTG – Most farms producing RfSDTG are small, less than 10 dunum. This fragmentation is a major hindrance for farmers when seeking to access efficient equipment. Furthermore, very low prices during the peak season render small farmers vulnerable to severe economic losses. RfSDTG are mostly produced in Hebron and Bethlehem governorates using mainly grafted transplants. Some farmers plant rooted cuttings without grafting on tolerant rootstocks. RfSDTG FSC is the traditional form of extensive agriculture. This extensive production of grapes without irrigation uses few chemical inputs. Farmers add manure and limited amounts of chemical fertilizers such as superphosphate and complete fertilizers during the dormant season, and ammonia by the bud break. Pest management against powdery mildew, grape berry moth, and occasionally downy mildew is widely practiced. The harvest period of RFSDTG starts by the end of August and continues to mid-November.

RfSDTG are marketed predominantly in the local domestic market through wholesale markets and retailers, with the remainder marketed to Israel. RfSDTG production is not profitable for many farmers, prices are too low during the season, and there are no opportunities yet to extend the marketing window.

A significant proportion of rainfed grapes is processed to a variety of products such as malban, dibs, and jam. Unfortunately, the grape varieties suitable for processing are limited to just a few, including the widely cultivated Zaini variety. Grape leaves (dawali) are becoming an important product as the consumption of leaves increases steadily in Palestine.

IrSDTG – IrSDTG is a cash crop with high inputs of agrochemicals during production (productivity 3–4 tonnes per dunum). Clusters are marketed through traders, with over 60 percent of the product destined for the Israeli market. A common practice is to enter into advance agreements between producers and dealers. The remaining portion, around 30 percent, is delivered to domestic central

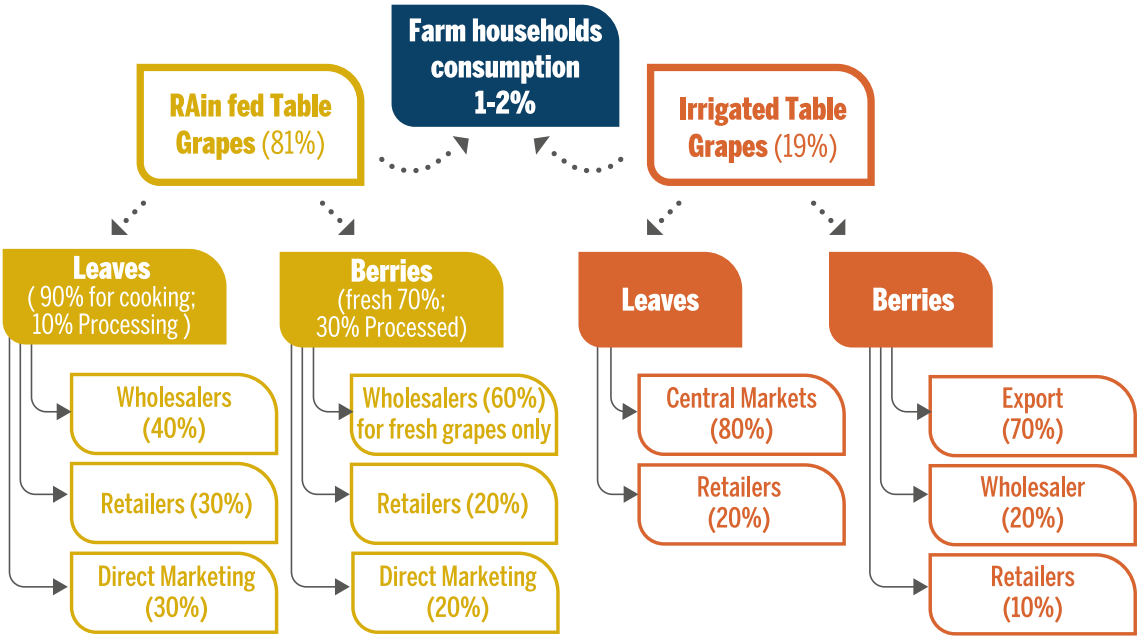
markets and retailers, and a small portion, 10 percent, is marketed directly by farmers to retailers. Almost 100 percent of the product is consumed fresh without processing, unlike rainfed grapes. Finally, leaves are an important product, with over 50 percent being sold in wholesale markets and retailers (productivity = around 400 kg per dunum).

SLTG – SLTG FSC are highly industrialized and rely heavily on marketing products to Israeli traders and food companies. Agreements with Israeli traders and processing plants require that farmers adhere to strict regulations concerning food safety and quality of their products. The adherence to quality regulations requires strict sorting of the products resulting in relatively large amounts diverted to local markets, which entails economic losses. Nonetheless, interviews with farmers and respondents indicate the cultivation of seedless grapes is highly profitable. Notably, the major market for SLTG is the Israeli market through regular marketing channels, along with a significant smuggling channel.

In addition to wholesalers and retailers, there is an increasing trend for traders, mostly from Hebron governorate, to directly travel to farms and collect fresh products and sell them to retailer shops in their regions. Although their share in the market is not high, their role will be significant in the coming years.

Figure 5 shows the product flow of rainfed and irrigated table grapes revealing different marketing channels for different product.

**Figure 5 Table Grapes – product flow**




**Source:** Authors' elaboration.

## a) Table grapes subsector actors' involvement and their benefit

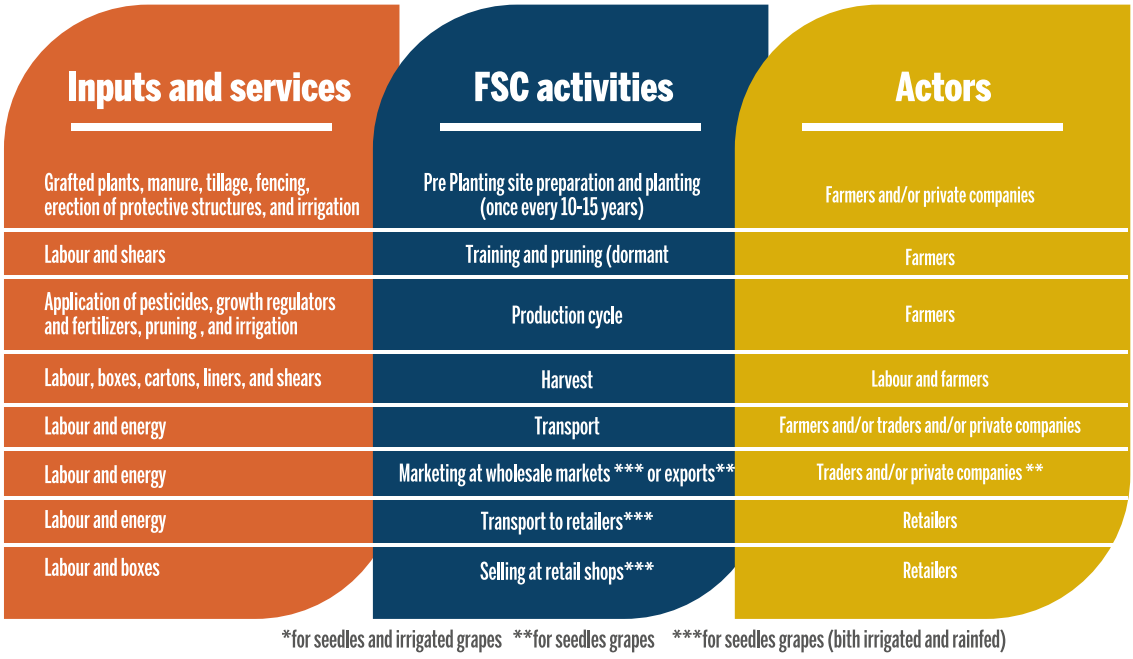
For SLTG, the major actors are farmers, owners of collection centres and traders for the Israeli market, and wholesalers and retailers for product diverted to local markets. Some SLTG farmers interviewed deliver product directly to consumers, mostly upon request for wedding parties in the central West Bank (such as Jerusalem). Farmers benefit greatly as they have almost no competition early in the season; prices reached USD 2.5 per kg at that time, which yielded a profit of around USD 6000 per dunum. Such profit is not the norm for Palestinian farmers. Israeli traders also greatly benefit from

this FSC. There is no specific data, however, an indicator is the consumer price in Israeli markets that is over USD 5 per kg. During field visits, it was observed that a large number of jobs were created in the last few years in this FSC.

In contrast, RfSDTG FSC is less profitable, and farmers experience frequent losses. A significant number of farmers were forced to abandon their plots, and other farmers switch to other cultures with more stable prices and less effort, such as rainfed olive and stone fruits.

Figure 6 below illustrates the actors and their activities in addition to the services and inputs used in the Table Grape FSC.

**Figure 6 Actors, activities and inputs and services in the table grape FSC**




**Source:** Authors' elaboration.

## b) Detailed description of the table grapes FSCs

The SLTG FSC is new in Palestine and most farms are in the warm regions east of Nablus governorate and Jordan Valley. Farmers benefited highly from a harvest very early in the season with almost no competition from other regions, making this intensive culture very profitable. Accordingly, the production area has dramatically increased in recent years. The FSC starts with highly skilled farmers that have access to irrigation, which is the key factor in their success. Vines are grown in protected cultures and receive intensive care. This includes training, pruning, and excessive use of chemical fertilizers, pesticides, and growth regulators, mainly gibberellins to increase berry size. At harvest time, farmers have arrangements with traders, mostly Israeli traders, to sell their products at prices that can exceed USD 2.5–3 per kg. Farmers also harvest and sell grapevine leaves, a product that is gaining in importance especially in the local market.

The IrSDTG FSC is also relatively new, and currently concentrated in the northern West Bank in Qabatiya and Jenin. Farms are medium-sized, and farmers are mostly skilled. Farmers employ the same cultural practices as for SLTG, except without the use of growth regulators to increase berry size. Agrochemicals are used intensively, and for most of the season, vines are irrigated. Harvest should be

conducted upon the ripening of fruits, but farmers tend to harvest earlier. This results in poor quality and reduced sweetness. The principal markets are the Israeli and local markets.

RfSDTG FSC covers the largest production area, stretching from southern remote locations in the West Bank to the central mountains of Hebron, Bethlehem, Jerusalem, Ramallah and Nablus. Cultivation is extensive, as no water resources are available for irrigation. Consequently, the use of agrochemicals is limited to the control of common pests and diseases, mainly powdery mildew. Productivity is low, but the production volume for the West Bank is substantial, with marketing congestion during the harvest period (September – October). Farmers deliver their product to wholesale markets and retailers source from wholesalers. Direct channelling from farms to retailers has also been observed. Furthermore, smuggling to the Israeli market is an open secret.

Tables 36, 37 and 38 below present basic information about the three FSCs in the table grapes subsector. Each phase of the FSC is detailed, including the geographical location, the production periods, the tonnage, and other related information. The grapes cluster is considered the main product throughout the phases of the FSC. Tables 39, 40 and 41 then describe the social structures in detail for SLTG, IrSDTG and RfSDTG FSCs, respectively. The emphasis in these three tables is on the level of involvement of women and men, the organization level of the actors in the FSC, and additional information according to informants.

**Table 36 Detailed description of the SLTG FSC – basics.**

| Phase for Seedless grapes | Months of the year | | Quantity (tonnes, 2020) | By-products | Duration/ Distance | Services | Food safety and quality controls applied by that part of the chain |
|---|---|---|---|---|---|---|---|
| | From | To | | | | | |
| **Production** | 15.12 | 20.06 | 10 800 | Grapevine leaves | 1 month | Irrigation/ fertigation, pest control, pruning, thinning, hormonal control | None |
| **Harvest** | 20.05 | 20.06 | The amounts listed above minus harvest losses | none | 1 month | Picking, packaging and partial sorting | Frequent tests for pesticide residues in export markets |
| **Post-harvest handling** | 20.05 | 20.06 | The amounts listed above minus post-harvest handling losses | None | 1 day | Packing, partial sorting (discarding damaged parts of clusters), packaging | Frequent testing for pesticide residues |
| **Transportation** | 20.05 | 20.06 | The amounts listed above minus transportation losses | None | Less than 12 hours | Moving product to wholesale markets | None |
| **Wholesale Market** | 20.05 | 20.06 | The amounts listed above minus wholesale market losses | None | Less than 12 hours | Purchasing and selling the product. Most SLTG are channelled to Israeli market through traders, not wholesale markets. | None |
| **Retailers** | 20.05 | 20.06 | The amounts listed above minus retail losses | None | 1–3 days | Selling product to consumers | None |

**Source:** Authors' elaboration.

**Table 37 Detailed description of the IrSDTG FSC – basics**

| Phase for Irrigated seeded table grape | Months of the year | | Quantity (tonnes)* | By-products | Duration/ Distance | Services | Food safety and quality controls applied by that part of the chain |
|---|---|---|---|---|---|---|---|
| | From | To | | | | | |
| **Primary production** | 15.01 | 01.10 | 24 000 | Grapevine leaves | 2 months | Irrigation/ fertigation, pest control, pruning, thinning | None |
| **Harvest** | 01.08 | 01.10 | The amounts listed above minus harvest losses | none | 2 months | Picking, packaging and partial sorting | Rarely tests for pesticide residues for export market |
| **Post-harvest handling** | 01.08 | 01.10 | The amounts listed above minus post-harvest handling losses | None | 1 day | Packaging and partial sorting (sometimes discarding damaged parts of clusters) | Rarely testing for pesticide residues |
| **Transportation** | 01.08 | 01.10 | The amounts listed above minus transportation losses | None | Less than 12 hours | Moving product to wholesale markets | None |
| **Wholesale Market** | 01.08 | 01.10 | The amounts listed above minus wholesale market losses | None | Less than 12 hours | Purchasing and selling the product | None |
| **Retailers** | 01.08 | 01.10 | The amounts listed above minus retail losses | None | 1–3 days | Selling product to consumers | None |

**Source:** Authors' elaboration.

**Table 38 Detailed description of the RfSDTG FSC – basics**

| Phase rainfed seeded table grape | Months of the year | | Quantity (tonnes, 2020)* | By-products | Duration/ Distance | Services | Food safety and quality controls applied by that part of the chain |
|---|---|---|---|---|---|---|---|
| | From | To | | | | | |
| **Primary production** | 15.01 | 15.11 | 47 000 | Grapevine leaves | 2.5–3.0 months | Pest control, pruning, thinning | None |
| **Harvest** | 01.09 | 15.11 | The amounts listed above minus harvest losses | molasses, malban | 2.5–3.0 months | Picking, packaging, and discarding damaged parts from clusters. | None |
| **Post-harvest handling** | 01.09 | 15.11 | The amounts listed above minus post-harvest handling losses | molasses, malban | 1 day | Packaging and partial sorting, rarely discarding damaged parts of clusters | None |
| **Transportation** | 01.09 | 15.11 | The amounts listed above minus trans-portation losses | None | Less than 12 hours | Moving FSC to whole-sale markets | None |
| **Wholesale Market** | 01.09 | 15.11 | The amounts listed above minus whole-sale market losses | None | Less than 12 hours | Purchasing and selling the product | None |
| **Retail** | 01.09 | 15.11 | The amounts listed above minus retail losses | None | 1–3 days | Selling product to consumers | None |

**Source:** Authors' elaboration.

**Table 39 Detailed description of the SLTG FSC– social structures**

| SLTG FSC/ STEPS | Involvement of Women | | Involvement of Men | | Who is mainly involved | Organization level of FSC actors* | Gender / social patterns |
|---|---|---|---|---|---|---|---|
| | Girls | Women | Boys | Men | | | |
| **Primary production** | 0** | 2 | 1 | 3 | Mainly men<br>Occasionally women in some areas | Family, private companies, sometimes large companies | • Women work as family labourers; they do not have the skills and access to equipment as men do |
| **Harvest** | 1 | 3 | 1 | 3 | Men and women | Family<br>Occasional day laborers | • Women work as family labour, and as day laborers, arranged through a mediator/driver, or for longer intervals alongside their families.<br>• Older children work with families in grapes harvest |
| **Post-harvest handling** | 0 | 3 | 1 | 4 | Men | Family or day laborers | • Women involved in sorting before transport<br>• This step is typically required for export or transfer to Israeli markets. |
| **Storage** | - | - | - | - | Storage does not typically take place at farms | None | • No long-term storage at the farms or markets visited. Crates for temporary storage and transport varied in quality. |
| **Transport** | 0 | 0 | 0 | 4 | Male traders | Traders and private companies | • Farmers take care of transport, or occasionally traders<br>• Absence of women due to the horizontal separation |
| **Market sales** | 0 | 0 | 0 | 4 | Men deal with traders who take the produce to markets | Private companies | • Farmers sell through intermediaries, with little bargaining power<br>• Absence of women in markets, illustrating the traditional and cultural barriers women face<br>• Related to the agricultural tenure, men dominate the whole cycle |

**Source:** Authors' elaboration.

* f.i. Individual/Household level/Cooperative
** Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad, 0: does not exist.

**Table 40 Detailed description of the IrSDTG FSC– social structures**

| IrSDTG FSC/ STEPS | Involvement of Women | | Involvement of Men | | Who is mainly involved | Organization level of FSC actors* | Gender / social patterns |
|---|---|---|---|---|---|---|---|
| | Girls | Women | Boys | Men | | | |
| **Primary production** | 0** | 1 | 1 | 4 | Mainly men, occasionally women in some areas | Families or small companies | • Determination of harvest time<br>• Women collect grapevine leaves |
| **Harvest** | 1 | 2 | 1 | 3 | Men and women | Families,<br>Small companies,<br>Occasional day laborers | • Women work as family labour, and as day labourers, arranged through a mediator / driver, or for longer intervals alongside their families<br>• Older boys and girls involved during vacations |
| **Post-harvest handling** | 0 | 1 | 0 | 4 | Men | Families and small companies. | • Packing, packaging, and sorting conducted by men for the Israeli market |
| **Transport** | 0 | 0 | 0 | 4 | Men transport produce to wholesale and Israeli markets | Family<br>Traders | • Farmers and traders transport to Israeli markets<br>• Absence of women at this stage |
| **Market sales** | 0 | 0 | 1 | 4 | Men market grapes in wholesale markets and retailer shops | Families<br>Small companies | • Farmers sell through interme-diaries, with little bargaining power<br>• Women absent in markets and in retailer shops |

**Source:** Authors' elaboration.

* f.i. Individual/Household level/Cooperative
** Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad, 0: does not exist.

**Table 41 Detailed description of the rainfed table grapes FSC– social structures**

| RfSDTG FSC/ STEPS | Involvement of Women | | Involvement of Men | | Who is mainly involved | Organization level of FSC actors* | Gender / social patterns |
|---|---|---|---|---|---|---|---|
| | Girls | Women | Boys | Men | | | |
| **Primary production** | 0** | 1* | 2 | 4 | Men for tasks with physical strength: tillage, pruning.<br>Women collect, sort and market grapevine leaves | Family | • Women restricted to wood collection after pruning, and grapevine leaves collection (e.g. in Al-Kader region near Bethlehem). They have neither skills nor access to equipment. |
| **Harvest** | 1 | 2 | 1 | 3 | Men and women | Family or day labourers | • Men lead this task. In Bethlehem, 25% of the work is done by women |
| **Post-harvest handling** | | 1 | | 1 | Men | Family or day labourers | • Men pack and transport grape clusters. |

| RfSDTG FSC/ STEPS | Involvement of Women | | Involvement of Men | | Who is mainly involved | Organization level of FSC actors* | Gender / social patterns |
|---|---|---|---|---|---|---|---|
| | Girls | Women | Boys | Men | | | |
| **Processing grapevine leaves** | 1 | 4 | 0 | 0 | Leaves processed for own use or marketing | Family | • Task for women, within families |
| **Transport** | 0 | 0 | 0 | 4 | Male traders or wholesalers | Farmers, Wholesalers | • Absence of women due to horizontal separation |
| **Wholesale and retail markets** | 0 | 2 | 0 | 4 | Men typically deal with wholesalers | | • > 75% grapes are sold in wholesale markets. Less than 25% sold by women directly to consumers, in Jerusalem and Ramallah markets |
| **Processing and marketing molasses and Malban** | 0 | 4 | 0 | 1 | Women mainly process grapes, in Hebron and Bethlehem governorates | Family, small businesses, women cooperatives | • Grape products are a major marketing channel for grape growers |

**Source:** Authors' elaboration.

* f.i. Individual/Household level/Cooperative
** Qualify the equipment, conditions, access to services and training, 4: excellent, 3: good, 2: moderately good, 1: bad, 0: does not exist.

## c) Economics of the table grapes FSCs

Farmers cultivating SLTG bear the costs of ploughing, fertilizers, irrigation, labour, protected structures management, pesticides, growth regulators, spraying, farm management, and manual harvesting. The cumulative cost for farmers is 0.65 USD/kg. SLTG production is relatively profitable, averaging between 2.35 to 3.35 USD/kg for farmers, 2.80 USD/kg for wholesale traders and 3.25 USD/kg for retailers. However, the quantity sold in local market is low since the average consumer price is 5.40 USD/kg.

The production of seeded table grapes is less profitable to farmers than SLTG. The average profit for farmers is 0.97 USD/kg for IrSDTG (Table 46) and 0.80 USD/kg for RfSDTG (Table 47). The price of the final product at the time of study was 1.35 USD/kg for IrSDTG and 1.5 – 2.0 USD/kg for RfSDTG. Consumers differentiate between rainfed and irrigated grapes especially via prices and varieties. The only irrigated variety is Bairuti, which has green berries with a specific shape. Some pioneering farmers, however, are testing new varieties at small scale. There are at least ten widely-cultivated varieties in the rainfed farms with a wide range of colours and shapes. Taste is another indicator, as consumers prefer the taste of table grapes from rainfed regions.

The economics of each FSC are detailed in Table 42 for SLTG, Table 43 for IrSDTG, and Table 44 for RfSDTG, including costs and value added for each stage of the FSC. Values given in the tables below are based on the period from June to October 2020.

### Table 42 Detailed description of the SLTG FSC– economics

| Seedless Table Grapes FSC stage | Cost of operation USD/kg | Cumulative Cost USD/kg | Value USD/kg final product | Value-added / Margins USD/ kg | Remarks |
|---|---|---|---|---|---|
| **Pre-harvest** | 0.37 | 0.37 | | | Ploughing, fertilizers, irrigation, labour, protected structures management, pesticides, growth regulators, spraying and farm management |
| **Harvest and packing** | 0.28 | 0.65 | 3.0–4.0[a] | 2.35–3.35 | Manual harvesting, packaging, and transportation |
| **Traders** | 1.05 | 1.70 | 4.50[b] | 2.80 | Transport and packaging |
| **Retail** | 0.45 | 2.15 | 5.40[c] | 3.25 | Transportation, labour, equipment, and electricity |

**Source:** Authors' elaboration.

[a] price at farm gate; [b] price at traders marketing units; [c] consumer price.

### Table 43 Detailed description of the IrSDTG FSC– economics

| Irrigated Seeded Table Grapes FSC/ stage | Cost of operation USD/kg | Cumulative Cost USD/kg | Value USD/kg final product | Value-added / Margins USD/ kg | Remarks |
|---|---|---|---|---|---|
| **Pre-harvest** | 0.14 | 0.14 | | | Ploughing, fertilizers, irrigation, labour, pesticides, spraying and farm management |
| **Harvest and packing** | 0.09 | 0.23 | 1.20[a] | 0.97 | Manual harvesting, packaging, and transportation to markets |
| **Wholesale** | 0.12 | 0.35 | 0.47[b] | 0.12 | Municipality fee, labour, and equipment |
| **Retail** | 0.12 | 0.47 | 1.35[c] | 0.88 | Transportation, labour, equipment, and electricity |

**Source:** Authors' elaboration.

[a] price at farm gate; [b] price at wholesale market gate; [c] consumer price.

### Table 44 Detailed description of the RfSDTG FSC– economics

| Seeded Table grapes FSC stage | Cost of operation USD/kg | Cumulative Cost USD/kg | Value USD/kg final product | Value-added / Margins USD/ kg | Remarks |
|---|---|---|---|---|---|
| **Pre-harvest** | 0.32 | 0.32 | | | Ploughing, fertilizers, irrigation, labour, greenhouse, fumigation, seedlings, pesticides, spraying and farm management |
| **Harvest/ packing** | 0.08 | 0.40 | 1.2a | 0.8 | Manual harvesting, packaging, and transportation to markets |
| **Wholesale** | 0.12 | 0.52 | 1.35b | 0.83 | Municipality fee, labour, and equipment |
| **Retail** | 0.09 | 0.53 | 1.5–2.0c | 0.97–1.47 | Transportation, labour, equipment, and electricity |

**Source:** Authors' elaboration.

[a] price at farm gate; [b] price at wholesale market gate; [c] consumer price.

## d) Environment-related inputs and factors for table grapes

There are similar challenges between SLTG and IrSDTG cultivation, including severe pruning, use of large amounts of fertilizers, and partial removal of leaves which is labour-intensive. The main difference between these two cultures is the widespread use of growth regulators with SLTG, the aim being to increase fruit size (growth regulators do not increase the berry size of seeded grapes). It is worth noting that farmers of SLTG and IrSDTG are specialized and have valuable experience. Farmers of RfSDTG, on the other hand, are less specialized and grapes cultivation is usually a second job or activity, since RfSDTG are not as profitable as irrigated grapes.

The culture of rainfed grapes is different from the irrigated grapes FSCs. It is extensive rather than intensive, and since supplementary irrigation is not an option for almost all farms, the productivity is very low. Pest control is restricted to a few pests. Furthermore, a significant proportion of berries from rainfed grapes are used to produce molasses and other processed grape products. The quality losses at harvest time are not of great concern to processors, which are small-scale family enterprises or farming families themselves.

Energy use to pump water and move products within farms, and from farms to wholesale markets and retailers, is high, except for in rainfed regions. This is at the cost of much lower productivity.

Tables 45, 46, 47 below describe the factors affecting the environment in the SLTG, IrSDTG and RfSDTG FSCs, respectively. Tables 48, 49 and 50 describe environmental factors affecting the same FSCs, based on information collected through discussions with farmers and other actors.

**Table 45 Detailed description of the SLTG FSC– environment**

| PRODUCTION | | Quantity | Unit for 1 Dunum |
|---|---|---|---|
| Tools, Equipment, Facilities | **Harvesting equipment** | | |
| | Pruning shears | 3 | No. |
| | - Cartons (capacity 10kg) | 400 | No. |
| | - Plastic strings | 3 | Kg |
| | **Irrigation system** | | m |
| | - pipes | 350 | No. |
| | - drippers | 240 (discharge: 16 L/h) | No. |
| | - Fertigation unit | 1 for 10 dunums | No. |
| | Tractor | 1 tractor per 10–15 dunums | No. |
| Materials, Chemicals | Manure | 3 once every 2 years | $M^3$ |
| | Fertilizers | 50 starters + 40 complete fertilizers per season | Kg |
| | Hormonal treatment | 2 | Packages (GA) of 50 mg*2 |
| | Pesticide | 2.5 | Litre |
| Energy | Fossil fuel (diesel or gasoline) | 100 NIS per season (20 litre) | Litre/hour |
| Water | Groundwater | 300 | $M^3$ |

| PRODUCTION | | Quantity | Unit for 1 Dunum |
|---|---|---|---|
| TRANSPORTATION | | | |
| Tools, Equipment, Facilities | Rented pickup truck | 1 | No. |
| | Tractor | 1 | No. |
| Energy | Diesel or gasoline | NA | Litre |
| WHOLESALE, RETAIL | | | |
| Tools, Equipment, Facilities | Forklift | 15–20 for each market | No. |
| | Keeping rooms (few with cold units) | Less than 5 in each wholesale market | No. |
| | Refrigerated unit | 2–3 by each retailer | No. |

**Source:** Authors' elaboration.

**Table 46 Detailed description of the IrSDTG FSC – environment**

| PRODUCTION | | Quantity | Unit for 1 Dunum |
|---|---|---|---|
| Tools, Equipment, Facilities | **Harvesting equipment** | | |
| | -Pruning shears | 3 | No. |
| | **Packaging equipment** | | |
| | - Cardboard boxes | 600 | No |
| | **Irrigation system (pipes and drippers)** | | |
| | - Pipes | 250 | m |
| | - drippers | 500 | No. |
| | - Fertigation unit (one for 10 dunums) | 1 | No. |
| | **Manual or motorized sprayers for pesticides or using a tractor** | 1 | No. |
| Materials, Chemicals | Manure | 3 | $M^3$ |
| | Fertilizers | 70 superphosphate + 40–50 complete fertilizers) | Kilogram |
| | Pesticide | 3.5 | Litre |
| Energy | Fossil fuel (diesel or gasoline) | 20 | Litre |
| Water | Groundwater | 250–300 | $M^3$ |
| TRANSPORTATION | | | |
| Tools, Equipment, Facilities | Rented pickup truck or another vehicle | 1 (owned or rented) | No. |
| WHOLESALE, RETAIL | | | |
| Tools, Equipment, Facilities | Forklift | 15–20 for each market | No. |
| | Keeping rooms (few with cold units) | Less than 5 in each wholesale market | No. |
| | Refrigerated unit | 2–3 by each retailer | No. |

**Source:** Authors' elaboration.

**Table 47 Detailed description of the rainfed seeded table grapes FSC– environment.**

| PRODUCTION | | Quantity | Unit for 1 DU* |
|---|---|---|---|
| **Tools, Equipment, Facilities** | **Harvesting equipment** | | |
| | -Pruning shears | 3 | No. |
| | **Packaging equipment** | | |
| | - Cardboard boxes | 600 | No. |
| | **Manual or motorized sprayers for pesticides** | 1 | No. |
| | Or Tractor | 1 | No. |
| **Materials, Chemicals** | Manure | 4 | $M^3$ |
| | Fertilizers | 60 | Kilogramme |
| | Pesticide | 1.0 | Litre |
| **Energy** | Fossil fuel (diesel or gasoline) | 10 (estimated to be 50% of irrigated grapes) | Litre |
| **Water** | Groundwater | 0 (rainfed) | $M^3$ |
| TRANSPORTATION | | | |
| **Tools, Equipment, Facilities** | Rented pickup truck or another vehicle | 1 (owned or rented) | No. |
| WHOLESALE, RETAIL | | | |
| **Tools, Equipment, Facilities** | Forklift | 15–20 for each market | No. |
| | Keeping rooms (few with cold units) | Less than 5 in each wholesale market | No. |
| | Refrigerated unit | 2–3 by each retailer | No. |

**Source:** Authors' elaboration.

**Table 48 Factors for the environmental assessment: SLTG FSC**

| Factors | Description | Details |
|---|---|---|
| **Type of production System** | Intensive culture using protected structures. | Heavy use of agrochemicals and energy. Establishment costs for the protected structures are high, energy consuming, and labour intensive compared to cultures of seeded grapes. |
| **Land preparation practices** | • Soil preparation<br>• Irrigation system Installation<br>• Tillage and application of fertilizers | Grapevines are cultivated using protected structures. Soil is prepared intensively to support maximum growth. Levelling of land is a common practice, followed by tillage. Pipes for irrigation and the accessory units are installed. |
| **Soil quality and land degradation** | • Excessive use of chemical fertilizers<br>• Negative consequences | Over the years, excessive amounts of plant nutrients accumulate – nitrogen, phosphorus and magnesium – creating imbalances |
| **Water regime** | Drip irrigation. Moderate amount of water is applied. | Water is scarce in Palestine. Water is applied efficiently, but there is room for improvement |

| Factors | Description | Details |
|---|---|---|
| **Ecosystem impacts** | Intensive culture of seedless grapes relies on agrochemicals impacting negatively on ecosystem. | • Negative impact of agrochemicals on soil on the long run (salinization and accumulation of plant nutrients)<br>• Use of pesticides negatively impacts on biodiversity |
| **Sources of GHG emissions** | Use of agrochemicals for agriculture and fuel of for transport | • Production of agrochemicals needs energy, mostly diesel, to power the machines. There is a need to optimize their use.<br>• Impact for irrigated cultures is high. |
| **Climatic factors** | Negligible effects of weather on the crop | • Grapevines are produced in protected structures, so the impact of climatic factors is minimal. However, the greenhouses can have effects on the climate, from GHG emissions, plastic and organic waste and energy use, for example. |
| **Utilization of residues in the supply chain** | Residues are discarded | • Farmers do not use residues, since they believe they are sources of pathogens<br>• Composing is not a common practice<br>• Vine leaves are a valuable food in the local market while they are considered as residues elsewhere<br>• Most leaves are sold at higher prices in the local market. They are also used as animal feed or discarded at the farm. |
| **Re-use of food losses** | Damaged and injured berries are discarded. | • It is not feasible to reuse injured clusters<br>• No processing units to make various grape products<br>• Cultivated SLTG varieties are not suitable for processing |

**Source:** Authors' elaboration.

**Table 49 Factors for the environmental assessment: IrSDTG FSC**

| Factors | Description | Details |
|---|---|---|
| **Type of production System** | Intensive culture that needs continuous irrigation | Establishment costs are much higher than rainfed culture, but more productive. Heavy use of agrochemicals and energy. |
| **Land preparation practices** | Preparation for planting. Tillage and application of fertilizers | Grapevines are cultivated using protected structures. Soil is prepared intensively to support maximum growth. Holes are dug for the new plants. |
| **Soil quality and land degradation** | Excessive amounts of fertilizers leading to negative consequences | Over the years, large amounts of plant nutrients accumulate – nitrogen, phosphorus and magnesium – creating imbalances. |
| **Water regime** | Drip irrigation. Moderate amount of water is applied. | Water is scarce in Palestine. Water is applied efficiently, but there is room for improvement |
| **Ecosystem impacts** | Intensive culture that relies heavily on agrochemicals | • Agrochemicals cause, on the long-run, salinization, and accumulation of plant nutrients<br>• Pesticides use impacts negatively on biodiversity |

| Factors | Description | Details |
|---|---|---|
| **Sources of GHG emissions** | Use of agrochemicals for agriculture and fuel of for transport | Production of agrochemicals needs much energy, mostly diesel, to power the machines. There is a need to optimize their use. Impact for irrigated cultures is high |
| **Climatic factors** | • Negligible effects of climate on the production<br>• But high temperature and irradiance stresses the plant | • Grapevines are produced in protected structures, so the impact of climatic factors is minimal<br>• High temperatures and high irradiances during the fruiting period affect berries and induce losses |
| **Utilization of residues in the supply chain** | Partial use of residues | • Farmers do not use residues as they believe them to be sources of pathogens<br>• Composting is not a common practice<br>• Leaves are valuable foodstuff in the local market and sold at high prices, or used as animal feed |
| **Re-use of food losses** | Damaged and injured berries are discarded. | • It does not seem feasible to reuse injured grape clusters.<br>• There is not enough processing capacity for grape products |

**Source:** Authors' elaboration.

**Table 50 Factors for the environmental assessment: RfSDTG FSC**

| Factors | Description | Details |
|---|---|---|
| **Type of production System** | Extensive culture that relies on rainfall | • Traditional cultures, no intensive use of agrochemicals<br>• Supplementary irrigation is not an option for almost all farms.<br>• Productivity is much lower than irrigated cultures |
| **Land preparation practices** | • Tillage and fertilization during dormant periods.<br>• Soil preparation<br>• Preparation for planting | • Soil receives minimal preparation limited to ploughing before the rainy season. Leveling and simple terracing, when needed, are the common practices<br>• Tillage before the rainfall season. Digging holes for the new plants |
| **Soil quality and land degradation** | • Minimum soil preparation<br>• Extensive culture that maintains soils | • The extensive culture of grapevines protects soil and land from degradation. Terraces maintain soil and prevent soil erosion<br>• Rates of fertilizers applied are low<br>• The negative impact on soil is negligible |
| **Water regime** | No irrigation for the cultivated vines | • Farmers have no access to water resources and do not practice supplementary irrigation<br>• Water resources for irrigation are absent in Hebron and Bethlehem governorates where grapevines are cultivated widely |

| Factors | Description | Details |
|---|---|---|
| **Ecosystem impacts** | Extensive cultures have minimal negative impacts on the ecosystem | • Use of fertilizers is low. Terracing is a good practice to reduce soil erosion<br>• The impact on the ecosystem is positive, as it preserves biodiversity and prevents soil erosion in mountainous regions. |
| **Sources of GHG emissions** | Agrochemicals and fuel | Minimal impact |
| **Climatic factors** | High temperature, high irradiance, and water stresses can have negligible effects | • Most of the cultivated varieties are well adapted to local environment as climatic factors are suitable. However, abiotic stresses, particularly drought, can lead to qualitative losses |
| **Utilization of residues in the supply chain** | Residues are partially discarded | • Farmers use part of the residues for heating<br>• Leaves are valuable foodstuff and sold in the local market, or used as animal feed or discarded in the farm |
| **Re-use of food losses** | Damaged and injured berries are discarded | Farmers use the parts of grape clusters that are injured for processing into various grape products |

**Source:** Authors' elaboration.

## e) Expected food loss in table grapes FSC

The two FSCs cultivated intensively and under irrigation, SLTG and IrSDTG, are different from the RfSDTG cultivated without supplementary irrigation. SLTG are cultivated under a protected structure and frequent sprays of pesticides are added to prevent the development of diseases, keeping losses due to pathogens very low. The major critical loss points are mostly physiological, as many farmers tend to harvest grape clusters at an improper stage to catch the highest prices at the beginning of the harvest season. Later in the season, delays in harvest lead to an increase in decayed fruits. Another issue is the rachis browning and wilting of clusters as a consequence of prolonged storage and shipping time, as cold chain throughout the entire chain is practically absent. Mechanical injuries are minimal with seedless grapes, as packing containers are not overloaded.

For seeded grapes, losses due to pathogens are much higher. Informants reported losses of up to 25 percent in certain regions due to major pests, namely powdery mildew, berry moth, fruit fly, and occasionally downy mildew, a devastating fungal disease occurring in humid periods. Fortunately, cultivation regions in Hebron and Bethlehem governorates are dry land, and downy mildew is not a major risk. According to informants, mechanical injuries account for around 5 percent of losses. The major cause for mechanical injuries is the inferior quality of cartons and the overloading of these cartons and other packing containers.

Results of the preliminary screening of food losses in the table grapes subsector in general are presented in Table 51. It is worth noting that SLTG outcomes differ from seeded grapes especially in terms of fertilization and irrigation programmes. Additionally, harvest of SLTG is much earlier (May – June) compared to seeded grapes.

**Table 51 Preliminary screening of food losses in the table grapes FSC**

| Step in the FSC | Expected Critical Loss Points | | Comments / Remarks, Losses possibly due to: |
|---|---|---|---|
| | Quantitative | Qualitative | |
| **Preharvest** (Production phase) | 1–2% | 0% | • Improper fertilizers programmes*<br>• Nutrient deficiencies<br>• Infections and Infestation<br>• Irregular irrigation* |
| **Harvest** | 10–15% | 5% | • Fungal infections<br>• Insect injuries<br>• Compaction<br>• Sunscald |
| **Harvest*** | 5–10% | 10–15% | • Fungal infections<br>• Drought<br>• Improper packaging<br>• Wilting |
| **Transportation** | 2% | 5% | • Overloading boxes and cartons<br>• Low-quality dirty boxes |
| **Wholesalers** | 1–2% | 1–2% | • Dirty boxes and cartons<br>• Overloading boxes and crates<br>• Lack of cold chain |
| **Retailers** | 10–15% | 15–25% | • Lack of cold chain<br>• Delay in marketing<br>• Overloading boxes and cartons |

**Source:** Authors' elaboration.

* Applicable to seedless grapes only.

The lack of cold chain is a major causal factor in grapes loss. Weight loss, decay and progressive rachis browning are the consequences for the lack of cold chain. During the period from late August to mid-November, the production volume from Hebron and Bethlehem governorates exceeds the local demand. This results in fresh grape prices that are too low for grape culture to be economically feasible. This situation is fluid, and significantly influenced by many factors including the ability to market or smuggle the fresh product to the Israeli market. In addition, demand in the local market is closely related to the economic situation in Palestine. Higher unemployment rates and the inability of local government to pay salaries seriously affect purchasing power.

The crisis caused by the COVID-19 pandemic seriously disrupted the grapes subsector. Consumers suffered severe financial losses and could not afford to purchase fresh table grapes at the prices of recent years. Lower demand led to low prices, and farmers could not viably market their products. Many farmers were unable to control pests using costly pesticides, particularly in IrSDTG cultivation in Hebron and Bethlehem.

A common practice leading to loss in the three table grapes FSCs is harvesting at the wrong time. The major causes for this malpractice are:

1. Early or late market demands. Many farmers delay harvesting of clusters to avoid low prices during the peak period from late August to mid-November. This was observed with samples obtained from retailer shops late in the season (first week of November). This grapes batch arrived late in the season because farmers delayed harvesting part of their product while waiting for better prices. This compromises the

quality of the clusters and risks huge quantitative losses. Farmers in the warm regions of Jordan Valley, east of Nablus, and the Jenin governorate sometimes harvest their grapes too early to catch the higher prices early in the season;

2. To a lesser extent, lack of instruments to measure the brix value of berries. Farmers rely on their experience and the berries' taste, which results in a good determination of harvest time.

In both cases, early harvesting leads to physiological losses, whereas late harvesting leads to losses of a pathological nature.

Pest control in irrigated grapes (both SLTG and IrSDTG) is effectively managed by farmers, but is achieved through excessive applications of pesticides. Food safety must, therefore, be addressed by governmental institutions. RfSDTG encounters mild losses due to pests, with pathogen loads in dry rainfed regions being much lower than in northern regions like Jordan Valley where irrigated vineyards are found. The low prices during the last phase of fruit ripening make it difficult for many RfSDTG farmers to apply costly pesticides. In this sense, it is of value to assess the tolerance of the existing grape genotypes to major pests.

It is worth noting that post-harvest handling of table grapes is not problematic, particularly for SLTG. In that FSC, farmers have incentive to pack and transport their fresh product properly to sell in Israel. Otherwise, they will lose this very valuable market.

## f) The food losses in table grapes – Study findings and results

Thirty grape farms, six retailer shops, and six wholesale markets were surveyed. Samples, in triplicates, were assessed for all possible defects and injuries, and categorized for all classes of qualitative and quantitative losses (physiological, mechanical, and pathological).

The production phase proved to be the major CLP for both irrigated and rainfed table grapes (Tables 52 and 53). The second CLP is at the retail level due to the lack of cold chain, as well as low purchasing power among local consumers which resulted in table grape clusters being held for long periods at retailer shops without cooling.

A potential loss reduction measure to overcome the improper determination of harvest time is to enforce regulations that secure the adherence of farmers to quality specification that entails minimum brix values in addition to titratable acidity, if possible. Such an approach might not be adopted soon however. Experience with olive harvesting shows that farmers do not adhere to regulations announced by governmental institutions.

Table 54 shows the analysed samples for one week after picking; quantitative losses increased dramatically over this period. Here, the normal path of the FSCs is simulated, where farmers picked their fruits/clusters, moved them to wholesale markets/collection centres, and then to retailer shops/processing plants. This process took between 3–7 days. The reasons for higher losses at 7 days after harvest are directly related to conditions at farms at the time of harvest, as well as to the lack of cold chains; physiological qualitative losses significantly increased 3 days as well as 7 days after harvest.

**Table 52 Quality scoring of table grapes.**

| Quality score | Category | Description of the quality (Farms –irrigated) | Percent reduction of market value | Description of the quality (Farms – rainfed) | Percent reduction of market value | Description of the quality (Wholesale markets) | Percent reduction of market value | Description of the quality (Retailer shops) | Percent reduction of market value |
|---|---|---|---|---|---|---|---|---|---|
| 0–1 | Completely unfit for consumption (to be discarded) | *Physiological, pathological mechanical | 100% | Physiological, pathological then mechanical | 100% | Physiological, pathological mechanical | 100% | Pathological, physiological mechanical | 100% |
| 2–6 | Medium defects | Mechanical, pathological physiological | 20% | Physiological, pathological then mechanical | 10% | Physiological, pathological mechanical | 10% | Mechanical, physiological | 10% |
| 7–10 | In perfect shape | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 | No obvious injuries or damages | 0 |

**Source:** Authors' estimations according to primary data collection.

*The causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and followed by pathological disorder).

**Table 53 Quality analysis of sampled units of table grapes**

| Unit evaluated | Overall quality score | Type of damage (deterioration) if any | Potential cause and symptoms |
|---|---|---|---|
| Farmers | 7.66 | • Physical damage in irrigated farms<br>• Physiological damage in rainfed farms | • For irrigated farms, the type of damages is mechanical due to improper packing of clusters<br>• The potential causes of qualitative losses in rainfed farms are the abiotic stresses, including drought and high temperatures |
| Wholesalers | 7.19 | • Physical damage in irrigated farms<br>• Physiological damage in rainfed farms | Losses recorded at wholesale level reflect losses incurred on the farm. Given that clusters are relatively robust, and grape cartons are moved to market within 24 hours, losses at the wholesale level are minimal |
| Retailer shops | 6.65 | Physiological followed by pathological | Lack of cold chain is the most important issue. Another potential cause is the improper packing and packaging. |
| Average score: | 7.17 | | |

**Source:** Authors' estimations according to primary data collection.

*The causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder and followed by pathological disorder).

**Table 54 Summary result matrix of food losses in table grapes**

| FSC stage/ process | Type of loss Qt./Ql. | Percentage lost in this process Quant (Informal local standards) | | | Percentage of the product that incurred quality loss in this process | | | Percentage of product that goes through this stage | Percentage loss in the FSC | Cause of loss/ Reason for low loss** | Reduced market value (percent) | CLP / LLP | Destination of food loss | Impacts on the environment/ climate change/ natural resources | Impact/ FSC actors affected (men / women) | Loss perception of FSC actors (men / women) | Suggested solutions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *T1 | T2 | T3 | T1 | T2 | T3 | T1; T2; T3 | | | | | | | | | |
| **Pre-harvest** | Qt | 9.5 | | | | | | | | | | | | | | | |
| **Production and harvest – irrigated** | Qt/Ql | 2.6 | 3.1 | 8.7 | 0.6 | 3.6 | 5.6 | 97.5; 96.9; 91.4 | 4.8 | T1: Pathological, physiological, mechanical<br>T2: Physiological, pathological<br>T3: Physiological, pathological | 5 | LLP | waste | Waste of resources mainly labour, water, and agrochemicals | men | low | None. No need for any interventions with such low losses. |
| **Production and harvest – rainfed** | Qt/Ql | 4.8 | 5.7 | 22.0 | 1.00 | 2.4 | 5.6 | 95.2; 94.3; 78.1 | 10.8 | T1: Pathological, physiological mechanical<br>T2: Physiological, pathological mechanical<br>T3: Physiological pathological | 11 | CLP | waste | Waste of resources, mainly labour | men | medium | Cold rooms at retailer shops |
| **Wholesale markets** | Qt/Ql | 6.2 | 6.0 | - | - | - | - | 93.8; 94.30 | 6.1 | 80% of losses emanate from farms | 6 | LLP | waste | Waste of resources mainly labour, water, land, and agrochemicals, particularly under irrigation | men | medium | Securing cold chain from farms to retail |
| **Retailers** | Qt./Ql. | 4.5 | - | - | 1.1 | - | - | 95.5; 98.2 | 3.2 | T1: Pathological physiological mechanical<br>T2: Pathological physiological | 3 | CLP | waste | | men | low | Securing cold chain from farms to retailers |
| **Transport (load tracking)** | Qt./Ql. | 1–1.5 | | | | | | | | | | LLP | waste | | men | low | None |

**Source:** Authors' estimations according to primary data collection.

*T1: one day after harvest; T2: after a shelf-life of three days at room temperature; T3: after a shelf-life of 7 days at room temperature
** the causes of losses as they occur chronologically (e.g. mechanical injury followed by physiological disorder then pathological disorder).

# Load tracking trial results – table grapes

A common practice by table grapes producers is to harvest very early or delay harvesting to avoid the price gluts that occur during peak production periods. This practice has been associated with various causes of losses. A potential food loss reduction measure is to extend the shelf-life, and thus the marketing window for table grapes produced from the rainfed regions, for another one or two months through the adoption of cold chain. The most promising technology is modified atmosphere packaging (MAP) coupled with cold storage. However, this requires electricity and other sources of energy and, at present, the requisite infrastructure is not available in the Palestinian context.

The section adapts the load tracking method in FAO (2016) to trial the application of cold storage and MAP to seeded table grapes (Bairuti variety) obtained from irrigated and rainfed farms. For IrSDTG, the aim is to store for one month, which would extend the marketing window until the beginning of the RfSDTG season. For RfSDTG, which can better tolerate prolonged storage, the aim is to extend the marketing window for two months to avoid the supply peak which lasts for around 5 weeks.

The treatments considered were:

1. Control: 5 kg of grape clusters placed directly in cartons,
2. MAP: 5 kg of grape clusters placed in a plastic liner and then placed in a carton,
3. MAP+S: same as MAP, but with an SO2-releasing pad placed in each liner.

All three treatments were subject to load tracking from harvest to cold storage. IrSDTG samples were held in cold storage for 8 weeks and RfSDTG samples were held in cold storage for 10 weeks. This chapter presents the control results. The details of the trial of all three treatments are available in Annex 1.

For the control treatment, at harvest time, IrSDTG and RfSDTG clusters were collected directly from farms and packed into 5kg cartons (with neither plastic liners nor SO2-releasing pads) then transported for 8–12 hours. Cartons were then placed in cold storage (3°C) for 8–10 weeks. Samples were taken at harvest time and then in two-week intervals during cold storage. At each sampling time, three cartons were selected representing three replicates, then clusters were removed from the cartons and assessed for losses against various quality parameters. The assessments took place one day after the removal of cartons from the cold storage (3°C), as well as after 3 and 7-days shelf-life periods at room temperature.

Additionally, transport trials were conducted at specific times. Losses due to transport were assessed at week 4 and 6 for IrSDTG, and at week 10 for RfSDTG. Values for weight losses due to transport were recorded at the corresponding weeks/assessment times along with the sample results from cold storage.

Results of the control trial are found in Table 55. Quantitative losses increased over the duration of 6 weeks storage period, mainly due to cracking of berries. The results of all three trials suggest that IrSDTG (Bairuti variety) be cold stored in MAP for no more than four weeks, and it is highly recommended to store RfSDTG in cold storage for 4–6 weeks, however without MAP.

**Table 55 Presentation of load tracking results for the control treatment (cold storage in carton box) for IrSDTG and RfSDTG**

| | | | | |
|---|---|---|---|---|
| Product | Table grape from irrigated and rainfed farms | | | |
| Events | Transport and cold storage | | | |
| Duration of event | 8–12 hours for transport and 8 weeks for storage | | | |
| Location | **Qabatiya and Hebron** | | | |
| Before the event | **Experimental Unit** | **Weight of unit** | **Nr. of units** | **Total weight** |
| Load | Tonnes | 2 Tonnes | One truck | 2 Tonnes |
| 1st-stage sample | **Transport** | | | |
| Load | **Tonnes** | 2 Tonnes | One truck | 2 Tonnes |
| | **Cartons** | 5 kg | 27 cartons IrSDTG | 135 kg |
| | | | 18 cartons RfSDTG | 90 kg |
| 2nd stage sample | **Cold storage 3°C** | | | |
| | Kg | 1 | 9kg at each sampling time | 150kg for IrSDTG |
| | | | | 75kg for RfSDTG |

## 1. IrSDTG

| **Before the event** | **Value (score)** | | |
|---|---|---|---|
| **Average quality score (0 – 10)** | 8.7 | | |
| **percent unfit (< 2)** | 2.47 | | |
| **percent low quality (2–6) but marketable** | 13 | | |
| **After the event** | **sampling times** | | |
| | **Week 2** | **Week 4** | **Week 6** |
| **Average quality score (0 – 10)** | 8.1 | 8.2 | 7.6 |
| **percent unfit (< 2)** | 4.3 | 6.2 | 13.4 |
| **percent low quality (2–6) but marketable** | 19 | 18 | 24 |
| | **Value (percent)** | | |
| **Quantity loss** | 1.83 | 3.73 | 10.93 |
| **Percent increase in quantity loss** | 42.6 | 60.2 | 81.6 |
| **Quality reduction** | 6 | 5 | 11 |
| **Percent increase in quality loss** | 31.6 | 27.8 | 45.8 |
| | | | |
| **Weight loss during storage** | 9.7 | 11.5 | 8.7 |
| **Weight loss during transport** | -* | 1.03 | 0.99 |
| | **Observations / Causes** | | |
| Quantitative losses increased over the duration of extended storage period (6 weeks)<br>Weight loss in cold storage increased.<br>Cracking of berries is the main cause of quantitative losses. | | | |

## 2. RfSDTG

| Before the event | Value (score) | | |
|---|---|---|---|
| Average quality score (0 – 10) | 8.8 | | |
| percent unfit (< 2) | 1.80 | | |
| percent low quality (2–6) but marketable | 12 | | |
| **After the event** | **sampling times** | | |
| | Week 4 | Week 8 | Week 10 |
| Average quality score (0 – 10) | 8.1 | 7.75 | 7.25 |
| percent unfit (< 2) | 3.1 | 10.7 | 10.2 |
| percent low quality (2–6) but marketable | 24 | 23 | 28 |
| | Value (percent) | | |
| Quantity loss (Q–J) | 1.3 | 8.9 | 8.4 |
| Percent increase in quantity loss | 41.9 | 83.2 | 82.4 |
| Quality reduction (R–K) | 12 | 11 | 16 |
| Percent increase in quality loss | 50.0 | 47.8 | 57.1 |
| | | | |
| Weight loss during storage | 3.2 | 5.7 | 6.1 |
| Weight loss during transport | -* | -* | 1.5 |
| **Observations / Causes** | | | |
| Transport had minimal effect on losses | | | |

**Source:** Authors' estimations according to primary data collection.

* Transport trial was not conducted at that sampling time

# The food loss reduction strategy – conclusions and recommendations

## 1) Impact of food losses in the selected FSCs

The losses reported in this study have direct impacts on farmers, retailers, and final consumers. These losses entail loss of valuable resources, in particular water, which is the major limiting resource for Palestinian agriculture. The impacts of food losses differ among the investigated FSCs.

The impact of losses in SLTG is low on farmers, as they can market their products in the Israeli market. Consequently, they do their best to avoid losses, particularly pathological losses. Further, they use growth regulators, mainly gibberellins, to improve berry size which results in almost uniform fresh product. The summary matrix shows that the quantitative loss directly after harvest is less than 3 percent. Losses after a shelf-life of three days at room temperature did not increase significantly but reached 8 percent within a week at room temperature. These losses became high because of a lack of cooling. Qualitative losses were also very low, and accordingly the impact on farmers, retailers, and wholesalers is negligible. Despite this positive result, consumers often complain about the low sweetness of SLTG and seeded grapes bought early in the season. Given that grape is a non-climacteric fruit that does not ripen after harvest, it is clear they were harvested when mature but not fully ripe.

Losses in RfSDTG are relatively higher than irrigated grapes; quantitative losses reached 20 percent after one-week shelf life. The impact is high on farmers, who already suffer economic losses due to very low prices. The RfSDTG FSC is a major one for the grape subsector, and marketing congestion is the major problem it faces. In the last decade, the marketing problem and food losses forced many farmers to search for other jobs in addition to cultivating grapes. It is noticeable that grape culture is diminishing in rainfed regions. Solutions for this negative development are urgently needed since Palestinian markets need that product. One solution will be the storage of grapes to extend the marketing window beyond the congestion period that occurs from September to the end of October. This solution will be discussed in depth in the following chapter.

As regards the FSCs for the cucumber subsectors, the results indicate that qualitative losses, rather than quantitative losses, are the main concern. For the CP FSC, quantitative losses are also significant. These losses are due to various factors, among which is the lack of cold chain. The major impact is on farmers, particularly for CP, but also on consumers who complain about mechanical (injuries) and physiological (shrivelling) losses. It is believed that a significant portion of the purchased cucumbers lands in garbage as waste.

The last FSC is zucchini, for which both quantitative and qualitative losses are high. The reasons for these losses were discussed previously. The impact is firstly on farmers, followed by retailers. Farmers suffer large economic losses that occur frequently, and which depend mainly on the climatic conditions. Certain farmers informed us that losses, due to 'abortion' and/or 'whitening' problems, may cost them one fourth of their harvest. Fortunately, that does not happen on a yearly basis, but in 2020 farmers in certain regions suffered great losses (e.g. Shaik near Tulkarem).

For all FSCs in Palestine, the burden of losses lies on farmers and then on consumers. Wholesalers and retailers manage to compensate for potential and actual losses at the expense of farmers and, to a lesser extent, consumers. Wholesalers earn 10 percent of the value of the marketed product. They do not store, and do not take responsibility for, fruits and vegetables they do not sell. These will be taken back by farmers. In turn, retailers obtain fresh produce from wholesale markets, and some directly from farmers, and sell them to final consumers within 1–2 days. They do not store, therefore ultimately, the cost of losses is built into the cost structure of the whole FSC including the consumer price.

The social impact of losses is directly related to rural families. Their tedious work in the field and very hot greenhouses provides unfair returns. The young generation in rural areas are abandoning agricultural activities to work as day labourers in Israeli businesses. Many farms lack even unskilled workers. It is worth noting that the daily fair wage in Palestinian farms is around USD 25, whereas it might reach USD 70 or 80 in Israeli businesses. Table 56 develops the assessment of social implications of potential food loss reduction solutions

## 2) Food loss reduction measures

**(1) Extend the marketing window for IrSDTG as well as RfSDTG by adopting cold chain and proper packaging material**

The marketing window for table grapes extends from June (SLTG) through to August (IrSDTG), and ends up with RfSDTG from September to November. The major challenge is for RfSDTG, and to a lesser extent, IrSDTG. Both experience low prices during peak harvest periods. Extending the marketing window for 1–2 months will allow farmers to increase their income. The simplest way is to store clusters unpackaged in cold rooms for 4–6 weeks. Additionally, using specific liners for modified atmosphere packaging (MAP) will ensure the acceptable quality of specific varieties for up to 8–10 weeks. The load tracking trial (in Annex 1) shows that a few varieties can be successfully packaged and stored for 2–2.5 months. Further, our data shows that this procedure (new for Palestine) is economically feasible. The cost-benefit analysis of this measure is estimated in Table 57.

**(2) Optimization of planting dates for zucchini cultivated in open fields**

Preharvest quantitative losses caused by abortion of very small zucchini fruits is related directly to climate conditions. The suggested measure here is a research project that aims to reduce food losses through better determination of planting times. Setting exact days for planting is not an easy task since farmers are used to relatively fixed dates. Accordingly, there is a need to generate evidence on the optimum planting date(s) for zucchini in every governorate.

**(3) Optimization of plant nutrition programmes for the FSCs that are produced under irrigation**

Excessive application of chemical fertilizers is a major problem in Palestine. That is the case for almost all plants cultivated under irrigation, including five of the six FSCs covered in this study. Generally, Palestinian farmers apply excessive amounts of nitrogen, phosphorus and magnesium at the wrong times. Large application before planting is not suitable for optimum plant growth and development. There is a need for better scheduling of plant nutrients applications that include carefully regulating the timing, amounts, and types of fertilizers.

### (4) Improving pest management practices

Cucumber, zucchini and IrSDTG production uses large amounts of pesticides throughout the entire growing season. It is difficult to change such practices, given that most cultivated varieties are imported and highly sensitive to various pests. With previous efforts having been largely ineffective, there is a need for a long-term approach that defines the proper non-chemical measures to control main pests that also addresses new pests, such as biological agents and physical agents. Furthermore, there is also an urgent for chemical pesticides that are less toxic and have a short safety period, particularly for cucumbers and zucchini, for which farmers are forced to pick their fruits every two days to avoid losses being caused by extra-large fruits.

Table 56 below presents a summary of food losses, including causes and solutions, for the table grapes subsector for which a solution was investigated in the load tracking trial. Introducing cold chain storage can reduce food loss, improve incomes and create employment, but a trade-off will be the high energy requirements and GHG emissions.

**Table 56 Summary table of table grapes FSC food losses, causes and solutions**

| Critical Loss Point | | | Production and harvest | Wholesale markets or collection centres | Retailers | Total |
|---|---|---|---|---|---|---|
| Magnitude of losses in the FSC | Irrigated | Quantitative | 4.77 | 6.14 | 3.16 | 18.00 |
| | | Qualitative | 3.26 | - | | 6.42 |
| | Rainfed | Quantitative | 10.82 | 6.14 | | 14.07 |
| | | Qualitative | 2.96 | - | 1.02 | 3.98 |
| Causes of loss | Physiological disorders followed by pathological causes. Mechanical are minor | | | | | |
| Intervention to reduce losses | Cold chain coupled with modified atmosphere packaging | | | | | |
| Loss reduction | 30% | | | | | |
| Cost of intervention (USD) | 4,0000,000 | | | | | |
| Economic implications | Improve the profitability for farmers and traders | | | | | |
| Social implications | Creation of new jobs | | | | | |
| Food security implications | Increase supply with affordable prices during the period from Mid-November to December | | | | | |
| Environmental and climate change implications | Increase the emission of GHG | | | | | |
| Policy implications | A need to have a policy that support companies to create cold chains. | | | | | |

**Source:** Authors' elaboration.

**Table 57 Assessing social implications of potential food loss reduction solutions (cold chain coupled with modified atmosphere packaging)**

| (How) Does the suggested solution ... | Description of the potential impact | Gender dimension of the impact (women and men may be affected differently) | Suggestions to mitigate negative impacts |
|---|---|---|---|
| 1. ...impact the employment situation of FSC actors? | It will increase employment | Women are now absent in FSC. Storage facilities may offer more opportunities for women. Such workplaces are equipped with better facilities for women. | Encourage women to work in these safe facilities |
| 2. ... increase or reduce the work-load of FSC actors? | It will increase workload | More women can get jobs in these facilities | None |
| 3. ...raise or increase the need for training to apply solutions? | A professional training programme is needed | More training for women in post-harvest handling | None |
| 4. ...distribute benefits to the FSC actors? (Income access and control) | Traders will have more benefits than farmers | More involvement of women's' cooperatives | Promotion of cooperatives to invest in this sector |

**Source:** Authors' elaboration.

**Table 58 Budget calculation for food loss reduction scenario – cold chain coupled with modified atmosphere packaging for table grapes**

| | Item | Value | Unit | Calculation |
|---|---|---|---|---|
| A | **Product quantity** | 30 000 | tonne/year | Quantity accommodated in cold rooms using plastic liners. |
| B | **Product value** | 1200 | $/tonne | The farm gate value |
| C | **Loss rate** | 18 | % | Quantitative |
| D | **Anticipated loss reduction** | 30 | % | |
| E | **Cost of intervention** | 40 000 000 | $ | Cold rooms and plastic liners |
| F | **Depreciation** | 10 | Years | |
| G | **Yearly costs of investment** | 400 000 | $/year | E / F |
| H | **Yearly costs of operation** | 800 000 | $/year | Building, wages, and indirect expenses (fuels, electricity, water and repair) |
| I | **Total yearly costs of solution** | 1 200 000 | $/year | G + H |
| J | **Solution costs per tonnes product** | 40 | $/tonne | I / A |
| K | **Food loss** | 5 400 | tonne/year | C x A |
| L | **Economic loss** | 6 480 000 | $/year | K x B |
| M | **Loss reduction** | 1 620 | tonne/year | K x D |
| N | **Loss reduction savings** | 1 944 000 | $/year | M x B |
| O | **Total Client costs** | 1 200 000 | $/year | A x J = I |
| P | **Profitability of solution** | 744 000 | $/year | N – O |

**Source:** Authors' elaboration.

The suggested measures need supportive policies and strategies to effectively reduce food loss. In the framework of the National Food and Nutrition Security Policy in Palestine (2019–2030), elements targeting FLW can include:

1. training programme(s) to improve extension services through applied research programmes;
2. locally adapted standards and regulations;
3. regulation and capacity development on marketing of fresh agrifood products;
4. regulation and capacity development on handling of agrochemicals;
5. advocacy to improve sources of electric power;
6. researching and adopting the map technology by the private sector.

The Palestinian MoA can act as the umbrella organization to convene stakeholders implicated in FLW reduction, and develop, implement, and oversee policies and strategies. However, the participation of local communities, the private sector, universities, and non-governmental organizations (NGOs) is crucial, as these stakeholders are well connected to farmers, and actors in the supply chain. An action plan for FLW reduction can be developed, indicating role and responsibilities, as follows:

1. prioritize urgent needed measures, policies, and strategies;
2. formulate new measures, policies and strategies, or modify existing ones;
3. formulate workplans for selected subsectors to reduce food losses;
4. secure financial resources to implement activities in workplans;
5. supervise the implementation of the activities;
6. assess the impact of the implemented activities.

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# Annex 1: Preliminary results of load tracking trial with MAP packaging

The trial involved introducing MAP and cold storage of "Bairuti" table grapes cultivated in irrigated farms as well as rainfed farms. Both trials were conducted separately. In addition, transport trials were carried out for both FSCs, at week 4 and 6 for IrSDTG, and at week 10 for RfSDTG.

The experiment included collecting clusters directly from the farm at harvest time and packing in 5kg cartons. Three treatments were applied, namely: (1) control, where clusters were placed in cartons alone; (2) MAP, where around 5kg of grape clusters were placed in a plastic liner and then placed in a carton, and (3) MAP+S, where the same process as for MAP was used but with a SO2-releasing pad placed in each liner. All treatments were placed in cold storage (3 °C) for up to 10 weeks. For each treatment and sampling time, there were three cartons, which represent three replicates. At harvest time and at each sampling time, clusters were removed from cartons and assessed for losses and against various quality parameters. The samples were assessed one day after the removal of cartons from the cold storage, as well as after 3 and 7days shelf-life periods at room temperature.

The most obvious results are that, first, MAP resulted in significantly less weight loss compared to cold storage alone without the use of plastic liners. This is significant, as it can improve the profitability for farmers. Second, there was no clear difference in quantitative losses for IrSDTG between cold storage alone in comparison with MAP. However, drastic differences were found with rainfed table grapes, where both MAP treatments resulted in much higher quantitative losses as compared to unpackaged grapes. This could be related to higher sugar levels in table grapes produced in rainfed regions. Third, IrSDTG packaged in plastic liners tend to have better quality than unpackaged clusters. Finally, transport had little impact on losses.

The economic impact of the suggested solution, MAP and cold storage, can be very positive for farmers and traders; prices were 40 percent higher one month later than at harvest time. In addition, storing grapes will create jobs at the packinghouses and most probably for women. It is suggested to repeat this trial to confirm the results

**Table A1.1 Load tracking trial results: modified atmosphere packaging, cold storage and transport trial of IrSDTG and RfSDTG**

| | |
|---|---|
| **Product** | IrSDTG and RfSDTG |
| **Events** | Modified atmosphere packaging and transport |
| **Duration of the event** | 6 weeks cold storage for MAP for IrSDTG, 10 weeks for RfSDTG. Transport 8–12 hours |
| **Location** | **Qabatiya and Hebron** |
| **Before the event** | Experimental Unit |
| **Load** | Tonnes |
| **1st-stage sample** | **MAP** |
| **Load** | Cartons |
| **1st-stage sample** | **Transport** |
| **Load** | tonnes |
| | cartons |

| 2nd-stage sample | Cold storage 3°C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | kg | | | | | | | | |
| **1. IrSDTG** | | | | | | | | | |
| Before the event | Value (score/percent) | | | | | | | | |
| Average quality score (0 – 10) | 8.7 | | | | | | | | |
| percent unfit (< 2) | 2.47 | | | | | | | | |
| percent low quality (2–6) but marketable | 13 | | | | | | | | |
| After the event | treatments | | | | | | | | |
| | Control | MAP | MAP+S | Control | MAP | MAP+S | Control | MAP | MAP+S |
| | sampling times | | | | | | | | |
| | Week 2 | Week 2 | Week 2 | Week 4 | Week 4 | Week 4 | Week 6 | Week 6 | Week 6 |
| Average quality score (0 – 10) | 8.1 | 8.54 | 8.775 | 8.2 | 8.45 | 8.38 | 7.6 | 8.54 | 8.3 |
| percent unfit (< 2) | 4.3 | 4.6 | 3.8 | 6.2 | 8.2 | 3.7 | 13.4 | 5.9 | 11.0 |
| percent low quality (2–6) but marketable | 19 | 15 | 13 | 18 | 16 | 16 | 24 | 15 | 17 |
| | value (percent) | | | | | | | | |
| Quantity loss | 1.83 | 2.13 | 1.33 | 3.73 | 5.73 | 1.23 | 10.93 | 3.43 | 8.53 |
| Percent increase in quantity loss | 42.6 | 46.3 | 35.0 | 60.2 | 69.9 | 33.2 | 81.6 | 58.1 | 77.5 |
| Quality reduction | 6 | 2 | 0 | 5 | 3 | 3 | 11 | 2 | 4 |
| Percent increase in quality loss | 31.6 | | | | | | | | |
| | | | | | | | | | |
| Weight loss during storage | 9.7 | 3.9 | 1.7 | 11.5 | 3.3 | 1.7 | 8.7 | 5.2 | 3.8 |
| Weight loss during transport | -* | -* | -* | 1.03 | 1.03 | 1.05 | 0.99 | 0.78 | 0.66 |
| Observations / Causes | | | | | | | | | |

Quantitative losses increased over the duration of extended storage period (6 weeks)

MA-packaged grapes tend to be of better quality.

Weight loss by MAP is much lower than cold storage alone.

Cracking of berries is the main cause of quantitative losses.

## 2. RfSDTG

| Before the event | Value (score/percent) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Average quality score (0–10) | 8.8 | | | | | | | | |
| percent unfit (< 2) | 1.80 | | | | | | | | |
| percent low quality (2–6) but marketable | 12 | | | | | | | | |
| After the event | treatments | | | | | | | | |
| | Control | MAP | MAP+S | Control | MAP | MAP+S | Control | MAP | MAP+S |
| | sampling times | | | | | | | | |
| | Week 4 | Week 4 | Week 4 | Week 8 | Week 8 | Week 8 | Week 10 | Week 10 | Week 10 |
| Average quality score (0 – 10) | 8.1 | 8.4 | 8.3 | 7.75 | 7.88 | 7.9 | 7.25 | 7.66 | 7.5 |
| percent unfit (< 2) | 3.1 | 16.7 | 17.3 | 10.7 | 11.9 | 15.0 | 10.2 | 44.1 | 47.1 |
| percent low quality (2–6) but marketable | 24 | 21 | 22 | 23 | 21 | 21 | 28 | 23 | 25 |
| | value (percent) | | | | | | | | |
| Quantity loss | 1.3 | 14.9 | 15.5 | 8.9 | 10.1 | 13.2 | 8.4 | 42.3 | 45.3 |
| Percent increase in quantity loss | 41.9 | 89.2 | 89.6 | 83.2 | 84.9 | 88.0 | 82.4 | 95.9 | 96.2 |
| Quality reduction | 12 | 9 | 10 | 11 | 9 | 9 | 16 | 11 | 13 |
| Percent increase in quality loss | 50.0 | 42.9 | 45.5 | 47.8 | 42.9 | 42.9 | 57.1 | 47.8 | 52.0 |
| | | | | | | | | | |
| Weight loss during storage | 3.2 | -0.4 | -0.3 | 5.7 | 0.9 | 0.1 | 6.1 | 0.22 | 0.16 |
| Weight loss during transport | -* | -* | -* | -* | -* | -* | 1.5 | 0.6 | 0.7 |
| Observations / Causes | | | | | | | | | |
| Quantitative losses increase drastically upon packaging of clusters in plastic liners<br>There are no consistent trends concerning quality<br>Weight loss was much lower in packaged clusters<br>The high sugar levels of berries led to cracking, in particular with MAP; osmotic potential might be the direct reason.<br>Transport had minimal effect on losses | | | | | | | | | |

**Source:**: Authors' estimations according to primary data collection.

* Transport trial was not conducted at that sampling time

# Annex 2: List of experts consulted

**Table A2.1 List of experts consulted**

| Expert name | Title/position | Institution |
|---|---|---|
| Hasan AlAshqar | General Director | Ministry of Agriculture |
| Dafir Salhab | Extension officer | Qalqylia, Ministry of Agriculture |
| Isam Abus Khaizran | Expert | Private sector |
| Doaa' Zayed | Manager | UAWC |
| Abedelkader Kharraz | Director | Department of Vegetables, Ministry of Agriculture |
| Talat Tamimi | Assistant Professor/ Economist | Hebron University |
| Abu Madi | Owner of plant nursery | Private sector (TUL) |
| Fadwa Abu Shara | Extension officer | Ministry of Agriculture |
| Sayel Atawneh | Extension office | UAWC |
| Agricultural Cooperative Manager | Manager | Non-governmental institution (TUL) |
| Anan Salah | Retailer | Al Ferdaws for Fruits and Vegetables |
| Husam Esaied | Plant ecologist | Freelancer |
| Ashraf Barakat | Director | Ministry of Agriculture (Headquarter) |
| Ayman Al-Saba | Owner of plant nursery | Private sector (QAL) |
| Rana AlKarmi | Planning | Ministry of Agriculture |
| Quasay Qawasimi | Extension officer | Private sector |
| Eid Abusharkh | Wholesaler | Abusharkh for Fruits and Vegetables |
| Ali Rababaa | Extension officer | Private sector |

# Annex 3: Figures illustrating the crops

**Figure A3.1: Normal-healthy grapes from seedless irrigated farms in Al Nassaria and Qabatiya**

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**Figure A3.2: Direct losses from farms for seedless irrigated grapes in Al Nassaria and Qabatiya**

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**Figure A3.3: Normal healthy grapes from seeded irrigated farms in Qabatiya**

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**Figure A3.4: Normal healthy grapes from seeded rainfed farms in Hebron**

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**Figure A3.5: Losses of irrigated seedless grapes in Qabatiya, Jenin governorate**


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**Figure A3.6: Losses of seedless grapes from Al Nassaria, Nablus governorate**

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**Figure A3.7: Losses for table grapes sampled from the wholesale market in Tulkarem**

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**Figure A3.8: Losses of rainfed seeded grapes sampled from a farm and the wholesale market at Hebron**

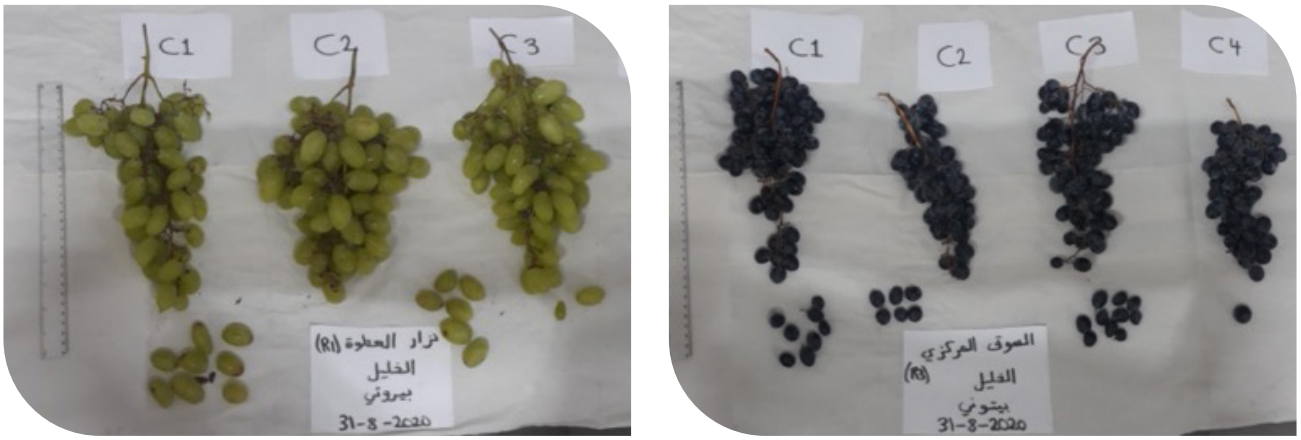


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**Figure A3.9: Direct losses from cucumber from greenhouses**

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**Figure A3.10: Direct losses from zucchini farms**

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**Figure A3.11: Losses assessment for zucchini from Beta, Nablus and Tulkarem wholesalers**

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**Figure A3.12: Losses assessment for zucchini farms in Jenin governorates**

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**Figure A3.13: Losses assessment for fresh cucumber-greenhouse from farms in Tulkarem and Hebron governorates**

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**Figure A3.14: Losses of processed cucumber from open field farms in Jenin governorate**

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**Figure A3.15: Losses of cucumber from a wholesale market in Nablus**

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Cairo, Egypt

ISBN 978-92-5-138177-9

CC7787EN/1/09.23