Applying Lean Green Strategies and Value Stream Mapping in the Apple Crispy Industry: A Case Study of Crispa Snacks

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Abstract:
In the modern food industry, sustainable production and efficient resource utilization are increasingly essential for competitiveness and environmental accountability. Crispa Snacks, an organic apple chip producer based in Azerbaijan, exemplifies this transformation by applying Lean manufacturing principles, Green strategies, and Value Stream Mapping (VSM) to enhance productivity and minimize waste. By reimagining apple peels, cores, and seeds as sources of value, the company transitions toward a “zero waste, zero loss” model. This paper outlines how Lean and Green methods can be systematically applied to optimize production, reduce environmental impact, and generate over 10,000 AZN in additional monthly profit. The case highlights how small-scale processors can lead sustainable innovation through structured waste valorization, process redesign, and data-driven decision-making.

Keywords:
Lean methodology, Green manufacturing, Value Stream Mapping, zero waste, food processing, circular economy, sustainability, by-product utilization, productivity.

1. Introduction

In today’s rapidly evolving food industry, shifting consumer expectations, increasing emphasis on food safety, and environmental accountability are compelling manufacturers to adopt more sustainable and innovative production models.The food industry faces mounting pressure to adopt sustainable practices that reconcile economic growth with environmental stewardship, particularly in resource-intensive sectors like fruit processing (Abdul Rashid & Anuar, 2016, p. 1382) Within this context, Crispa Snacks has emerged as a leading player in Azerbaijan’s organic fruit processing sector, specializing in the production of apple-based chips. The company’s commitment to natural products, local resource efficiency, and minimal waste sets it apart as a

forward-thinking enterprise aligned with global sustainability trends. Additionally, this company offers around 30 different product varieties besides apples. These approaches are intended for apple production as a pilot project. If applied to other products as well, the figures could reach significantly higher levels.

Currently, Crispa Snacks processes approximately 1,000 kg of apples per day, following a five-stage production process:

1. Washing of apples
2. Peeling
3. Removal of the core
4. Thin slicing and drying of the flesh to produce chips
5. Partial reuse of by-products in vinegar production

A breakdown of the processed apple mass reveals that:

- **Peels** account for roughly 100 kg (10%), mostly discarded or minimally used for vinegar.
- **Cores** contribute 150 kg (15%), with limited utilization.
- **Flesh** represents 700 kg (70%), used for chip production.
- **Other residues** make up 50 kg (5%), partially repurposed or wasted.

These figures suggest that only around 70% of the raw material is effectively integrated into the primary product line, while up to 30% is underutilized or wasted, reflecting a significant opportunity for both economic and environmental optimization.

2. Methodology

This study adopts a case study approach, combining Lean manufacturing principles, Green production strategies, and Value Stream Mapping (VSM) tools to assess current operations and propose efficiency improvements. Value Stream Mapping, when combined with Green Manufacturing principles, enables systematic identification of both operational inefficiencies and environmental waste streams (Garza-Reyes, 2015, p. 24) Primary data were obtained through direct observation of the production process, internal company data on raw material input and output, and informal interviews with plant management. Secondary data included literature on food industry best practices, circular economy models, and energy/resource efficiency techniques.

The research process was conducted in three stages:

2.1 Current State Analysis

The existing production flow was mapped from raw apple intake to final packaging. Data were collected on process timing, material yields, by-product ratios, and energy/water usage. Waste sources—both material and operational—were identified across all stages.

2.2 Lean-Green Integration Framework

Based on observed inefficiencies and underutilized by-products, the Lean-Green integration strategy was developed. This involved:

- Identifying value-adding opportunities for apple peels, cores, and seeds.
- Proposing process improvements to reduce water and energy consumption.
- Designing a circular production model to enhance sustainability and profitability.

2.3 Value Stream Mapping (VSM)

VSM tools were used to visualize the entire workflow, highlighting non-value-adding activities (e.g., waiting times, transport inefficiencies, rework). A future-state map was created to propose a more balanced and continuous production flow, integrating visual management tools (Kanban), improved drying systems, and real-time monitoring of key performance indicators (KPIs).

3. Analysis and Results

The analysis of Crispa Snacks' current production process revealed key areas for improvement in terms of raw material utilization, energy and water efficiency, and waste management. By applying Lean-Green principles, it became clear that the company could significantly enhance productivity while also contributing to environmental sustainability. Below are the key findings and proposed solutions derived from the methodology.

3.1 Raw Material Utilization

Currently, only 70% of the raw apple mass is converted into the final product, with the remaining 30% underutilized. Of this waste, 10% consists of apple peels, 15% cores, and 5% other residues. These by-products, though minimally used for vinegar production, present significant opportunities for waste-to-value initiatives.

Proposed Solution:
By applying Lean principles of value maximization, the company can transform these by-products into profitable products. For instance:

- **Apple Peel Vinegar:** The daily 100 kg of apple peels can be processed into approximately 1,750 liters of vinegar per month, generating a monthly profit of 2,762.5 AZN.
- **Apple Jam:** Recovering the edible tissue around the cores could yield 875 kg of apple jam per month, resulting in an additional 4,140 AZN of income.
- **Apple Seed Oil:** Cold-pressing 25 liters of oil per month from apple seeds would contribute 3,431 AZN to monthly profits, particularly in the cosmetics sector.

These by-products would not only reduce waste but also contribute an estimated 10,333 AZN in monthly profits, demonstrating the value of resource efficiency and sustainability in the production process.

By-product	**Estimated Monthly Yield**	**Monthly Profit (AZN)**	**Notes**
Apple Peel Vinegar	1,750 liters	2,762.5	From 100 kg daily apple peels
Apple Jam	875 kg	4,140	From edible tissue around cores
Apple Seed Oil	25 liters	3,431	Particularly for the cosmetics sector
Total Estimated Monthly Profit		**10,333**	

Table:1(Proposed Solution**)**

3.2 Energy and Water Efficiency

The production process involves considerable energy and water use, primarily during washing, drying, and other treatment processes. In its current state, Crispa Snacks does not fully optimize water or energy consumption.

Proposed Solution:
The introduction of energy-efficient systems and water recirculation technologies could significantly reduce the environmental footprint of the company's operations. Specifically:

- **Water Recirculation and Filtration Systems:** These systems would allow the company to reuse wash water, thus reducing overall water consumption by up to 30%.
- **Energy-Efficient Drying Systems:** Transitioning to continuous-flow ovens could reduce drying times, cutting energy usage and increasing overall throughput by 20%.

These initiatives would lower both resource consumption and operational costs, aligning with Green production strategies aimed at sustainability.

3.3 Waste-to-Value Initiatives

Waste-to-value strategies were identified as crucial for reducing environmental impact and enhancing revenue generation. Crispa Snacks' ability to convert waste into secondary products presents a clear path toward achieving a circular economy approach.

Proposed Solution:
As previously mentioned, by developing side-stream products such as apple peel vinegar, apple core jam, and apple seed oil, Crispa Snacks can reduce its total waste by 30%. Additionally:

- **Biogas Production or Composting:** The remaining waste can be processed into compost or biogas, further reducing the environmental impact of production.
- **Circular Economy Integration:** These processes would be incorporated into a circular economy model, where no material is wasted, and all by-products are repurposed into marketable goods.

This approach not only maximizes the value derived from each apple but also aligns Crispa Snacks with global sustainability practices.

3.4 Supply Chain and Logistics Optimization

While Crispa Snacks already sources apples locally, there remains an opportunity to improve logistics and inventory management, which would further reduce costs and environmental impact.

Proposed Solution:

- **Shared Logistics and Local Sourcing:** By collaborating with other local producers for shared logistics, Crispa can reduce transportation emissions and delivery costs.
- **Lean Inventory Management:** Implementing Just-In-Time (JIT) inventory systems would minimize overproduction and storage waste, further enhancing overall operational efficiency.

3.5 Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is a crucial Lean tool that helps visualize and analyze the entire production process from raw material intake to the final product. At Crispa Snacks, VSM was applied to identify non-value-adding activities, improve lead time and product quality, and streamline the flow of apples into crispy chips.

Objectives of VSM:

- Identify and eliminate non-value-adding activities (waste).
- Improve lead time and reduce process delays.
- Streamline the transformation of raw apples into finished apple chips.

3.5.1 Current State Production Flow

STEP	DESCRIPTION
Raw Apple Receiving & Inspection	Apples delivered from local farms; quality check for size, ripeness, and visible defects.
Washing & Sorting	Removal of dirt and pesticide residues; sorting based on size and apple type.
Peeling, Coring & Slicing	Peeling is optional based on product; cores are removed; apples sliced into uniform, thin pieces.
Pretreatment (Optional)	Slices may be dipped in lemon/ascorbic acid to prevent browning.

STEP	DESCRIPTION
Quality Control	Moisture levels, crispness, and color are inspected to meet product standards.
Packaging	Chips are nitrogen-flushed or vacuum-sealed for extended shelf life; packed into pouches.
Storage & Dispatch	Final products are stored and dispatched for sale.

Table: 2(Current State Production Flow**)**

3.5.2 Identified Wastes (7 Waste Categories)

1. **Overproduction** – Producing more than needed due to lack of real-time data.
2. **Waiting** – Idle time between slicing and drying or drying and packaging.
3. **Transport** – Excessive movement between distant workstations.
4. **Overprocessing** – Unnecessary peeling or pretreatment for certain varieties.
5. **Inventory** – Build-up of semi-processed apples due to batch systems.
6. **Motion** – Unnecessary movement by workers due to poor layout.
7. **Defects** – Rework needed due to improper drying or uneven slicing.

3.5.3 Future State VSM Goals

To improve productivity and sustainability, the following Lean-Green interventions are proposed:

- **Reduce drying time** by implementing continuous-flow ovens, which also save energy.
- **Introduce visual Kanban systems** at critical points (e.g., slicing and packaging) for better workflow control.
- **Real-time quality monitoring** to detect issues earlier and minimize rework.
- **Line balancing** to eliminate idle times and evenly distribute tasks among workers.

These improvements aim to reduce waste, lower production costs, and significantly improve throughput and quality.

4. Lean Green Integration for the Apple Crispy Industry

4.1 Raw Material Optimization

Lean manufacturing begins with maximizing resource use. Crispa implements the following initiatives:

INITIATIVE	DETAILS	ESTIMATED MONTHLY PROFIT (AZN)
Apple Peel Vinegar	100 kg/day of peels → ~1,750 liters/month of vinegar	2,762.5
Apple Core Jam	Recover edible tissue near cores → 875 kg/month of jam	4,140
Apple Seed Oil	Cold-pressed cosmetic oil → 25 liters/month	3,431

Table:3

These practices represent a circular economy approach that enhances product diversity while minimizing waste.

4.2 Energy and Water Efficiency

Green strategy calls for minimizing resource footprints:

- Recirculation and filtration systems reduce water use in washing.
- Energy-efficient drying (e.g., continuous-flow ovens).
- Dashboards monitor KPIs like energy/unit, water/liter, waste/kg.

Where waste occurs: Overprocessing, waiting time, transport, inventory, and defects.

Future-state goals:

- Reduce drying time via continuous ovens.

- Implement Kanban systems at slicing/packing.
- Balance production line to reduce idle time.
- Real-time quality monitoring to cut rework.

VSM helps redesign the workflow to improve flow, lead time, and overall quality.

4.3 Sustainable Supply Chain

Lean-Green supply chain improvements:

- Local sourcing to reduce transport emissions.
- Shared logistics to lower delivery frequency.
- JIT systems reduce overproduction and storage waste.

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5. Conclusion

Crispa Snacks has successfully demonstrated how Lean, Green, and Value Stream Mapping principles can be applied in the food industry to transform waste into opportunity. This case study aligns with circular economy paradigms where by-product valorization generates competitive advantages while reducing ecological footprints (Geissdoerfer et al., 2017, p. 760) Through smart utilization of apple by-products, the company not only achieves zero-waste goals but also adds over 10,000 AZN in monthly revenue—without significant capital expenditure.

This transformation improves operational efficiency, strengthens brand sustainability, and positions Crispa as a regional leader in circular food production. The study affirms that even small-scale processors can adopt industrial best practices to drive both productivity and environmental value, contributing to a resilient and innovative agro-industrial ecosystem.

In conclusion, this article is not merely a theoretical study. It presents a new and distinct perspective developed through extensive discussions with the manufacturing company, a thorough analysis of their current situation and challenges, and a review of recommendations from both local and international advisors, all integrated with lean methodologies.

I anticipate that this approach—currently applied only to apple production as a pilot project—will also be implemented by the company for other applicable products. Imagine that if such additional profit can be generated from just one product in a month, that would amount to 120,000 AZN per year. When multiplied by 30 products, this results in nearly 4 million AZN in extra income. If so, the additional benefits will reach a significant level for the company. As a

result of this approach, economic, environmental, and social benefits will be achieved. The winner will not only be the company but also society and nature.

Since this article is both scientific and based on a real case, it is expected to positively influence the thinking and mindset of more young people, supporting their personal and professional development.

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