Waste Reduction by Improved Quality Control And Hadzad Analysis And Critical Control Point (HACCP) Implementation: A Case Study From Edfina Company For Presrved Foods, Alexandria, Egypt

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Abstract:

Under the Under the project Support for Environmental Assessment and Management (SEAM), This project is being implemented by Reduction of Milk Losses at Miser Company for Dairy and Food, Mansoura, Egypt. It was implemented under the National Industrial Pollution Prevention Programmers (NIPPP). NIPPP focuses on the introduction and promotion of low-cost improvement measures, which can be easily and quickly implemented by factories. It also emphasizes the importance of economic benefits of any such intervention, particularly those with short pay-back periods. A summary of how these improvements were identified and the underlying problems solved, follows. Waste minimization through improved quality control procedures was implemented at Edfina Company for Preserved Foods, Alexandria, Egypt. A number of interventions costing LE 65,200 (Egyptian Pound) have yielded annual savings of LE 382,622. Quality control training and the implementation of Hazard Analysis and Critical Control Point (HACCP) system will lead to improved product quality and further savings. Although it is difficult to quantify at this stage further savings of LE 550,000 could be expected in the short term.

Keywords: HACCP system, Jam fruits, Fruit Juices, Canned Beans - green beans, Tomato paste, frozen foods, honey

1.0. Introduction

Edfina is a public sector company and its factory at Montazah, Alexandria is one of the largest producer of preserved foods in Egypt. Built in 1958 on 56,000 m² theplans, to its current level of 600 employees. Production is seasonal and is around 12,100 tons per year comprising; 4,600 tons of fruit juice and syrup; 3,900 tons of jam; 1,700 tons of canned beans and vegetables; 1,050 tons of frozen foods; 500 tons of tomato paste; and 350 tons of honey and other products (Figure 1).

Figure 1: Edfina company for preserved foods products (ton/year).

2.0. Process Description

Processing at Edfina Company for Preserved Foods the 5 main products can be summarized as follows [1, 2].

2.1. Fruit Juices

Fresh fruits are received, sorted, washed and squeezed. Pulp is heated, screened and mixed with ingredients. The mixture is heated, screened, homogenized, either bottled or canned then pasteurized [3]. Product is incubated before final packaging and storage (Figure 2). Here are Nutrition Facts and Nutrition Facts 15 health benefits of orange juice [4, 5] that we can make use of in our daily life (Tables 1 and 2).

Figure 2: Fruit Juices Process description

Table 1: Health benefits of orange juice

Health benefits of orange juice
Fortifies Our Immune System , Improves Digestive Health
Lowers the Risk of Cancer , Protects the Cardiovascular System
Prevents Kidney Diseases, Assists in Weight
Cleanses the Skin , Reduces Wrinkles
Improves Eyesight, It Has Incredible Healing Properties
Prevent Hair Loss, Makes Your Hair Beautiful
Lower Cholesterol Levels, It's A Natural Anti-Inflammatory
Provides Nutrients During Pregnancy

Table 2: Orange Juice Nutrition Facts

Orange Juice Nutrition Facts			
Nutritional value per 248 g (1 cup)			
Calories		112 kcal	
Carbohydrate		25.79 g	
Sugar		20.83 g	
Dietary fiber		0.50 g	
Fat		0.50 g	
Saturated fat		0.06	
Monounsaturated fat		0.089	
Polyunsaturated fat		0.099	
Protein		1.74	
Vitamins		Quantity	%DV*
Vitamin A		25 µg	3%
equiv.		496 IU	
Vitamin A			
Thiamine (B1)		0.223 mg	19%
Riboflavin (B2)		0.074 mg	6%
Niacin (B3)		0.992 mg	7%
Vitamin (B12)		0.00 µg	0%
Vitamin (B6)		0.099 mg	8%
Folate (B9)		74 µg	19%
Vitamin C		124.0 mg	149%
Vitamin K		0.2 µg	0%
Minerals		Quantity%	DV*
Calcium		27 mg	3%
Iron		0.50 mg	4%
Magnesium		27 mg	8%
Sodium		2 mg	0%
Phosphorus		42 mg	6%
Potassium		296 mg	11%
Zinc		0.12 mg	1%
Other constituents		Quantity	
Water		218.98	
* Percent Daily Values are based on a 2000 calorie diet.			

2.2. Jam Fresh Fruits

Fruits are sorted, washed, peeled then cut. The fruit is then mixed with sugar, steam cooked and concentrated under vacuum. Concentrate is packed in tin cans, or jam pots, sterilized and Stored [6-8]. Table 3 Illustrated Nutrition Facts Jam fresh fruits.

2.3. Frozen Vegetables Fresh

Vegetables fresh are received, weighed, sorted, trimmed, peeled and cut manually. Peeled vegetables are sorted, blanched, frozen, sieved, and packed in pouches. Frozen vegetables are vegetables that have had their temperature reduced and maintained to below their freezing point for the purpose of storage and transportation until they are ready to be eaten (Table 4). They may be commercially packaged or frozen at home. A wide range of frozen vegetables are sold in supermarkets [9,10].

Table 3: Jam fresh fruits Nutrition Facts

Jam fresh fruits Nutrition Facts	
12 Serving per container Serving size 19 g	
Calories 30	
% Daily Value*	
Total Fat 0 g	0%.
Saturated fat 0 g	0%
Polyunsaturated fat 0 g	
Monounsaturated fat 0 g	
Cholesterol 0 mg	0%
Sodium 0 mg	0%
Total Carbohydrate 8 g	3%
Dietary fiber 0 g	0%
Total sugar 6 g	
Includes 5g sugar added sugars	10%
Protein 0 g	0%
Vitamin D 0 mg	0%
Calcium 0 mg	0%
Iron 0 mg	0%
Potassium 94 mg	2%
* Percent Daily Values are based on a 2000 calorie diet.	

Source: Nutrient data for this listing was provided by USDA

Table 4: Frozen vegetables Nutrition Facts

Frozen vegetables Nutrition Facts	
Amount Per 100 g	
Calories 60	
% Daily Value	
Total Fat 0.2 g	0%
Saturated fat 0 g	0%
Polyunsaturated fat 0.1 g	
Monounsaturated fat 0 g	
Cholesterol 0 mg	0%
Sodium 271 mg	11%
Potassium 169 mg	4%
Total Carbohydrate 13 g	4%
Dietary fiber 4.4 g	17%
Sugar 3.1 g	
Protein 2.9 g	5%
Vitamin A	235%
Calcium	6%
Vitamin D	0%
Cobalamin	0%
Vitamin C	14%
Iron	12%
Vitamin B-6	10%
Magnesium	15%
* Percent Daily Values are based on a 2000 calorie diet.	

Source: Nutrient data for this listing was provided by USDA

2.4. Canned Green Beans

Green beans are received, weighed, sprayed with insecticide, sieved, sorted, dip and spray washed, and soaked. For the best source of nutrients and lowest sodium, choose fresh or frozen green beans for cooking. Green beans also contain folate, thiamin, riboflavin, iron, magnesium, and potassium.

This is followed by steam cooking, rapid cooling and final sorting. Cooked beans are seasoned, canned and sterilized. Table5 show Raw green beans Nutrition Facts [11,12]. Health benefits of green beans are anti-aging, anti-oxidant, rich in fiber, cell protection, boosts immunity, vitamin K source, vitamin C source, good folate source, cardiovascular health and manganese source [13].

2.5. Tomato Paste

Raw tomatoes are received from suppliers, weighed, sorted and washed. Clean sorted tomatoes are pressed for juice and screened. Seasoning is added and juice is concentrated under vacuum and heat treated. Paste is automatically canned, Table6. Tomato paste Nutrition facts [14]. Top 10 health benefits of tomatoes: Keeps Skin Healthy, Supports Bone Health, Improves Vision, Reduces Hair Problems, Lowers Blood Sugar Levels, Wards Off Cancer, Controls Weight, Promotes Sound Sleep, Lowers Blood Pressure, Reduces Chronic Pain.

3.0. Process and Service Units

There are two canning facilities, a freezing unit, two can making plants, and a varnishing and printing facility on site. Service units include a water treatment facility, boiler station, quality control laboratories, freeze-storage and refrigerators in addition to cooling towers, garages and maintenance workshops [10,15].

Table 5: Green beans Nutrition Facts

Green beans Nutrition Facts		
Amount Per 100 g		
Calories 31		
% Daily Value		
Total Fat 0.1g		0%
Saturated fat 0 g		0%
Polyunsaturated fat 0.1 g		
Monounsaturated fat 0 g		
Cholesterol 0 mg		0%
Sodium 6mg		0%
Potassium 209mg		5%
Total Carbohydrate 7 g		2%
Dietary fiber 3.4 g		13%
Protein 1.8 g		3%
Vitamin A		2%
Calcium		3%
Vitamin D		0%
Cobalamin		0%
Vitamin C		27%
Iron		5%
Vitamin B-6		5%
Magnesium		6%
* Percent Daily Values are based on a 2000 calorie diet.		

Source: Nutrient data for this listing was provided by USDA

Table 6: Raw Red Tomatoes Nutrition Facts

Raw Red Tomatoes Nutrition Facts		
Amount Per 100 g		
Calories 18 kcal		
% Daily Value		
Fat	0.2 g	
Carbohydrate	3.9 g	
Dietary fiber	1.2 g	
Protein	0.9 g	
Vitamins	Quantity	%DV*
Vitamin A equiv.	42 µg	5%
Thiamine (B1)	449 µg	4%
beta-Carotene	123 µg	
lutein zeaxanthin	123 µg	
Thiamine (B1)	0.037 mg	3%
Niacin (B3)	0.594 mg	4%
Vitamin B6	0.08 mg	6%
Vitamin C	14 mg	17%
Vitamin E	0.54 mg	4%
Minerals	Quantity%	DV*
Magnesium	11 mg	3%
Manganese	0.114 mg	5%
Phosphorus	24 mg	3%
Potassium	237 mg	5%
Other constituents	Quantity	
Water	94.5 g	
Lycopene	2573 µg	
* Percent Daily Values are based on a 2000 calorie diet.		

Source: Nutrient data for this listing was provided by USDA

3.1. Energy and Water Consumption

Annual consumption is typically electricity 5.95 million kWh, fuel 2,419 tons and water 700,000 m³.

3.2. Wastewater

Around 520,000 m³/year of effluent are discharged untreated into the public sewerage system. Table 7 show the analysis of final effluent. The factory is in the process of installing a wastewater treatment plant.

Table 7: Analysis of Final Effluent

Analysis of Final Effluent	
Characteristics	Effluent quality
Volume (m ³ /year)	520,000
BOD	845
COD	1,445
TSS	2,225
TDS	1,275
Oil & Grease	95

BOD (ppm): Biochemical Oxygen Demand (Part per million);
 COD (ppm) Chemical Oxygen Demand (Part per million), TSS (ppm)
 Total Suspended solids (Part per million), TDS (ppm)
 Total Dissolved solids (Part per million)

4.0. Cleaner Production Opportunities

Cleaner production opportunities were initially identified by means of an industrial audit of the factory. An assessment was made of the different factory processes which highlighted high product losses and recalls at around 400 tons per annum. Table 8 show that Juice losses accounted for 204 tons (4.5%); jam losses, 58 tons (15%); tomato paste losses, 57 tons (11.5%); frozen vegetables losses, 45 tons (4.5%); and cooked bean losses, 23 tons (1.5%). Issues that need addressing included: Quality control capabilities needed strengthening through additional employee training programmes, Product reject rates were high and could be reduced by better on-line production controls, Considerable amounts of jam pots were wasted due to faulty packaging, Manual packaging and poor handling of the vegetable paste resulted in unnecessary losses [16], For frozen food production, vegetables are washed and cooled manually, Product rejects arise due to improper handling and Post blanching contamination, Insects were posing a problem to product quality particularly in jam production, Considerable amounts of packaging waste were generated particularly tin and reject cans (1,500 ton/year) and glass bottles (22 ton/year), Large amounts of steam and water were being wasted due to condensate losses, leaking valves, insufficient thermal insulation and excessive use of water and Pollution loads in discharge effluents were above permissible limits.

Table 8: Losses and Recalls (ton/year)

Losses and Recalls (ton/year)		
Preserved foods	Losses and recalls (ton/year)	% Losses and recalls
Juice	204	4.5
Jam	58	15
Tomato paste	57	11.5
Frozen vegetables	45	4.5
Cooked bean	23	1.5

4.1. Cleaner Production Application

To address the above issues a series of improvement measures were identified and implemented. Priority was given to improvements that could entail significant savings at least cost.

4.2. Involving the Employees

An in-house team was established to identify opportunities for improvements that will minimize wastage in the factory's different production lines. The team was headed by the quality control manager, and included members from other key departments. The team enhanced the communication between all levels of management and workers and facilitated co-operation between the different departments.

4.3. Quality Control Training and Awareness Raising

A training needs assessment was undertaken with management, process engineers, production supervisors and line workers in order to tailor an appropriate employee training and awareness programmes. Training over 8 weeks was provided for 23 employees, mainly from the production and quality control departments, in the following areas [17,18] :Improved quality control for food industries, Good manufacturing practices in food processing, Hazard Analysis and Critical Control Point (HACCP) Systems, Cleaner Production principles and waste reduction techniques, On-line quality control monitoring and environmental measurements and Computer applications to improve monitoring, data analysis and reporting. Training manuals were disseminated and on the job training was an integral part of the programmes.

4.4. Monitoring to Improve Process Control

To reduce product losses, the factory's laboratory facilities were upgraded with partitioning, new benches and air conditioning. Additional equipment purchased to improve on-line monitoring included: Portable refract meters, pH meters, thermometers and color meters that provide quick and reliable on-line analysis of product quality, Turbidity meters to test process water quality, Computer, printer and software to improve monitoring of data and reporting of results. Consideration is also being given to obtaining: Equipment for testing coating thickness, can seams and vacuum seals, to reduce losses caused by canning defects and Environmental test kit and BOD.

4.5. Cleaner Production Interventions

4.5.1. Improve Packaging of Fruit Jam

Packaging of jam in single-use foil pots was resulting in around 15% losses due to poor cutting and seal defects. During seasonal production as many as 12,000 pots (0.36 ton) were lost daily giving rise to annual losses of 43.2 tons. Improving the design of the trimming machine has overcome the problem and led to higher quality packaging. Operational costs are marginally lower. The new machine reduced downtime by 80% thereby increasing production capacity by 6% or 36 tons per year. Net marginal value of the increased capacity is LE16,200.

4.5.2. Improve Packaging of Vegetable Pastes

The blanched and chopped vegetable leaves “Molokhia” are packed manually resulting in handling and packaging losses of 17.5 tons per year. A semi-automatic packaging system made of a dispensing assemblage and a sealing device has been introduced to eliminate these losses. As a result, packaging time has been reduced by 50% thereby saving labor costs and increasing productivity.

4.5.3. Modification to Vegetable Processing

The production of frozen vegetables involved a lot of manual handling resulting in product losses and increasing the risk of contamination. To minimize manual handling during cooling of the vegetables after blanching a special sprinkler and screening system was installed. This measure has reduced product rejects by 10 tons per year. In addition, cooling water requirements were reduced by 25% (10,920m³/year) and labor requirements reduced by 30%.

4.5.4. Improve Pest Control

The current pest control program was upgraded by installing window screens and insect cutters to control flying insects. Frequent inspection and pest surveys were also initiated. These improvements were required to bring the factory into line with international hygiene specifications and have eliminated 29.3 tons per year in product losses. 15% losses in jam packaging were eliminated by improving the trimming mechanism for foil pots.

5.0. Hazard Analysis and Critical Control Points (HACCP)

A summary of the 12 HACCP implementation steps suggested by the [19]. Figure 2 Integrating HACCP with ISO9000 under one management system [18, 20].

Table 9: HACCP implementation steps

HACCP implementation steps
12. Establish documentation and records
11. Establish procedures for verification
10. Establish the corrective action
9. Establish a monitor control of CCP.
8. Establish critical limit(s) of CCP .
7. Determine the Critical Control Points (CCPs).
6. Conduct a hazard analysis.
5. Verify flow diagram
4. Construct flow diagram
3. Identify Intended Use
2. Describe the Product
1. Assemble HACCP

5.1. Benefits and Achievements

The main benefits of this project have been to reduce raw material wastage and product rejects through better quality control. Employee training, improved process monitoring and the preventative approach of HACCP have led to greater efficiencies and operational controls yielding benefits that are better quantified over time. The application of HACCP will be essential in maintaining and assured products from the United States and European buyers are already evident for the following: Frozen vegetables for which Edfina have exported 2,000 tons to Europe and the United States, valued at LE7.6 million and Fruit drinks for which Edfina presently exports 25 tons per year valued at LE73,000. HACCP that was implemented for bottled fruit drink production is being replicated by the factory in other production lines. Environmental improvements have included a reduction in water consumption, pollution loads and volume of effluent discharges.

Figure 2: Integrating HACCP with ISO9000

5.2. Economics

A summary of the cost benefits that have been quantified for the four interventions is given below Table 10. In addition to the above costs LE33,230 was spent on on-line monitoring equipment and a further LE40,000 was spent on quality control training and HACCP implementation. Although the direct benefits of improved quality control practices are difficult to quantify it is expected that in the short term at least a further 2% of wasted raw materials and products will be recovered yielding savings in excess of LE550,000.

Table 10: Intervention of packaging processing

Intervention of packaging processing			
Intervention	Costs LE*	Annual Savings	Payback Months
Improve packaging of fruit jam	18,000	206,256	1
Improve packaging of vegetable paste	13,950	57,750	<3
Modifications to vegetable processing	10,750	49,720	<3
Improve pest control	22,500	68,896	<4
Total	65,200	382,622	2

LE* Egyptian Pound

6.0. Conclusion

It has carried out focuses on the introduction and promotion of low-cost improvement measures, which can be easily and quickly implemented by factories. It also emphasises the importance of economic benefits of any such intervention, particularly those with short pay-back periods. Benefits of Pollution Prevention It can reduce: production costs; losses of valuable raw materials; on site treatment costs; energy and water costs; the volume of solid and liquid wastes generated; the risk of spills and accidents. and improve: overall operating efficiency; generation of income through reuse and recycling of wastes; this approach can be easily replicated in sister factories to achieve similar savings; safety of employees; legislative compliance and company image.

7.0. Acknowledgement

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