

COST-EFFECTIVE IMPROVEMENTS IN SMALL AND MEDIUM SIZED DAIRY FACTORIES: CASE STUDY OF MAHROUS DAIRY

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EXECUTIVE SUMMARY

Small and Medium-sized enterprises (SMEs) generate more than 80% of milk and cheese products in Egypt, with a total value of production about LE 150,000,000. Despite their large market share though, individual factories often incur high losses of raw milk through inefficient processing and under-investment, resulting in significant revenue losses and pollution of the surrounding environment.

The SEAM (Support for Environmental Assessment and Management) Programme has been working with an SME in Dakahleya to reduce some of the losses associated with poor recovery of curds from milk whey as well as overuse of salt. Installing a mechanised vat and installing more efficient cutting knives reduced curd wastage such that an additional 650kg of cheese could be produced each day. The organic load of the wastewater was also reduced. Salt consumption was reduced by 52%, resulting in an improved product taste and quality and a further improvement in wastewater quality.

In addition the owner of the company changed the way of heating the vat from direct heating using a locally made heating burner to an indirect heating using hot water generated by a hot water boiler. The installation of the boiler resulted in fuel savings of LE 1300 per month and a reduction in the release of air pollutants.

For a total capital investment of LE 102,261 annual savings of LE 121,320 have been achieved. In the Dakahleya Governorate alone, where there are around 300 such factories, implementing such improvements would result in significant savings for the sector.

1 INTRODUCTION

The “Cleaner Production” (CP) approach was used in the small cheese-making factory “Mahrous and Sons for Dairy Products” to identify a range of improvements that were both economically and environmentally feasible for them. Work commenced with a rapid audit of the factory to identify areas with low productivity, inefficient use of raw materials and product loss or wastage, etc. Each was then assessed to determine which would be economically and financially feasible for the factory to implement and jointly implemented by SEAM and the factory. The improved productivity, financial gains and environmental improvements were then determined with a view to encouraging replication in similar factories in Egypt.

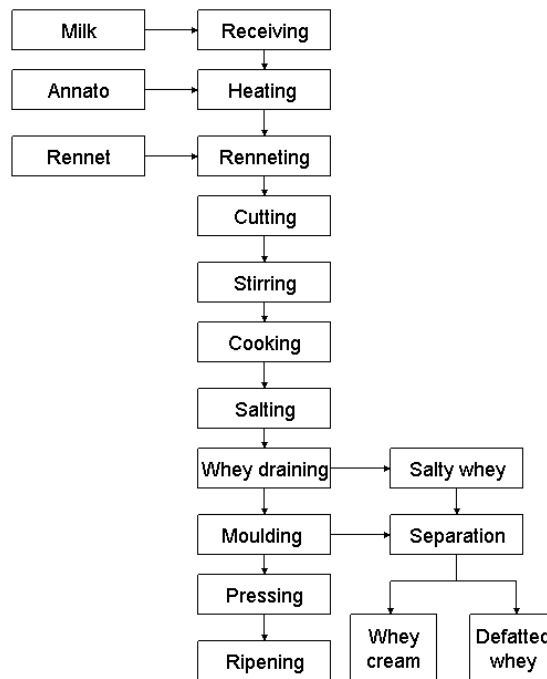
2 AN OVERVIEW OF THE FACTORY

The factory has been in business since the 1950s, using traditional cheese making techniques. It is located on the ground floor of a residential building and occupies an area of 77 m² and has 8 employees. It receives and processes 10 tons of raw milk each day using traditional vats. *Roumy* cheese (hard cheese) is produced during winter and *Domiaty* (soft white cheese) in the summer. CP interventions were implemented in the *Roumy* cheese line only.

3 PROCESS DESCRIPTION

The main process steps for the production of *Roumy* cheese are shown in the Figure 1, following:

Figure 1: Process Flow Diagram for Cheese Making at “Mahrous and Sons”



The key steps in terms of Cleaner Production (CP) opportunities included:

3.1 Cutting and Stirring

Annatto¹ and rennet² are first added to the raw milk, which is then stirred and allowed to settle for 25 minutes to allow the curd to form. Before the curd can be cut, it needs to have a suitable consistency and strength. The factory determines this based on experience and the amount of time elapsed. The curd is then cut into columns using a long metal knife and allowed to remain quiescent for 5 minutes. This is not very efficient, as the columns are too large and the settling time too short, resulting in considerable amounts of curd not being separated. After this, the vat is manually stirred with a wooden paddle until all the curd is broken.

3.2 Cooking and Salting

The curd is cooked using hot water (44°C) in a double-jacketed vat, whilst being stirred vigorously. The cooking continues until the curd is firm and can be squeezed between the hands without being deformed. About 15 minutes before the cooking ends, one third of the salt needed is added (66 Kg per 5 tons of milk) and stirred in. Once dissolved, the remainder of the salt amount is added to the vat (131 Kg per 5 tons of milk).

1 Annatto is the additive used to provide yellow colour to *Roumy* cheese.

2 Rennet is the curdling agent used in the cheese manufacturing process. The rennet used in Mahrous is locally manufactured bovine / calf rennet.

3.3 Whey Draining and Moulding

The salted, cooked curd is transferred to a cheesecloth filter placed over plastic barrels. The collected curd is then divided into 12.5 kg cloth-lined moulds. The filtered whey remaining in the barrels is processed to recover butterfat (whey cream) and the defatted whey discharged to the sewer.

4 THE CLEANER PRODUCTION APPROACH

A preliminary examination of the cheese making process at Mahrous revealed the following key areas of concern in terms of high pollution load and lower productivity:

- Excessive use of salt in the preparation of milk, due mainly to the lack of process optimisation and control.
- Discharge of the defatted whey to the drains. This practice, along with the excessive use of salt was a major environmental concern for Mahrous; for the 10 tons of milk processed each day, around 9m³ of whey and 5m³ of wash water were discharged. This led to a daily release of about 423kg of BOD and 383kg of salt to the environment.
- Direct heating of vats with solar and butane burners.
- Excessive water used for washing and cleaning, resulting in excessive volumes of water being discharged to the drains.

5 CLEANER PRODUCTION INTERVENTIONS

During the audit stage, particular attention was paid to those improvements that could be carried out at low or no cost to the factory. These were given a high priority, as they are easy to implement and often entail significant savings.

The measures that have already been implemented by the factory through the Cleaner Production Demonstration Projects of the SEAM Project are briefly outlined below.

5.1 Low Cost “Housekeeping” Improvements

An In-plant housekeeping intervention included a draining table for the cheese making process and laboratory equipment for quality control. As a result, the quality of cheese was improved with a lower volume, lower strength wastewater being discharged to the sewer system.

Experiments were carried out to determine optimum amounts of salt required in the cheese making process. These demonstrated that salt use could be reduced by 50%, whilst maintaining product quality and reducing the saltiness of the whey.

Cost of Implementation: LE9,261

5.2 INSTALLATION OF NEW EQUIPMENT

5.2.1 Installation of New Mechanical Vat

The traditional vat used for cheese making (Curd) is stirred manually using a wooden paddle, however curd is not efficiently separated from whey. A mechanical cheese vat was supplied to the factory, consisting of double-walled, horizontal stainless steel with an overhead cutting and stirring mechanism. The stirring mechanism is driven by two motors, one for longitudinal movement and the other for a rotating motion. All parts are made from stainless steel 304. All welds in contact with the product are argon shielded. The control panel for this has a touch screen, fitted to the wall.

A summary of the technical specification follows:

- Vat capacity: 5 tons.
- Curd/whey discharge/ CIP out /milk - 3 inch outlet with a butterfly valve.
- Water-in jacket: 1 inch diameter pipe. Water-out jacket: 2 inch diameter pipe.
- Longitudinal agitation: 15 cm / sec.
- Rotational cutting speed: 0 – 45 rpm
- Accessories: working platform and a curd reception vat (300 L)

Cost of Implementation: LE33,000

5.2.2 Installation of Hot Water Boiler

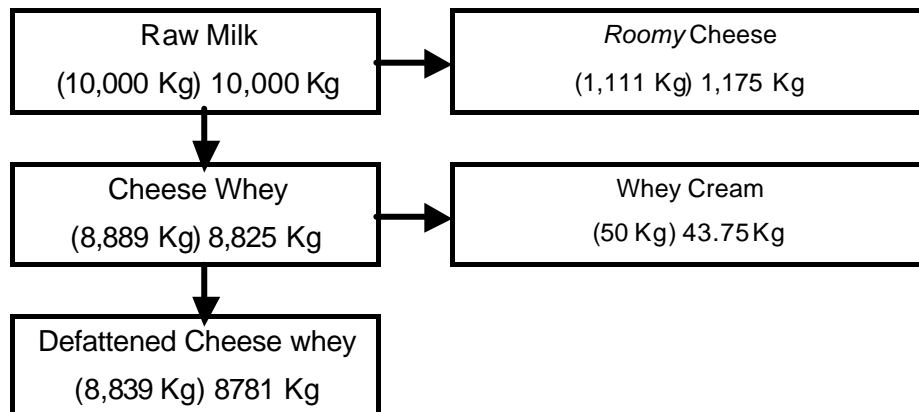
The vats were originally heated with burners fired by butane and solar. These were replaced with a solar-fired boiler, to provide hot water for heating the vats indirectly. Bottled butane was phased out completely and solar consumption reduced by half. Air emissions from the burners were eliminated.

Cost of Implementation: 60,000LE

6 FACTORY MASS BALANCES BEFORE AND AFTER IMPLEMENTATION

Figure 2 represents the overall mass balance before and after the implementation of the CP options. The overall cost-benefit analysis for Cleaner Production options implemented at Mahrous is shown in the Table 1. It may be observed that the payback period for the investments made is only 5.1 months if a locally produced mechanical vat is purchased³.

Figure 2: Mass Balance before and after Implementation of CP Interventions



Note: figures in brackets represent the situation prior to CP implementation. Figures not in brackets show the post-implementation status.

³ If an imported mechanical vat is installed, then the payback period will be around 10 months.

7 COST BENEFIT ANALYSIS OF CLEANER PRODUCTION OPTIONS

Table 1: Cost benefit Summary		
(A) Before Implementation		
Material⁴ consumed:	Volume:	Costs incurred (LE):
Milk	10 tons	10,000
Salt	414 kg	47
Fuel:		
Solar	160 L	64
Butane gas	1 cylinder	11
Material produced:	Volume:	Revenue gained (LE):
Roumy cheese produced	1.11 ton	11,100
Whey cream produced	50 kg	350
Gross earnings per day (without including costs of transportation, storage, labour, taxes, maintenance, etc.)		1,328
(B) After Implementation		
Material consumed	Volume:	Amount (LE):
Milk	10 tons	10,000
Salt	197 kg	22
Fuel:		
Solar	80 L	32
Butane gas	0 cylinder	0
Material produced:	Volume:	Revenue gained (LE):
Roumy cheese produced	1.175 ton	11,750
Whey cream produced	43.75 kg	306.25
Gross earnings per day (without including costs of transportation, storage, labour, taxes, maintenance, etc.)		2,002
Net savings per day after implementation of Cleaner Production options		674
Net savings per year (6 months of Roumy production)		121,320
Total capital costs for mechanical vat, draining tables, boiler and laboratory equipment ⁵		102,261
Simple payback period	10 months	

⁴ Rennet, not being so expensive and required in very small quantities in cheese making at Mahrous, has not been included in the overall cost benefit analysis.

⁵ Capital costs include the costs of the mechanical vat (33,000 LE), draining tables (5,000 LE), boiler (60,000LE) and laboratory equipment (4,261 LE).

8 CONCLUSIONS

The measurements showed that after implementation of the CP options:

- Protein content in the Roumy cheese increased by 8.5%, resulting in an improved quality and improved nutritional value.
- Although the volume of whey discharged remained the same, its pollution load decreased: Total suspended solids were reduced by 25% and BOD and COD were reduced by 8.5%.
- Productivity of *Roumy* cheese increased by 6%.
- Salt use was reduced by 52%.
- Air emissions were reduced with the phasing out of open burners.
- For a total investment of LE 102,261, annual savings of LE 121,320 were made, giving a payback period of around 10 months.
- The combined economic and environmental benefits make implementing similar improvements attractive for other SMEs in the cheese-producing sector.