J. Int. Environmental Application & Science, Vol. 2 (1&2): 1-4 (2007)

Utilization of whey for waste minimization of white cheese industry: a case study

Mustafa Şamil ARGUN[a], Adem ELGÜN[b], M. Emin ARGUN[c], Mustafa KARATAŞ[c]

[a]*Izi Süt Company, Konya, TURKEY*
[b]*Department of Food Engineering, Agriculture Faculty, Selcuk University, 42031 Konya, TURKEY*
[c]*Department of Environmental Engineering, Engineering & Architecture Faculty, Selcuk University, 42031 Konya, TURKEY*

Accepted 17 April, 2007

Abstract: Cheese industry wastes have a major impact on the ecology because of high organic content. Thus, waste minimization is an important concept in the application of the waste management in the white cheese industry. In this article, a case study on the waste minimization of a white cheese industry by reuse of whey has been investigated. Our results indicated that high strength organic content of whey reduced from 64,300 mg L^{-1} to zero by reusing whey to produce whey powder.
Keywords: Whey; minimization; white cheese; waste water; reuse.

Introduction

Whey is a by-product of the dairy industry in which the principal components are lactose, proteins and mineral salts (Vasala et al., 2005). Approximately 47% of the 115 million tons of whey produced world-wide every year are disposed of in the environment (Leite et al., 2000; Zhou and Kosaric, 1993; Siso, 1996). This represents a significant loss of resources and causes serious pollution problems since whey is a high strength organic pollutant with high BOD_5 (Biological Oxygen Demand) and COD (Chemical Oxygen Demand), with values of 40,000–60,000 mg/l and 50,000–80,000 mg/l, respectively (Ben-Hassan and Ghaly, 1994; Fournier et al., 1993). More than 90% of whey BOD_5 is due to lactose (Kisaalita et al., 1990).

Treatment methods of white cheese industry waste water have been studied intensively during last decade years. Problems of the pollutants removal from waste water were increased with fast industrialization. These waste waters are produced large volumes and must be absolutely treated before discharge. Due to the high organic content of whey, regular treatment processes such as the activated sludge process are completely inappropriate (Gavala et al., 1999). However some treatment process such as anaerobic membrane process (Saddoud et al., 2007), reverse osmosis (Re et al., 1998), electrodialysis and ion exchange (Greiter et al., 2002) can be used.

On the other hand, waste minimization seems to be more reasonable because of other processes have high operating cost and the difficulty of treatment of by-products. Waste minimization in general can be classified into two categories: recycling/recovery and source reduction. Generally, source reduction takes priority before the other and is the most economic tool for waste minimization. Reducing the amount of process water will be effective in reducing the quantity of total wastes (Argun et al., 2006; Lo and Tsao, 1997). The recovery processes includes reuse of whey by passing whey through evaporation processes. The recovered whey powder can be used again with the relevant industry (Elgun, 1981).

Our goal in the present study was to demonstrate reuse of whey could have acceptable reduction efficiency for removing COD, BOD_5 and TSS (Total Suspended Solids) and could thus offer an effective and economical alternative to more expensive treatments.

Material and Methods

Site description

Whey samples were collected from the Izi Sut Company, Konya. Milk powder, whey powder, white cheese, kaşar cheese, yoghurt, ayran, butter and labne are produced in the factory and its capacity is 300 ton milk day^{-1}. Factory uses approximately 10,000 L of milk daily in white cheese production and approximately 7,500 L of whey is produced as by-product. Flow diagrams of white cheese and whey production process in Izi Sut were constructed in order to provide a clear, simple description of the steps involved in the process (Figure 1).

Sample characterization

COD was analyzed using an UV visible spectrophotometer (Dr Lange, Cadas 200, Germany). BOD_5 tests were performed according to Standard Methods for the Examination of Water (1998) Section 5210. No nitrification inhibitor was used in the stock BOD dilution water. To obtain BOD_5, the following equation (Eq. 1) was used:

$$BOD_5 = \frac{(DO_i - DO_f)}{F} \quad (1)$$

where DO_i is the initial dissolved oxygen of the sample (mg L^{-1}), DO_f is the dissolved oxygen after 5 days of incubation (mg L^{-1}), and *F* is the fractional dilution of the sample (i.e. the volume of the sample divided by volume of the BOD bottle). Dissolved oxygen was measured using a dissolved oxygen meter equipped with a self-stirring BOD bottle probe (Multi 340i, WTW, Weilheim Germany). The meter was calibrated prior to every test event. All BOD_5 measurements were performed in triplicate. Total suspended solids (TSS) were determined according to Standard Methods (APHA, 1992). The pH measurements were performed with digital ion analyzer with a combination electrode (Multi 340i, WTW, Weilheim Germany).

Result and Discussion

Pollution potential of whey

In Figure 1, 1st way shows flow diagram of white cheese production process without reuse step of whey. A lot of cheese production processes do not have a reuse step and as can be seen in Figure 1-1st way, whey directly discharges in waste water collection system. According to Table 1 it was clearly revealed that organic content of whey rather high and this water could be lead to shock loading on waste water treatment systems and could be threat habitat seriously.

Table 1. Chemical properties of whey

Sample	COD (mg L^{-1})	BOD_5 (mg L^{-1})	TSS (mg L^{-1})	pH	SH	T (^oC)
Whey	64,300	52,000	214,800	6.1	5.1	32

Effect of reuse of whey on the waste minimization

It was clearly understand that this whey must be either treated or reused. Figure 1-2nd way, shows flow diagram of white cheese production process with reuse step of whey. In this process whey is separated, evaporated and dried and it is separated as whey powder and water vapor. Thus whey is reused with zero waste water discharge and do not have an environmental risk on habitat. Produced whey powder can be used in various industries such as chocolate, biscuit and cake production and so it has also an economical advantage.

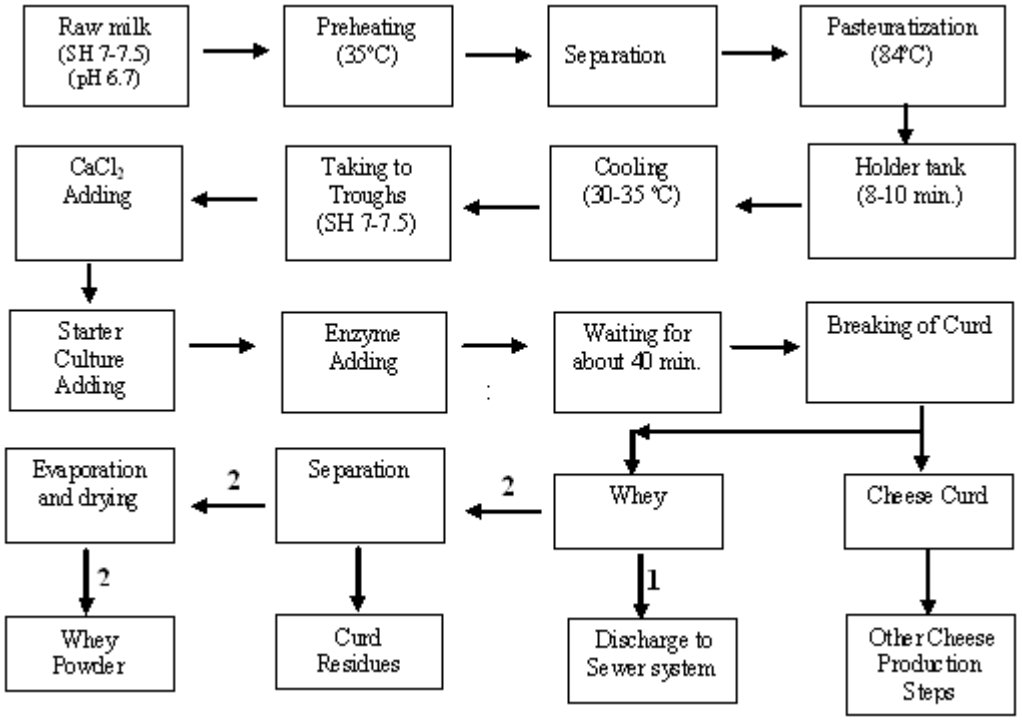

Figure 1: Typical flow diagram of white cheese production industry with and without reuse system of whey

Conclusion

The present study clearly establishes that reuse of whey as whey powder is an effective method for waste minimization from white cheese industry. The results obtained show that reuse process of whey in Izi Sut led to zero discharge and so did not have a hazardous effect on ecology. However classical treatment methods of whey have a high cost and by-products of them such as sludge is another problem for environment. Moreover, some other reuse methods of whey such as lactose production and production of concentrated protein are also possible and these methods are used already in some industry. According to our opinion obtained products from whey can also be used with cereal products as ingredient.

Acknowledgements: *The authors gratefully acknowledge the Izi Sut Comp. for its support of the work undertaken here.*

References

American Public Health Association (APHA). (1992). American Water Works Association (AWWA) and Water Environment Federation (WEF). In: Standard methods for the examination of water and wastewater, 18th Ed. American Public Health Association, Washington, DC, USA.

Anon. (1998). Standard Methods for the Examination of Water and Wastewater, 20th ed. APHA, AWWA and WEF, Washington, DC.

Argun M.E., Dursun S., Özdemir C., Karatas M. (2006). Industrial heavy metal pollution and hazardous effects on ecology: waste management perspective. *VI-th International Scientific Conference SGEM*. **2**, 421-433.

Ben-Hassan R.M., Ghaly A.E. (1994). Continuous propagation of Kluyveromyces fragilis in cheese whey for pollution potential reduction. *Appl. Biochem. Biotechnol*. **47**, 89–105.

Elgün A. (1981). Studies on the effect of dry whey on dough and bread properties. Ataturk University Agriculture Faculty, Erzurum, Turkey

Fournier D., Schwitzguebel J.P., Peringer P. (1993). Effect of different heterogeneous inocula in acidogenic fermentation of whey permeate. *Biotechnol. Lett*. **15**, 627–632.

Gavala H.N., Skiadas I.V., Lyberatos G. (1999). On the performance of a centralised digestion facility receiving seasonal agroindustrial wastewaters. *Water Sci. Technol*. **40**, 339–346.

Kisaalita W.S., Lo K.V., Pinder K.L. (1990). Influence of whey protein on continuous acidogenic degradation of lactose. *Biotechnol. Bioeng*. **36**, 642–645.

Leite A.R., Guimaraes W.V., de Araujo E.F., Silva D.O. (2000). Fermentation of sweet whey by recombinant Escherichia Coli KO11. *Braz. J. Microbiol*. **31**, 1517–8382.

Re G. D., Giacomo G. D., Aloisio L., Terreri M. (1998). RO treatment of waste waters from dairy industry. *Desalination*. **119**, 205-206.

Greiter M., Novalin S., Wendland M., Kulbe K. D., Fischer J. (2002). Desalination of whey by electrodialysis and ion exchange resins: analysis of both processes with regard to sustainability by calculating their cumulative energy demand. *Journal of Membrane Science*. **210**, 91–102.

Saddoud A., Hassairi I., Sayadi S. (2007). Anaerobic membrane reactor with phase separation for the treatment of cheese whey. *Bioresource Technology*. **98**, 2102–2108.

Siso G.M.I. (1996). The biotechnological utilization of cheese whey: A review. *Bioresour. Technol*. **57**, 1–11.

Vasala A., Panula J., Neubauer P. (2005). Efficient lactic acid production from high salt containing dairy by-products by Lactobacillus salivarius ssp. salicinius with pre-treatment by proteolytic microorganisms. *J. Biotechnol.* **117**, 421–431.

Zhou Q.H., Kosaric N. (1993). Effect of lactose and olive oil intra and extra cellular lipids of Torulopsis bombicola. *Biotechnol. Lett*. **15**, 477–482.