Utilization of whey

**1. Characteristics of whey**

Whey is a by-product in milk processing, the world production amounts to about 82 million metric tons, and especially the acid whey is seen as a waste product. In general three types of whey have to be differed: sweet, acid, and casein whey. Without regard to its origin the main component of whey is carbohydrate lactose. The amount of lactose exceeds 70% of total dry matter. Proteins and inorganic substances (ash) follow with differing weight proportions.

**2. Status of whey treatment and further utilization**

Whey may be separated by means of ultrafiltration or reversed osmosis into its main components proteins, lactose, and delactosed permeate (DLP). Whey with an average drymatter of 6% is first deproteinezed and whey protein concentrate (WPC) is sold. Furthermore, the deproteinized permeate is concentrated to a dry matter of about 60%, followed by a crystallization of the lactose. The purified lactose is sold and DLP disposed. It is not feasible to dry DLP-like whey because of the high contents of salts.

Overall the DLP remains with a pH of 5.2-5.5 and dry matter of about 25-30%, consisting of approximately 15% proteins, 15-20% ash, and 60-70% lactose. This remaining residue is costly in disposal due to its high COD.

**2.1. Ethanol production from whey**

The production of ethanol is considered to be a feasible technique to enhance the profit from the by-products of whey treatment and is used for both, producing spirits or liquid fuels. Ethanol production can be performed either as a fermentation with or without enzymatic pretreatment. Many of the microorganisms are not capable for direct conversion of lactose to ethanol. Thus enzymatic pretreatment with ß-galactosidase is required. The fermentation is feasible with *Aspergillusniger* at a pH between 3.5 and 4.5 or Streptococcus lactis at a higher pH level ranging from 6 to 7.

**2.2. Demineralization**

High salt concentration s in the fermenting solution can inhibit microorganism growth. Therefore, demineralization seems to be obligate for further biological treatment of DLP. Besides different physical effectslike precipitation, a high salt content requires halophilic microorganisms which are able to produce ethanol of adequate concentration.

Interesting possibilities for the utilization of specific salty fractions lie in the recovery of melting salts or table milk salts (salt substitutes), production of defined supplements for beverages, the feed or cosmetic industries, etc.

**2.3. Precipitation of Calcium Phosphate**

Calcium and phosphate rank approximately 16% of the total salt content. A removal of both would improve the “degradability” of whey significantly.

Calcium phosphate precipitation is enhanced by raising pH, temperature, and concentration.

Calcium phosphate milk salts are currently marketed as nutritional supplement to combat osteoporosis.

**2.4. Precipitation of Phosphate and Sulfate in DLP**

The best results were achieved with a CaO concentration of 1% by mass. The phosphate concentration could be reduced about 87%.

**2.5. Ion Exchange**

By ion exchange a removal p to 95% of theminerals from whey may be feasible.

**2.6. Electrodialysis**

Electrodialysis is a rather effective method for the removal of salts and bases upon the movement of ions through a membrane system forced by electric fields.

**2.7. Nanofiltration**

Nanofiltration has replaced electrodialysis as the preferred demineralization process.

**3. Alternatives of whey utilization**

In the literature there exist many approaches for the utilization of whey.

**3.1. EthanolicCofermentation with cereals or molasses**

The method is based on replacing water with whey in preparation of cereals fermenting media. IN the first stage ethanolic fermentation in whey is performed by *Kluyveromycesmarxianus subsp. Marxianus*. Such prefermented whey is then used for dilution of molasses instead of water and resulting medium subjected to the second stage fermentation performed with *Sachharomycescerevisiae*.

**3.2. Production of Lactic acid**

The anaerobic fermentation of whey with lactic acid bacteria for the production of lactic acid is feasible but probably not profitable.

Lactic acid is produced by homofermentative lactic acid bacteria, such as *Lactobacillus bulgaricus* or *Lactobacillus plantarum*. Lactic acid is separated from the fermenter solution with elctrodialysis or H2SO4 after neutralization with Ca(OH)2 or CaCO3.

**3.3. Production of Ammonium Lactate**

Experimental feeding of ruminants has shown that 27% of total nitrogen of the feed can be replaced by nitrogen of fermented whey containing ammonium lactate.

**3.4. Production of Single cell protein (SCP)**

SCP is used primarily for feeding but also for human nutrition.

**3.5. Production of Bakery Yeast**

An industrial process for producing bakery yeast (*Saccharomyces cerevisiae*) was adopted. After enzymatic treatment with immobilized ß-galactosidase, an inoculation with yeast strains that are able to metabolize galactose is required.

**3.6. Production f biogas**

The production of biogas from whey can be based on different products of the whey treatment.

* Whey
* Permeate (deproteinized whey)
* Mother liquor from lactose production
* Residues of ethanol production

**3.7. Whey drinks**

A well sold lactic acid fermented whey drink is Rivella (Switzerland). The supplement of ß-galactosidase can increase the sweetness of such products.

**4. Further Scientific approaches of whey utilization**

* Proteolytic enzymes
* ß-galactosidase
* Antibiotics
* Organic acids
* Propionate-containing whey to incorporate in bread formulations
* Vitamins
* Amino acids
* 2,3-butanediol, a basic material for the chemical industry
* Food gums
* Starter cultures
* Supplement to bakery products