Membrane separation technology in the food industry

Introduction The current food industry has come about through generations of cultural and technological developments, involving many aspects from food production to processing to retail before reaching the consumer. In this day and age, the highest level of quality and safety are expected from food products, and the market for value-added foods is ever-increasing. As such, much research has been spent in food processing to ensure maximum benefit and satisfaction for the consumer. Membrane separation technology is a prominent figure in ensuring that food meets those requirements, and is hence a much researched topic, advancements occurring constantly to improve the technology and make it as efficient and economical as possible. History of membrane filtration Separation technology is basically the division of different components within a sample.

These include distillation and other forms involving heat treatment, but in the food industry, the use of excessive heat may produce undesirable results that compromise the nutritional value, chemical makeup and overall quality of the produce. Hence, filtration is often the best option in such cases and may even used in conjunction with the abovementioned processes to enhance the quality of the product. In the food industry, the use of filters to separate solids from liquids is not a new innovation, and has traditionally been done through diatomaceous earth (Butchermaker 2004). However, its use as a filter medium has proved to have many disadvantages including health and safety issues, as well as waste disposal problems.

With membrane filters however, such complications can be overcome. Membrane technology began in the 1920s as a form of water treatment with microfiltration (Howell et al 1993), and only began to advance significantly in the past 30 or so years since the development of ultrafiltration in the 1970s for the dairy industry. Membrane filtration utilizes a pressure driving force to separate constituents in a colloidal dispersion or solution by passing it through a semi-permeable membrane, and is based mainly on the olecular size of particles, although shape and charge also play a minor role (Grandison & Lewis 1996). Initially, commercial membranes were made of cellulose acetate but due to limitations, they were replaced in the 1970s, with polyamides and polysulphones most widely used in the food industry. The use of membrane filtration covers many different aspects of food processing, with different membrane processes filter out different sizes of molecules, from fat globules (microfiltration) to ions (reverse osmosis). This versatility means that it can be used through a range of areas including the clarification of fruit juice and even the treatment of spent process water in the food industry for re-use (Blocher et al.

2002). Advantages The primary advantages of membrane techology revolve around several properties – the exclusion of chemical additives and heat treatment which allows processes to be performed at ambient temperature and pH, the ability to run at a small scale with simple equipment, as well as its low energy and maintanence requirements (Cai 2005). The former is especially applicable in the food processing industry as consumers can easily tell when the quality of food is compromised when taste or appearance is modified due to preservatives or heat. However, many food items do require treatment of sorts for many different reasons to prolong shelf life or to concentrate for transport and convenience which would make the foods more profitable and cost-effective. Membrane technology allows the fulfillment of the stringent criteria required by both the food industry and the consumer due to the properties of the processes as described above, and has even opened up new options such as its advantages to the increasing demand for functional or value-added foods. Types of membrane processes Reverse Osmosis (RO) RO is mainly used in food processing for concentration, purification and the recovery of valuable components (Butchermaker 2004).

It uses an external pressure to force the feed through a membrane against osmotic pressure, ence its terminology. While this allows the filtration of particles as fine as ions (<1 nm), the higher pressure required means that it incurs a greater cost to operate than other membrane processes, but is still significantly less than alternatives like mechanical vapour compression and freeze-concentration (Grandison & Lewis 1996). However, this process is relatively new and as such is currently less applicable than its counterparts, compared to UF in the dairy industry for example. It is primarily used for the treatment of water and fruit juices. Ultrafiltration (UF) UF is also pressure-driven, but functions at a much lower process than that of RO.

The process filters out particles between 1nm to 100nm such as macromolecules (eg proteins) and is especially useful in fractionation, concentration and purification (Butchermaker 2004) as it allows the separation of large molecular weight components in high concentration from low molecular weight components in a concentration close to that of the feed without the need for heat application or phase changes (Grandison & Lewis 1996). The dairy industry benefits the most from UF, especially with the large market for specialty milk-based beverages (Butchermaker 2004); not only is UF used in the more common processes like production of whey and cheese from milk, it is also useful in the preparation of products such as UF concentrated skim milk which is of high calcium and protein content. Other areas which utilize UF technology include the clarification of fruit juices and the isolation of protein from oilseeds (Grandison & Lewis 1996). Microfiltration (MF) The oldest form of membrane technology is MF, existing for several decades even before reverse osmosis was used industrially (Grandison & Lewis 1996). It can separate particles sized between 0. 1µm to 10µm and is primarily used for clarification and sterilization as an alternative to centrifugation and heat treatment respectively through the removal of suspended solids and high molecular weight proteins, and is theoretically ndistinct from UF save for the size ranges of materials separated.

In the food industry, with no need for chemical additives, the higher product quality and lower costs means that MF is most commonly used in the treatment of beverages such as cider and beer, as well as fruit juices (Grandison & Lewis 1996). In the dairy industry, it is used in the clarification of cheese whey and the removal of fat and microorganisms in milk (Butchermaker 2004). Nanofiltration (NF)NF operates very similarly to UF and MF in that it is also a pressure-driven process that passes samples through a membrane, and filters out particles with sizes between that of RO and UF (Grandison & Lewis 1996). It is a relatively new process that is often confused with UF but provides different functions in food processing. One major application of NF is the demineralization of whey in the dairy industry, allowing the recovery of lactose and protein concentrate with a reduced content of salt (Butchermaker 2004).

Case Examples of Applications in the Food IndustryA well-known example of how membrane processes have benefited the industry and introduced a whole new market of products is the extraction of whey from milk (Butchermaker 2004). Until recently, this liquid was often discarded as waste but has since then been identified as a good source of protein sold at a high price and has isolated for use in many sports foods and drinks. The different filtration processes were applied to treat whey to purify it to a more palatable state and even isolate the protein and nutrients by themselves. Today, membrane technology is very widely used in the dairy industry with a large variety of applications as described in the previous section.

The fruit juice industry also utilizes membrane separation technology extensively. Juices are particularly sensitive to heat and thus require processes to be carried out at ambient temperature and pH, and membrane separation allows these criteria to be met and still produce results of high quality. For example, UF membranes are used to clarify a variety of juices such as apple and blackcurrant by removing impurities like proteins and tannins, and this in turn allows the the final juice product to be more stable without much compromise in colour (Skelton 2000). RO can then further concentrate the juices into syrups, which allows for another variety of products altogether. Another major application of membrane technology in the food industry worth mentioning is its use in recycling spent process water (Blocher et al. 002).

In most industrial processes, the effluent water is flushed away but the option to treat it, for example with a membrane bioreacter and further purified with NF and UV disinfection to render the wastewater to drinking quality (as deemed by the limits of the German Drinking Water act) has become a more and more viable and economical option for the food and beverage industry. This treated water can then be re-used in areas such as boiler make-up water, cooling water, pasteurisation and bottle pre-washing. Membrane separation in such applications provide benefits to both the producers as an economical way of dealing with used process water as well as the environment as it allows much of the water to be recycled, resulting in less wastewater discarded. Conclusion With membrane techology still continually researched in many areas like new membrane materials, the elimination or reduction of process problems like membrane fouling, more economical ways of carrying out operations and new applications for the different processes, it is likely to grow rapidly into the future both in and out of the food industry.

As it is now, the technology is already widely used food processing particularly in the beverage and dairy sector, but relatively new areas like the treatment of industrial effluence and the increasing demand for nutrition-enhanced foods will probably make use of membrane separation extensively as well. References Blocher, C; Noronha, M. ; Funfrocken, L. ; Dorda, J.

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