# RECENT DEVELOPMENTS IN THE APPLICATION OF MEMBRANE TECHNOLOGIES FOR CONCENTRATION OF PLANT EXTRACTS

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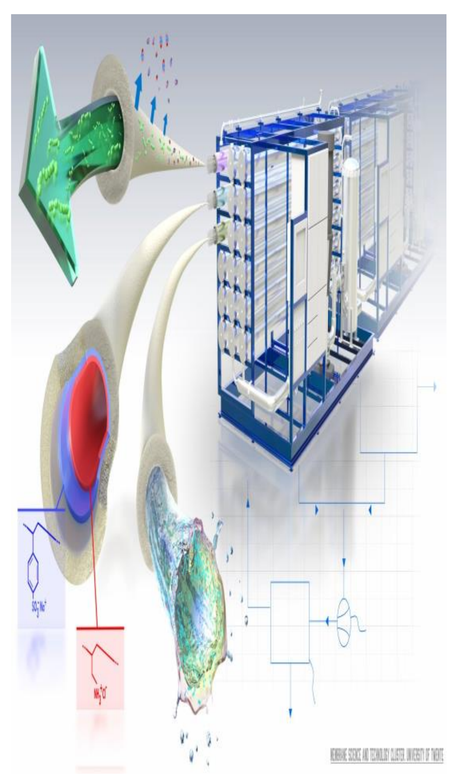
## Introduction

Today, medicinal plants are of great importance due to their special properties as a great source of therapeutic phytochemicals that may lead to the development of new drugs.

The study of medicinal plants begins with pre-extraction and extraction procedures, which are an important step in the processing of bioactive ingredients from plant materials *(Azwanida et al.,2015)*

The second step in obtaining these active substances is the step of purification and concentration as the crude extracts from solvent extraction cannot be used immediately, and intensive treatment such as purification or refining is required. Conventional purification approaches include distillation or evaporation to remove solvents or the use of additives such as caustic for oil refining processes. The first one requires a significant amount of energy. The addition of chemicals such as caustic to crude extracts can also lead to undesirable results *(Sereewatthanawut.,2018).*

In recent years, membrane technology has attracted a great deal of attention as an environmentally benign technology for purifying natural extracts. For two decades, various membrane-based technologies have been actively used to separate, restore and concentrate bioactive compounds *(Castro-Muñoz et al.,2020).* It can be said that membrane technologies represented a viable alternative to conventional techniques due to the low operating and maintenance costs, moderate operating conditions of temperature and pressure, ease of control and expansion, and highly selective separation *(Conidi et al.,2017).*



## Microfiltration (MF) and Ultrafiltration (UF):

**Microfiltration (MF):**

MF is one of the oldest pressure driven membrane applications' practiced commercially, Where it comes second after dialysis *(Eykamp et al.,1995)*

Microfiltration (MF) membranes are normally of average pore size between 0.1 and 10 µm where pores are uniformly distributed throughout the membrane. MF is done under a pressure gradient of 1-3 bar following a sieving mechanism *(Pal.,2020).* The wide range of pore size in these films has allowed them to be applied in many fields.

**Ultrafiltration (UF):**

UF is one of the membrane separation techniques that separates, purifies and concentrates solutions between microfiltration and nanofiltration. Its definition domain is to reject the molecular weight 500 – 500000 Da. The approximate diameter of the pore is about 0.001 – 0.1 µm, the operating pressure difference is generally 0.1 – 0.8 MPa, and the diameter of the separated component is about 0.005 – 10 µm *(Li.X et al.,2018).*

Table 1, present some studies on applying (MF) and (UF).

| The process | The application | The results | Reference |
|---|---|---|---|
| Cross-filtration process By using a 0.2 µm regenerated cellulose membrane and washing the concentrated pectin extracts using the fed-batch type diafiltration system as a second step | Concentrate and purify soluble pectin extracted from a ripe citrus peel | - The galacturonic acid content of pectin increased from 68.0 to 72.2%<br>- The recovery yield of pectin decreased from 10.5 to 9.9%. In<br>-After the diafiltration process, the galacturonic acid content of pectin increased from 72.2 to 75.6%.<br>-The yield of pectin, however, decreased from 9.9 to 9.4% at six volumes of diafiltration. | (Cho et al.,2003) |
| Ceramic membranes with different pore diameters (0.2 to 1.4 µm), transmembrane pressures (50 to 200 kPa) and temperatures (50 °C and 60 °C) | Obtain a natural extract enriched in lycopene from watermelon juice | At the best-operating conditions during microfiltration, the the permeate flux was close to110 L. $h^{-1} \cdot m^{-2}$, and the lycopene concentration increased 11-fold in the retentate | (Chaparro et al.,2016) |
| Two ultrafiltration (UF) membranes was evaluated, one made of polysulfone with 100 kDa (PS 100) and other polyetersulfone with 50 kDa (PES 50) | obtaining a purified lycopene | Lycopene retention was higher than 90%. and The inclusion of a diafiltration step proved to be effective in order to obtain a lycopene concentrate with higher purity | (Paes et al.,2015). |
| Cellulose membrane (MF; Millipore filters with 45). µm) followed by ultrafiltration using polysulfone PSF and polyacrylonitrile PAN membrane | Evaluated the antioxidant activity of Salvia officinalis L. (Labiaceae family) and Viscum album L. (Loranthaceae) | The PAN membrane has the greatest efficiency since it shows the highest permeate flux and the greatest retention degree for bioactive compounds | (Roman et al.,2009) |

## Nanofiltration (NF)

The term Nanofiltration (NF) first appeared commercially by in the mid-1980s to describe a new line of membrane products that had properties between UF and RO membrane. *(Bruggen et al.,2008)*

A molecular weight cutoff (MWCO) of the NF membrane is about 200 – 1000 Dalton (Da), which corresponds to pore sizes between 0.5 and 2 nm. Unlike UF and RO membranes which generally carry no charge on their surface, NF membrane often carries positive or negative electrical charges *(Strathmann, 2011).*

Two nanofiltration membranes (SelRO MPF-36, Koch membrane) and an organic-inorganic membrane (polysulfone with SBA-15-NH2) were evaluated to concentrate phenols and flavonoids and assess the antioxidant activity of (*Geranium robertianum* and *Salvia officinalis*) extracts. The results show in table 2 *(Paun et al.,2011).*

Table 2: *Rejection of total phenols and total flavonoids*

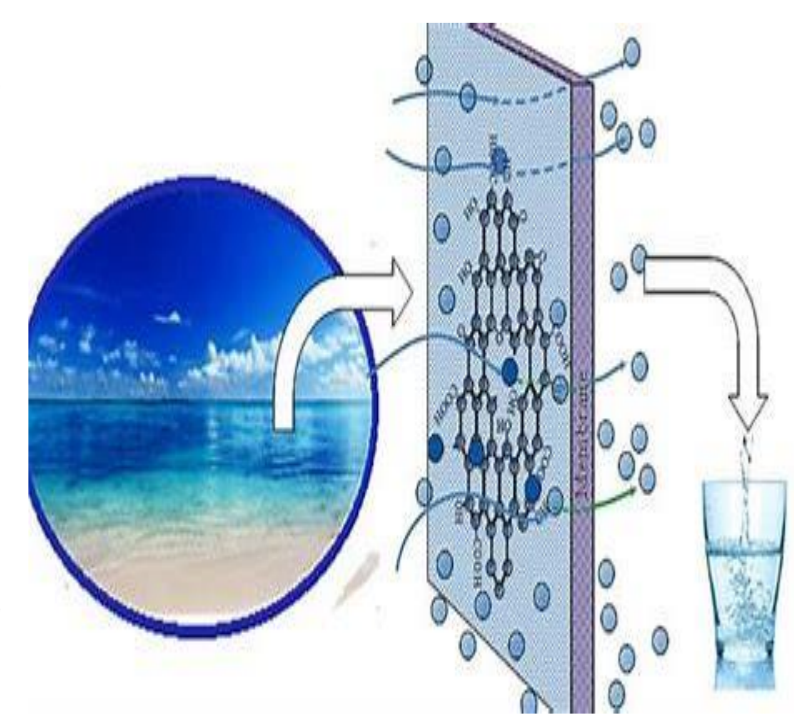
| Membrane type | Total polyphenols | | Total flavonoids | |
|---|---|---|---|---|
| | Geranium robertianum extract | Salvia officinalis extract | Geranium robertianum extract | Salvia officinalis extract |
| NF Koch membrane (MMCO 1,000 Da) | 70.4 | 70.1 | 77.3 | 80.4 |
| NF Organic-inorganic membrane (MMCO 1,000 Da) | 85.5 | 78.1 | 85.9 | 83.6 |

Also, the use of nanofiltration to concentrate phenolic compounds extracted from grape seeds showed good results, as the experimental value for procyanidin rejection was 96.36 ± 0.87%, and the antioxidant activity was increased arround 2.24 times *(Li.C et al.,2018).*

Nanofiltration showed high efficiency to concentrate the polyphenols and carotenoids (with retention coefficient around 100% and 97%, respectively by using (NF 90, Filmtec, Dow Chemical Company, São Paulo, SP, Brazil) membrane with a molecular weight cut-off around 200–300 Da, for the concentration of the aqueous extract of Pequi (Caryocar brasilense Camb.) *(Machado et al.,2013).*

## Membrane (MD) and Osmotic (OD) Distillation:

**(MD) and (OD)** are non-pressure driven membrane processes, capable of concentrating liquid foods and non-food aqueous solutions under ambient temperature and pressure, the driving force of separation is the difference in vapor pressure across the membrane resulting from either a temperature gradient (in MD) or water activity, i. e. osmotic pressure (in OD) (*Cassano et al.,2020)*



Concentrated camo camo (CC) with a ratio of high in vitamin C (52.01 ± 0.889 mg/g) at an increase of seven times higher was obtained using a reverse osmosis membrane (R25a, 500 Da, polyamide, and 5 bar area 3 $ft^2$), in addition, the concentration of phenolic compounds was increased by 3.2 times (25.798 mg GAE/g), and anthocyanins in 6.5 times (66.169 mg of cyanidin-3-glucoside/100 g) *(Rodrigues et al.,2020).*

Osmotic evaporation using polypropylene, hollow-fiber membrane presented the good potential for concentrating fruit juices and plant extracts where the final total soluble solids (TSS) contents achieved were 660, 570, and 610 g $kg^{-1}$ for grape juice, apple juice, and roselle extract, respectively. The physico-chemical, biochemical, and aromatic qualities of concentrates obtained by osmotic evaporation were much higher than those of thermal concentrates and close to those of the initial products *(Cissé et al.,2011).*

## Conclusion:

The different studies proved the efficiency and the ability of the membrane techniques to recover the bioactive components extracted from plants from their solvents. Most of the studies focused on studying and evaluating process variables more than focused on evaluating the quality of plant extracts and their content of active ingredients which will be the focus in our research

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