A review on pharmaceutical uses of sea buckthorn

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Abstract: -

Sea-buckthorn (Hippopha¨e rhamnoides L.) pulp oil (SBPO) is a highly valued source of bioactive components, such as fatty acids, phytosterols, tocopherols, carotenoids, and flavonoids. Its diverse properties have made it popular in the cosmetic, food, and medical industries. However, its potential is hindered by challenges like poor water solubility and chemical instability. To address these issues, colloidal vesicle systems are emerging as a vital solution for enhancing its effectiveness and application. The project focused on enhancing the health benefits of oil. To achieve this, we aimed to encapsulate sea-buckthorn oil within a bile salt-based system and evaluate its physicochemical properties. The process of nanobilosomal encapsulation was performed using varying concentrations of the oil, employing thin lipid film hydration followed by ultrasonic homogenization techniques.

Keywords:

Sea-buckthorn pulp, oil, fatty acids, bilisomes, cosmetic.

1. Introduction:

Sea buckthorn (SB) (Hippophae rhamnoides.L) is a thorny, soil-dwelling, deciduous shrub, or small tree (Wang et al., 2014, Fu et al., 2014). It occurs naturally in Northern and Central Europe, Caucasus Regio and Asia Assyrian as well as Siberia, China, and Tibet. Owing to its status as a high valuable species, SB was extensively cultivated worldwide, including many European countries, Canada, Russia and China (Wang et al., 2014, Li et al., 2002, Bartish et al., 2002).

Fig. 1: - Plant of Sea buckthorn

Food safety is a major concern whether you are someone who purchases food or someone who produces it. Nanotechnology in foods can be used to address the problems in food production and quality in a straightforward manner. Liposome nanoparticles are increasingly attractive as a material for use in both the food and drug industries (Liu et al., 2022). One interesting use of nanotechnology is the nanoencapsulation of bioactive compounds. In different food processing methods, liposome nanoparticles have been used to improve the taste and nutrition of foods, and they have been studied for their ability to hold natural substances that can protect foods from going bad. (Gómez-Alonso et al., 2004, Kaur et al., 2011). Liposomal encapsulation is a potential approach to improve the stability and bioaccessibility of bioactives. One of the major benefits of liposomal encapsulation is the improvement of the stability and bioactivity of the encapsulated agent. The use of liposomal encapsulation system for protection from oxidative breakdown is a good example, as the polyphenols and carotenoids, which are readily oxidized, are effectively protected by the liposomes, ensuring the physiological activities of the compounds and a longer shelf life. Such a protection is essential for maintaining health promoting effects of these compounds during storage, processing and consumption. For instance, liposome-encapsulated resveratrol, a polyphenol found in grapes, has shown significantly improved stability and bioavailability compared to its free form (Gibis et al., 2016, da Silva Haas et al., 2019). A second important benefit is the enhanced bioavailability of the liposome-encapsulated compounds. It is defined by the capacity of being absorbed across the intestine and reaching (in the unmodified active form) the bloodstream, in order to exert its metabolic/physiological functions. The high bioavailability of various polyphenols and carotenoids is limited by low water solubility and/or fast metabolism in the gastroin testinal track (Xu et al., 2023).

2. Method for obtaining the sb oil:

SB oil can be obtained when carrying out chemical cold pressing of the seeds containing up to 12.5 wt % oil. The oil is extracted (or cold pressed) from the fruit pulp, which comprises 8–12 wt % of oil. The collected fractions are filtered. All this process can be observed on fig.2.

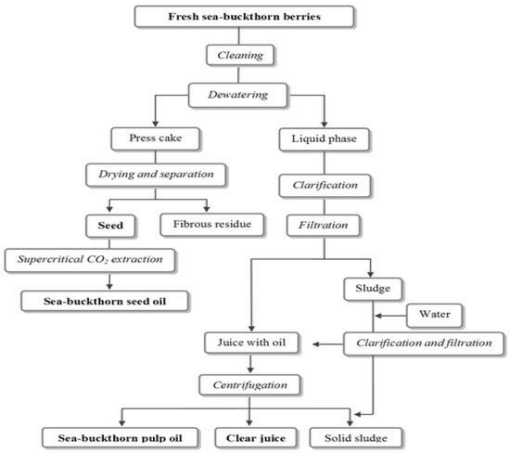

Fig. 2: - Barriers of fresh sea-buckthorn

The two oils are known to comprise considerable amounts of important unsaturated fatty acids (UFAs) such as palmitoleic acid (C16:1), which is precious for cosmetology. Amongst all vegetable oils, SB fruit oil contains the highest level of palmitoleic acid (ω-7) at 30–35 wt%, but lower than SB seed oil (Zielińska et al., 2017). Both oils are rich in tocopherols, tocotrienols, and plant sterols. Contrary to seed oil, pulp oil is rich in carotenoids (Arif et al., 2010) suggested that solvent extraction is not suitable for SB oil extraction because harmful solvent residues can be left behind in the extracted oil, which contributes to environmental pollution. Approximately 100-200 constituents have been reported in the entire plant. Therefore, Hippophae rhamnoides has been used as food and medicine for a long time (Li et al., 2002).

Compared different extraction methods in terms of how they affect the quality of SB oil by measuring the amount of fatty acids, tocopherols, carotenoids, and sterols. Petroleum-ether extraction consistently recovered oils with higher amounts of all analyzed nutritional components (Cenkowski et al., 2006).That solvent extraction is not suitable for SB oil extraction because harmful solvent residues can be left behind in the extracted oil, which contributes to environmental pollution (Kallio et al., 2002).

There are approximately 14 vitamins that have been found in sea buckthorn berry, such as vitamin A, C, D, E, F, K, P, and B complex vitamins (B1, B2, B6) (Chen et al., 2014, Yang et al., 2001). Vitamin C occurs in extremely high concentrations (up to 900 mg%). Compared with citric fruits, sea buckthorn berries contain approximately a 14-fold greater concentration of vitamin C compared with oranges (Kallio et al., 2014, Górnaś et al., 2014, Kallio et al., 2002). The concentration of vitamin C depends on the cultivar of the plant and the region where it is cultivated. Sea buckthorn from the coastal regions of Europe would have 120–315 mg% of vitamin C in fresh fruits and that from the Alps may reach up to 405–1100 mg% (Kallio et al., 2002, Yang & Kallio et al., 2002, Seglina et al., 2006, Rösch et al., 2003).

2.1. Unsaturated fatty acids:

UFAs, which are colorless liquids with double bonds, are predominantly cis configured (Gibis et al., 2016). It was concluded that UFAs favor the skin structure, appearance and tonus through a synergy of

actions, among these, the improvement on the cutaneous microcirculation that carries the necessary food and oxygen to the epidermis and the definitively removal of toxins excess. UFAs act after stimulation in the deep layers of the skin and are transformed into PGE 1 (Geetha et al., 2002).

The GLA (γ-linolenic acid) content is ensuring the transportation of nutrients, as well as is the material building intracellular cement and skin cell membranes phospholipids (Zielińska et al., 2017, Yang & Kallio et al., 2002). A deficiency of GLA can lead to dry and hard skin and the skin could be more prone to damage. It was concluded that the penetration of GLA from SB oil into the skin blocked skin allergies, inflammations, infection, and skin ageing (Geetha et al., 2002, Yang & Kallio et al., 2011). SB oil has been used as a source of GLA, even in the oral treatment of atopic dermatitis (Yang et al., 1999).

2.2. Saturated fatty acids:

The majority of saturated fatty acids (SFAs) have linear hydrocarbon chains with an even number of carbon atoms (typically 12–22 C-atoms) (Rustan et al., 2005). The most important role for SFAs in skin metabolism is to ensure proper turgor, firmness, smoothness, and softness of the skin. They support the skin's barrier function in a protective way by means of occlusion and in consequence block transepidermal water loss (Proksch et al., 2008).

SFAs present in SB oil are basically nourishing ingredients but may also serve for the stabilization of SB oil, as they prolong its resistance to oxidation (Cenkowski et al., 2006).

2.3. Complex lipids:

Complex lipids found in SB oil are phospholipids, glycolipids, and sterols (Zielińska et al., 2017).

3.3.1. Phospholipids and Glycolipids.

Phospholipids Acting as fatty acid esters of glycerol or sphingosine the base, they have along with one or more attached fatty acid a phosphate and alcohol which is linked to it. The fatty acid portion of the molecule is hydrophobic and the remainder hydrophilic (Krejcarová et al., 2015). It has been recorded that these lipids have a hydrating and skin-softening effect and can enhance skin elasticity, decrease inflammation and stimulate cuticle regeneration and cell proliferation (Edraki et al., 2014).

2.4. Sterols:

Sterols are solid alcohols from the steroid group (Yang et al., 2001). They reinforce the cutaneous lipid barrier, shield the skin against external noxious agents, help to reduce water loss, and enhance skin elasticity and firmness. The sterols of SB oil can come from the seed (0.1–0.2%) or the pericarp (0.02–0.04%) (Yang & Kallio et al., 2002). Its main sterol compound is beta-sitosterol which accounts for 57–83 wt % of total sterols and 576.9 mg/100 g oil (Yang et al., 2001). Sitosterol content in the seeds was 60–70% in SB oil, whereas in the fruit pericarp SB oil contained 80% sitosterol. Isofructosterol accounts for 10–20% of SB seed oil and for 2–5% of SB pericarp fruit oil. Campesterol, stigmasterol,

citrostadienol, avenasterol, cycloartenol and obtusifoliol have also been found in the seed oil (Yang & Kallio et al., 2002, Li et al., 2007).

2.5. Development of Sea-Buckthorn Pulp Oil-Loaded bilosomes:

The process of synthesizing bilosomes loaded with sea-buckthorn pulp oil (SBPO) utilized the established thin-film hydration method. To begin, L-α-phosphatidylcholine (EggPC), cholesterol (Chol), and Pluronic P123 (PP123) were combined in a molar ratio of 13:8:1. SBPO was incorporated at concentrations between 0.1 and 0.5 mg/mL and dissolved in 1 mL of chloroform. This resulting solution was placed into a 10 mL round-bottom flask. The organic solvent was then evaporated under reduced pressure at 40 °C while rotating at 100 rpm using a rotary evaporator (Hei-VAP Value Digital, Heidolph Instruments, Schwabach, Germany) (Waglewska et al., 2020).

Once a dried lipid film was obtained, it was hydrated with 5 mL of distilled water containing sodium cholate (SC) at a concentration of 5 mg/mL. The mixture was magnetically stirred for about 2 hours, leading to the formation of multilamellar vesicles (MLVs). Subsequently, the bilosome suspension underwent probe sonication (Ultrasonic Homogeniser Sonopuls HD 2070.2, Bandelin, Berlin, Germany) for 5 minutes at an amplitude of 80% and at 0.5 cycles per second to produce uniformly sized unilamellar vesicles. For comparative purposes, empty vesicles were prepared using the same procedure. All samples were stored at 4 °C until further analysis. (Barba-Bon et al., 2020).

2.6. Physicochemical characterization of sbpo-loaded elastic vesicles hydrodynamic diameter, polydispersity index, and zeta potential measurements:

Zeta potential (ζ) of the fabricated nanocarriers was measured using a Zetasizer Nano ZS (Malvern Instruments,Worcestershire, UK). The measurements were made at 173° with respect to the detection angle in standardized square polystyrene cells. Dynamic light scattering (DLS) was employed to measure some basic parameters, such as hydrodynamic diameter (DH) and polydispersity index (PdI). Each parameter was calculated as an average of three consecutive instrument runs, ensuring at least 10 individual measurements were made for accuracy. The zeta potential was analyzed through electrophoretic light scattering (ELS) and was assessed according to the Smoluchowski model within an aqueous environment. Results were compiled as an average from three runs, featuring at least 20 measurements. All measurements were conducted at a consistent temperature of 25 °C, and the DTS (Nano) instrument software was employed for data analysis (Lombardo et al., 2015).

2.7. Identification of chemical vibrations of functional groups in the SBPO/bilosome complexes:

The ATR-FTIR spectra of the empty bilosome, pure sea buckthorn pulp oil (SBPO), and SBPO-loaded bilosomes were analyzed to assess the incorporation efficiency of nutrient oil within the bilosome structure. As illustrated in the spectra were recorded across the full range from 4000 to 400 cm−1.

In the spectrum of the empty bilosomes the notable bands at 2924 cm−1 and 2854 cm−1 indicate the antisymmetric and symmetric stretching vibrations of CH2 groups found in the alkyl chains derived

from EggPC and Chol. A weaker peak at 2962 cm−1 corresponds to the antisymmetric stretch of terminal CH3 groups. Additionally, a broad band centered at 3367 cm−1 reflects the OH.O stretching vibrations associated with hydrogen bonding between water molecules and the bilayer of the bilosomes. The band at 1740 cm−1 arises from the stretching vibrations of the ester carbonyl groups (Arias et al., 2020). The strongest band observed in the spectra of the blank bilosomal formulation, which is situated at 1101 cm−1, corresponds to the symmetric PO2− stretching vibrations. An additional band at 1240 cm−1 is attributed to the vibration of the EggPC phosphate group (antisymmetric PO2− stretching). The weak peak at 966 cm−1 signifies the antisymmetric stretching of N+-(CH3)3 in the phosphatidylcholine head groups. The bands identified in phosphatidylcholine-based nanosystems align with findings from other researchers (Chen & Tripp et al., 2008, Arias et al., 2020, Pawlikowska-Pawlega et al., 2013).

When comparing the FTIR spectra for empty bilosomes and pure sea buckthorn pulp oil there are noticeable similarities, likely owing to the rich fatty acid composition of the incorporated SBPO . However, four significant differences emerge. The pure oil exhibits sharper, more intense bands associated with antisymmetric C-H stretching (2921 cm−1), symmetric C-H stretching (2852 cm−1), and C–O stretching of fatty acids and esters (1743 cm−1), which are more distinct than those in the bilosomal formulation. Additionally, a sharp band at 721 cm−1, originating from the out-of-plane bending of C-H groups, is also present. These pronounced bands in the spectrum of pure SBPO are primarily attributed to the stretching vibrations of aliphatic and olefinic functional groups, consistent with previous studies (Socaciu et al., 2020).

Upon encapsulating the oil in bilosomes, significant alterations in the infrared absorption spectra were observed Notably, the peak representing the stretching band of OH groups at 3367 cm−1 exhibited a slight flattening after loading the bilosome with oil, likely due to the stretching of hydroxyl groups from phenolic compounds or organic acids, such as malic and quinic acids, found in SBPO (Jaśniewska et al., 2021). This change suggests the potential for breaking hydrogen bonds and forming new intermolecular hydrogen bonds between the phenolic OH groups of bioactive compounds (for instance, catechin, epigallocatechin, or quercetin) present in SBPO and the functional groups of phospholipids (phosphate and carboxyl groups) (Hasan et al., 2016).

2.8. In vitro antioxidant activity:

The in vitro evaluation of enrinched formulated antioxidant activity were performed by two specific procedures: gastric and intestinal phases. In the gastric phase, 10 g of the product was suspended in 100 mL of hydrochloric acid (HCl) at pH 1.8 ± 0.1, to which 15 mg pepsin had been added. For the intestinal stage, 10 g of the product was dissolved in 100 mL NaHCO3 solution (pH. 6.2).During the whole test, the temperature of the samples was held at 37.0 ± 0.1 °C and stirred continuously at 95 rpm for 120 min. Aliquots were taken at time 0, 60 and 120 min to determine the spectrophotometric antioxidant activity by DPPH assay. All aliquots were centrifuged at a speed of 6000 rpm for 10 min and followed by 1 mL of the filtrate to be tested. The analysis for antioxidant activity was based on a direct reaction

involving 3.9 mL of DPPH solution and 0.1 mL of the sample in question. Methanol served as the control. The reactions were allowed to proceed for 30 minutes in a dark environment before the absorbance was measured at 515 nm with the "SHIMADZU-UV-1800" spectrophotometer (Pavan et al., 2014).

2.9. External application of sea buckthorn benefits for human health:

In comparison to other vegetable oils, SB oil is considered to have a unique composition of carotenoids, fatty acids, and complex lipids (Zeb et al., 2004, Kim et al., 2014).

SB oil contains an uncommon palmitoleic acid (ω-7 acid) which is a part of skin lipids and promotes regeneration of the epidermis, and wound healing. That is, the oil is capable of stimulating physiological skin functions for reducing scars and regeneration of skin. The suggested mechanisms of action of SB oil are skin regeneration and collagen synthesis activation, that is why SB oil heals wounds, in fact cavities with necrotic tissue (Ito et al., 2014).

The underlying mechanisms have been related to levels of unsaturated ω-3 and ω-6 fatty acids, and of carotenoids or tocopherols that promote fibroblast proliferation, collagen biosynthesis, and expression of certain matrix metalloproteinases inciting tissue repair and angiogenesis . SB oil based formulations have been identified to accelerate the healing of wounds. Wound healing of SB oil was observed even at a concentration lesser than that of the liquid crystals . SB oil has been used in the treatment of different skin diseases (e.g., eczema, dermatoses, ulceration, psoriasis, and atopic dermatitis). Externally applied SB oil may also reduce bedsores, spots, acne, scars, discoloration, and allergic and inflammatory lesions of the skin (Yang et al., 1999, Yang et al., 2000).

2.1.1. SB oil in cosmetics:

SB oil is produced by different processes and is supposed to apply to mature skin (Cenkowski et al., 2006, Zielińska & Nowak et al., 2014). One means to extract the lipids for cosmetics is to squeeze the berries to obtain the oil which separates in to three layers. The top is a thick orange cream, middle is surfer (UFA and SFA combo) and the bottom is like juice. The two upper layers have been faced and used for producing skin care product (Yang & Kallio et al., 2002, Stobdan et al., 2013).

Both SFAs and UFAs in SB oil contribute to the enhancement of skin hydration. Ω fatty acids-oleic acid (ω-9), linoleic acid(ω-6), and α-linolenic acid (ω-3) acid decrease TEWL (Kim et al., 2014). Signalling by UFAs is included in the receptor driven pathways leading to the synthesis of skin barrier lipids and proteins -''precursors'' of the natural hydrating factor (Yang et al., 1999).

Studies have demonstrated that a single applications of natural emollient creams (SB oil and olive oil) at 40%), increases skin hydration in a statistically significant manner in relation to those of a similar synthetic emollient cream (isopropyl myristate) (Yen et al., 2008). All of these formulations do not affect the pH of the skin . The constituents of SB oil penetrate into the different layers of epidermis, which is attributed to the different fatty acids that enhance dermal transportation (Li et al., 2007). SB

oil, a strong antioxidant, could slow down the aging process through scavenging for free radicals. It is most frequently incorporated into the anti-aging, anti-wrinkle cosmetics products for its firming and tonifying effect on the aging skin (Zielińska & Nowak et al., 2014). proposed sea buckthorn fruit blend for skin aging control as it elicits antioxidant activity through a modulation of moisture level and matrix metalloproteinase expression, and an enhancement of superoxide dismutase (SOD) activity . SB oil provides relief to dry, irritated, rough, flaking and itchy skin (Bath-Hextall et al., 2012). Radio-induced skin impairment due to UV or X-rays exposure is also well healed by SB oil, as it has a high quantity of carotenoids and tocopherols . As such, it is even used as adjuvant therapy in skin changes due to chemical compounds (Zielińska & Nowak, 2014).

3. Conclusion:

Sea-buckthorn pulp oil (SBPO) is rich in diverse bioactive constituents such as essential fatty acids, carotenoids, tocopherols, sterols, and vitamins, which are responsible for its well-documented nutritional and dermatological benefits. However, the practical exploitation of SBPO remains limited due to its low solubility in aqueous media, high sensitivity to oxidative degradation, and poor bioavailability.

In this study, bilosomal nanoencapsulation was explored as an effective strategy to overcome these formulation challenges. SBPO was successfully loaded into bile salt–stabilized vesicular carriers prepared using the thin-film hydration technique followed by ultrasonic homogenization. Physicochemical characterization along with ATR-FTIR analysis confirmed efficient encapsulation and strong interactions between the oil constituents and the bilosomal lipid matrix, resulting in enhanced structural stability.

Moreover, in vitro digestion studies revealed that encapsulated SBPO exhibited superior antioxidant activity under simulated gastrointestinal conditions, demonstrating the protective effect of bilosomes on oxidation-sensitive bioactives. Overall, SBPO-loaded bilosomes show considerable promise as an advanced delivery system for cosmetic, nutraceutical, and pharmaceutical applications, offering improved stability, bioactivity, and functional performance of sea-buckthorn oil.

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