

# Sea buckthorn oils: Towards healthy mucous membranes

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## BUCKTHORN

Sea Buckthorn (genus *Hippophaë*) belongs to the family *Elaeagnaceae*. It is a hardy bush bearing delicious yellow-orange berries. Six species have been described, of which *Hippophaë rhamnoides* is the major one. Sea buckthorn is naturally distributed in the mountainous and coastal areas of many Asian and European countries. In different languages, the plant is known as Sea Buckthorn, Shaji, Sanddorn, Olivello Spinoso, Oblepicha, Tyrni, Espino de Mar, Havtorn ...

Since the ancient Tibetans started using sea buckthorn more than one thousand years ago, hundreds of Asian traditional recipes have been developed and carried on through generations, utilizing the nutritional and medicinal properties of the berry. Through the long history of application as food and medicinal ingredients, sea buckthorn berry is known to be effective in treating wounds, inflammation, mucous-membrane-related disorders and diseases such as cough, sputum, gastric and gynecological problems.

During the past few decades, inspired by the long traditional use and the increasing public recognition of the benefits of natural products, scientists have carried out extensive research on sea buckthorn. This has resulted in an improved understanding of the health effects and the chemical composition of the berry (1,2). It is known that the berry is rich in multiple lipophilic and hydrophilic bioactive compounds such as vitamin C and E, carotenoids, flavonoids, fatty acids, plant sterols, lignans, and minerals. Sea buckthorn berry and berry products, for instance juice and oils, have been shown to have a wide range of beneficial effects, of which promoting regeneration of skin and mucous membranes, improving immune functions, reducing oxidation, and strengthening cardiovascular health are highlighted (1,2).

## SEA BUCKTHORN OILS

Sea buckthorn berry is rich in oil both in seeds (seed oil) and in the fruit soft parts i.e. flesh and

peel (pulp oil). Seeds contain typically around 10% oil, whereas the oil content in the soft parts varies over a much wider range from 0.5 to 10% (f. w.), largely depending on origins and varieties.

Sea buckthorn seed oil and pulp oil differ considerably in fatty acid composition (Table I). While linoleic (18:2n-6) and  $\alpha$ -linolenic (18:3n-3) acids are the major fatty acids in the seed oil, the high level of palmitoleic acid (16:1n-7, up to 50%) differentiates sea buckthorn pulp oil from most other oils of plant origin.

Both the seed and pulp oils are rich in tocopherols, tocotrienols and plant sterols. In addition, the pulp oil contains especially high level of carotenoids (Table I).

## SEA BUCKTHORN OIL AND HEALTH OF MUCOUS MEMBRANES

Mucous membranes cover the digestive, respiratory, and urogenital tracts and the inner surface of eyes. Mucous membranes are important channels for interactions and substance exchanges between human body and the environment. They are often the major routes for pathogens and external toxins and allergens to enter the body. Health condition of mucous membranes plays an important role in the general well-being of the whole body.

Mucous membranes are constantly under the challenges of

Table I – Composition of oils from seed and soft parts of sea buckthorn berry (I)

	Fatty acids (weight%)						
	Palmitic 16:0	Palmitoleic 16:1n-7	Stearic 18:0	Oleic 18:1n-9	Vaccenic 18:1n-7	Linoleic 18:2n-6	$\alpha$ -Linolenic 18:3n-3
<b>Seed oil</b>	6-10	< 0.5	2-4	15-20	2-4	35-40	20-35
<b>Pulp oil</b>	15-40	15-50	1-2	10-20	5-10	5-15	5-10
	Carotenoids (mg/100 g)	Plant sterols (weight%)		Tocopherols and tocotrienols (mg/100 g)			
<b>Seed oil</b>	10-50	1-2		100-200			
<b>Pulp oil</b>	100-400	2-3		100-400			

Table II – Effects of sea buckthorn oils on mucous membranes (1)

EFFECT	STUDY	COMMENTS
<b>Gastric and duodenal mucosa</b> <ul style="list-style-type: none"> <li>Protect and strengthen mucosa</li> <li>Cure ulcers</li> <li>Reduces gastric secretion</li> </ul>	<ul style="list-style-type: none"> <li>Clinical trials</li> <li>Animal experiments</li> </ul>	<ul style="list-style-type: none"> <li>Clear effects</li> <li>More studies on biochemical mechanism needed</li> </ul>
<b>Urogenital mucosa</b> <ul style="list-style-type: none"> <li>Cure cervicitis</li> <li>Anti-inflammation</li> </ul>	<ul style="list-style-type: none"> <li>Clinical practice</li> <li>Case reports</li> </ul>	<ul style="list-style-type: none"> <li>Mostly case reports and clinical practice</li> </ul>
<b>Mouth mucosa</b> <ul style="list-style-type: none"> <li>Speed up recovery and reparation of stomatitis and esophagitis</li> <li>Improve symptoms of dry mouth</li> </ul>	<ul style="list-style-type: none"> <li>Clinical trials</li> <li>Animal experiments</li> </ul>	<ul style="list-style-type: none"> <li>Mostly case reports and clinical practice</li> </ul>
<b>Anti-inflammation</b> <ul style="list-style-type: none"> <li>Heal burns, wounds, scalds</li> <li>Promote tissue regeneration</li> <li>Anti-inflammatory and analgesic effects</li> </ul>	<ul style="list-style-type: none"> <li>Clinical trials</li> <li>Animal experiments</li> <li>Clinical practice</li> </ul>	<ul style="list-style-type: none"> <li>Results of studies support health claims from traditional use and clinical practice</li> </ul>
<b>Anti-oxidation</b> <ul style="list-style-type: none"> <li>Reduce peroxidation of cell membrane</li> <li>Maintain membrane structure and functions.</li> <li>More effective than pure vitamin E</li> </ul>	<ul style="list-style-type: none"> <li>Animal and <i>in vitro</i> studies</li> <li><i>In vivo</i> studies in man</li> </ul>	<ul style="list-style-type: none"> <li>Well designed experiments with promising results.</li> <li>Maybe a fundamental mechanism related to most beneficial effects</li> </ul>
<b>Improve immune function</b> <ul style="list-style-type: none"> <li>Improve specific and nonspecific immune functions</li> <li>Antagonise the effects of immune suppressants</li> </ul>	<ul style="list-style-type: none"> <li>Animal experiments</li> <li>Clinical studies</li> </ul>	<ul style="list-style-type: none"> <li>Well designed experiments, conclusions based on results of animal experiments and clinical study</li> </ul>
<b>Safety</b> <ul style="list-style-type: none"> <li>No side effects reported</li> </ul>	<ul style="list-style-type: none"> <li>Animal studies</li> <li>Clinical experience</li> </ul>	<ul style="list-style-type: none"> <li>Isolated from an edible berry</li> <li>Safe to use</li> </ul>

genetic deficiencies, diseases, stress, ageing, side effects of medical treatments and environmental factors such as air and water pollutes. As a result, people often suffer from troubled mucous membranes. Dryness, high sensitivity and inflammation of mucous membranes are commonly found even among those generally considered as healthy. Furthermore, medical solutions for problems of mucous membranes are rather limited and often unsuccessful.

Dietary management with food supplements and nutraceuticals providing nutritional supports are initiative measures to maintain the health of mucous membranes. Nutrients such as lipids and proteins are essential for the normal structure and function and regeneration of mucous membranes. Antioxidants protect membrane lipids from oxidation.

Sea buckthorn seed and pulp oils combine high levels of beneficial fatty acids, natural antioxidants and vitamins as well as plant sterols. Clinical studies and animal experiments have shown multiple beneficial effects of the oils on mucous membranes (Table II). Promoting tissue regeneration, improving immune function and reducing lipid peroxidation are clearly the fundamentals of these effects.

### Gastric Mucosa

In a clinical experiment involving thirty cases of peptic ulcer (3), the patients took orally twelve sea buckthorn oil capsules daily for one month. A curing rate of 76.6% and a total effective rate of 96.7% were reported. Sea buckthorn oil was also used as an adjuvant treatment of 116 peptic ulcer patients, 71 with duodenal ulcer and 45 with gastric ulcer. Oral application of sea buckthorn oil relieved pain and accelerated the repair process of gastric and duodenal epithelial tissue and mucosa (4).

Protective and curative effects of sea buckthorn seed and

pulp oils against gastric ulcer have been extensively investigated using animal models.

Intra-gastric seed oil protected rat gastric mucosa from reserpine-, water-immersion- and pylorus-ligation-induced ulcer (5-7). Seed oil speeded up the healing of acetic acid- and reserpine-induced ulcers (7,8). In these studies, sea buckthorn oil treatment decreased the ulcer index by 40-60%. Similar studies showed ulcer preventive and curative effects of oils from pulp/peel (7-9) and whole berries of sea buckthorn (7,10). Oil isolation technology may have an impact on the anti-ulcerative efficacy of sea buckthorn oils by influencing the oil compositions. Figure 1 presents anti-ulcerative effects of sea buckthorn seed oil and pulp oil extracted by supercritical CO<sub>2</sub> (7). The anti-ulcerative mechanism of sea buckthorn oils was related to promoting the regeneration of mucous membranes and the epithelialisation of ulcer areas (10). Sea buckthorn oil also inhibited gastric secretion (8)

and proteolytic activity within gastric mucosa (10).

Furthermore, increasing the hydrophobicity of the surface of mucosa and retarding gastric emptying was suggested to be among the mechanisms involved.

β-sitosterol and β-sitosterol-β-D-glucoside in sea buckthorn oils are important for the anti-ulcerative activity (11-13). The efficacy of the two compounds may differ depending on the cause of ulcer formation (14).

### Urogenital Mucosa

In topical application sea buckthorn oils and preparations containing sea buckthorn oil improve the health of mucous membranes of urogenital tract. Anti-inflammatory and analgesic effects of sea buckthorn oils have been reported.

In topical treatment of patients with cervicitis, sea buckthorn seed oil and a suppository Shayoushuan (containing 50% sea buckthorn seed oil and other herbal ingredients) were very effective (18,19). Wang (20) treated 30 patients suffering from partial erosion of the cervix with topically sprayed sea buckthorn seed oil, once a day. All the 30 cases were cured after three months of treatment.

Cervicitis and vaginal inflammation is often associated with decreased tissue levels of carotenoids and vitamin E, compounds enhancing differentiation and regeneration of epithelial cells (21,22). The positive effect of the sea buckthorn oil and Shayoushuan suppository was probably related to its high content of natural carotenoids and vitamin E.

### Mouth Mucosa

Sea buckthorn seed oil was topically used (3-4 times a day) to treat sixty children (4 months – 12 years old) with ulcerative stomatitis (23). All the sixty cases significantly improved after two days of treatment. Fifty-five cases were

cured after 3-5 days of treatment, and two severe cases were cured after 8 days of treatment. Topical application of sea buckthorn seed oil was effective in treating stomatitis of patients with leukemia (24).

Orally taken sea buckthorn seed oil, pulp oil and a mixture of seed and pulp oils improved esophagitis caused by irradiation therapy (25). Carotenoids and vitamin E in the oils were suggested to be responsible for the clear tissue-regenerative effects observed. A synergistic effect between other herbal components and sea buckthorn oil in experimental models of irradiation esophagitis in rats was highlighted by Li and colleagues (26).

Dry mouth (xerostomia) is a common clinical complaint affecting up to 40% of adults, mainly women and the elderly. Dry mouth, often a symptom of salivary gland dysfunction, provokes unpleasant oral symptoms such as burning mouth, difficulty in speaking, chewing and swallowing. Oral treatment with sea buckthorn oil (a mixture of pulp oil and seed oil) capsules (5 g oil per day) for four weeks effectively relieved the dry mouth symptoms and improved the general condition of mouth mucosa (27).

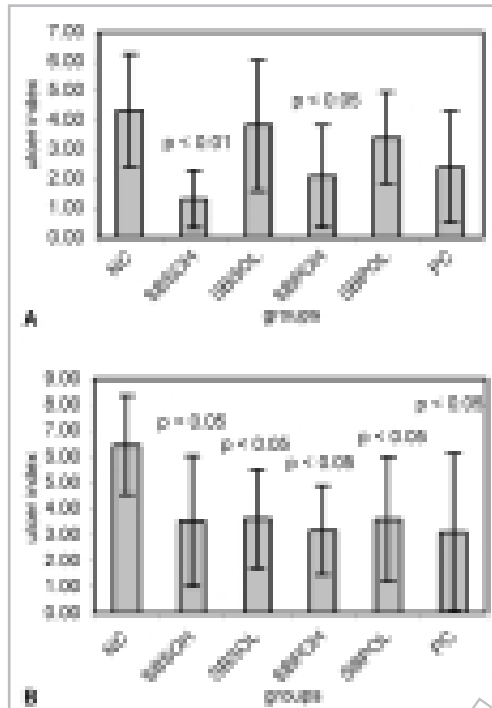
### Antioxidative Activity

The strong antioxidative activity of sea buckthorn oils is due to the high content of tocopherols and tocotrienols and carotenoids. All the natural isomers of vitamin E are present in sea buckthorn oils;  $\alpha$ -tocopherol is the major one in pulp oil and  $\gamma$ -tocopherol in seed oil. Lycopene,  $\alpha$ -,  $\beta$ -, and  $\gamma$ -carotenes are the main carotenoids in sea buckthorn oil. The natural isomers of vitamin E and carotenoids are more efficient antioxidants than single synthetic isomers. Working synergistically, vitamin E and carotenoids protect lipids and membrane structure from oxidation damage.

Malondialdehyde (MDA) is a product of lipid peroxidation. Interactions between MDA membrane components result in disturbed structure and function of cell membranes.

An increased level of MDA and a decreased level of tocopherols in plasma were found in patients with gastric ulcer compared with healthy subjects (15). Eating sea buckthorn oil for two weeks improved the ulcer symptom, decreased the MDA level and increased the level of tocopherols in plasma. Intra-gastric administration of sea buckthorn berry oil had preventive and curative effects against gastric ulcer in rats. The anti-ulcerative effects were clearly associated with a decreased MDA level and an increased level of  $\alpha$ -tocopherol in gastric mucosa (16,17).

In animal models, addition of sea buckthorn oils into feed inhibited lipid oxidation and damage of cellular structure induced by cold-exposure and chemicals. The effect was reflected as the suppression of MDA formation as well as the maintenance of normal cellular structure and activities of membrane-bound enzymes such as glutathione peroxidase, Na/K-ATPase, and superoxide dismutase (SOD) (1).



**Figure 1 – Anti-ulcerative effects of sea buckthorn seed and pulp oils (7)**  
**A**, protective effects against reserpine-induced gastric ulcer;  
**B**, curative effects on acetic acid-induced gastric ulcer. NC, negative control (4% Tween 80 solution, 7.0 ml/kg per day); SBSOH, sea buckthorn seed oil high dose (7.0 ml/kg per day); SBSOL, sea buckthorn seed oil low dose (3.5 ml/kg per day); SBPOH, sea buckthorn pulp oil high dose (7.0 ml/kg per day); SBPOL, sea buckthorn pulp oil low dose (3.5 ml/kg per day); PC, positive control (Cimetidine, 80 mg/kg per day). The treatment lasted for seven days, before the ulcer induction in the reserpine model, after the ulcer induction in the acetic acid model. P values shown in the figure indicate difference between treatments and negative control.

efficient harvesting machineries, berry picking and handling right after picking are still very laborious and limiting the availability of high quality berries for further processing.

Natural populations of sea buckthorn are classified into different subspecies. The major subspecies of commercial importance are *H. rhamnoides* subsp. *sinensis* (in China), subsp. *turkistanica* (in China and Russia), subsp. *mongolica* (in Russia and Mongolia), subsp. *rhamnoides* (in Western and Northern Europe), and subsp. *caucasica* (in Eastern Europe). These subspecies vary greatly in both content and composition of oil in seeds and berries (1). This partially explains the huge variations found in oils from different commercial sources.

Pretreatment of raw material including pressing, drying, separating and milling are important steps that should be under careful control to avoid oxidation, hydrolysis, and contamination.

### Oil Isolation Technology

Oil isolation technology has a significant impact on oil composition and quality. Different methods have been applied for isolating oil

### Immune Function

Sea buckthorn oils are known to regulate immune functions and antagonise the effects of immune suppressants (1). Feeding sea buckthorn oil to mice increased the phagocytivity of abdominal macrophages and spleen NK cell activity as well as SRBC (sheep red blood cell)-primed antibody production in normal and cyclophosphamide (an immune-suppressant)-treated mice. In clinical cancer treatment, per oral sea buckthorn oil has been used to reduce the immune-suppressive and hemotoxic effects of chemotherapy and irradiation therapy.

### INDUSTRIAL ASPECTS

#### Raw Materials

The global sea buckthorn resources add up to a total growth area of more than one million hectares, of which as much as 90% is in China. The rest is in Russia and other countries in Europe and Asia. It is estimated that the average annual yield is more than 30,000 tons of fresh berries. In many countries, planting and cultivation is highly encouraged as an ecological measure to fight against erosion and to improve the local economy. This will further increase the yield of sea buckthorn berries in the near future. However, due to the lack of

	Score 0	Score 100
Itching possible	not at all _____ X _____	worst
Burning possible	not at all _____	worst
Pain possible	not at all _____	worst
Disch. possible	not at all _____	worst

Figure 2 – Visual analogue scale (VAS)

from seeds, soft parts and whole berries of sea buckthorn.

Cold pressing has a clear disadvantage of low yield and is not suitable for processing of valuable raw materials like sea buckthorn. Solvent extraction with hexane is a relatively cheap and efficient method still used by most oil manufacturers. The solvent residue in the oils is increasingly limiting the use of these oils in value-added natural health products. Vegetable oils such as rapeseed oil and sunflower seed oil have been used to extract oil from sea buckthorn seeds. This ends with mixtures of different seed oils. Centrifugation is often used for isolating oil from sea buckthorn juice and pulp. The juice oils often possess good sensory properties such as pleasant colour and juice aroma. The composition of centrifuged juice oil often differs from other types of oils by lower content of unsaponifiables (vitamins, antioxidants and sterols) and higher content of water and water soluble fractions.

Supercritical fluid extraction (SFE) is a new technology for isolating oils and oil-soluble bioactive compounds and aromas. This technology utilises the special properties of supercritical fluid i.e. high density for a high solvating power and low viscosity for an efficient penetration through the raw materials. Carbon dioxide is most commonly used in SFE. The extraction process is carried out at low temperature, oxygen-free system. The oils and oil-soluble bioactive compounds are isolated in the natural forms free of thermal and oxidation damages and organic solvent residues. Sufficient yield and desired composition can be achieved by optimizing extraction parameters. SFE sea buckthorn seed and pulp oils are available in Europe and China. The prices of these oils are generally higher than oils isolated by conventional methods, due to the larger investment in extraction facility and higher production costs.

### Application of Sea Buckthorn Oils

Sea buckthorn oils can be used as either food supplements or food ingredients. Seed and pulp oils in small bottles or as gelatin and vegetable capsules are among the best sellers of natural products in some European countries such as Finland and Sweden. Several encapsulated products containing mixtures of sea buckthorn oil and other vegetable oils and fish oils are also available in some European markets.

Incorporating the oils into foodstuffs such as milk, yoghurt, cheese, butter, juice and snacks present new opportunities for food manufacturers.

### SEA BUCKTHORN BERRY OIL IN THE TREATMENT OF CHRONIC VAGINAL INFLAMMATION: A CASE STUDY

#### Background

Gynecologists, dermatologists, and general practitioners all recognize a female patient who presents with recalcitrant vulvar itching and/or burning, a tale of many physicians she has seen, and a long list of

Table III – Description of study subjects

No of subject	Age (yrs)	Duration of condition (yrs)	Diagnosis
1	65	7	Lichen ruber
2	58	3	Rheumatoid arthritis, Sjögren's syndrome
3	79	15	LSA
4	75	>20	Lichen ruber
5	35	10	Lichen ruber

medications she has used.

It is sometimes very difficult to make a differential or exact diagnosis of these conditions. Sometimes they are reflections of general skin diseases or systemic diseases. Into the first category belong e.g. lichen sclerosus and atrophicus (LSA), lichen ruber, lichen planus, psoriasis, erythema multiforme etc. Diseases as lupus erythematosus and Sjogren's syndrome are included into the second category. Furthermore,

many chronic infectious conditions as desquamative inflammatory vaginitis, and chronic viral, bacterial and parasitic inflammations may mimic the other above mentioned conditions.

Some common features of these conditions are itching, burning, reddening and increased vaginal discharge. Also pain at vulvar area, either vulvodynia or vulvar vestibulitis may be typical symptoms. Sometimes the conditions may lead to synechiae and strictures of the vagina. LSA appears as firm, flat pink-white, or translucent plaques which later coalesce, constricting the vulva and perineal areas in a crinkled white parchment-like skin. Atrophy of labia minora, phimosis of the clitoris, fissuring and traumatic ecchymoses often become prominent features.

Treatment options have been systemic and local estrogens, local testosterone, systemic and local corticosteroids, retinoids, and anti-inflammatory ointments, sometimes even surgery. Treatment has often been empirical and, in many cases, inefficient. Therefore there is a need to develop and investigate alternative possibilities to deal with these conditions.

### Designing a Study

Topical application sea buckthorn oils and preparations containing sea buckthorn oil have been shown to improve the health of mucous membranes of urogenital tract. Therefore we decided to design a trial by using orally administered sea buckthorn oils for the treatment of patient who had suffered from conditions described above, and had experienced a multitude of treatments. The patients took orally capsules of Omega 7 Sea Buckthorn Oil (extracted by supercritical CO<sub>2</sub>, kindly provided by Aromtech Ltd, Finland), a mixture of oils from seeds and berry soft parts, 3 capsules twice a day (3 g sea buckthorn oil per day) for 12 weeks. The committee of ethics accepted the study plan.

### Study Subjects

Five subjects recruited are described in Table III. The vaginal conditions of all the cases have shown resistance to the treatments given before. Four of the

five cases have been receiving high dose HRT and local corticoids earlier, but with poor results.

### Methods

Health history was taken before the treatment. Clinical investigation was performed, and plasma estrogen (estradiol) level was measured at 0, 6 and 12 weeks after initiating the treatment. Patients' subjective assessment of the condition was

Table IV – VAS scores and subjective assessment

No of the subject	Before treatment	At the end of the study	Subjective improvement
1	86	127	No
2	15	15	Slight
3	378	127	Great
4	240	103	Good
5	204	127	Good
<b>Average</b>	<b>185</b>	<b>100</b>	

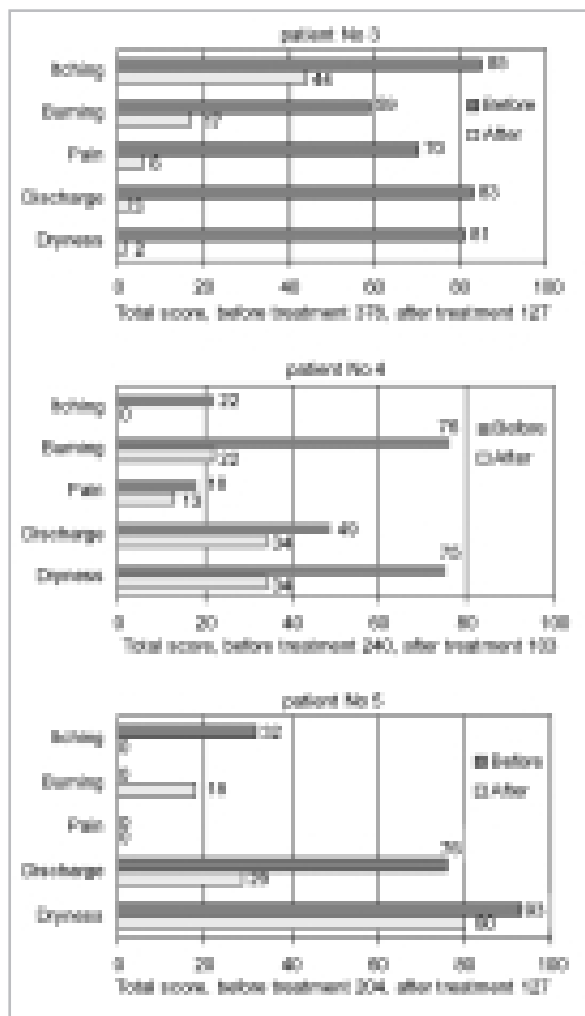


Figure 3 – Examples of individual assessment of VAS before and after the treatment

also asked by applying visual analogue scale (VAS) at the same time points, as shown in Figure 2.

## Results

All of them were able to continue through the trial. Table IV presents an overview of the total scores representing the sum of the scores of all the symptoms followed. Significant improvement was seen in three severe cases after sea buckthorn oil treatment. The best improvement was seen in patient No.2 representing as much as 66% decrease of the total VAS score. The average total score value was decreased by 46%, from 185 to 100 by sea buckthorn oil treatment. Estrogen levels at the end of trial were equal to the pretreatment measurements. None of the subjects reported any side effects.

Figure 3 gives examples of the VAS assessment before and at the end of trial.

## CONCLUSIONS

From this open 12-week trial we can summarize:

- Oral application of Omega 7 sea buckthorn oil capsules considerably improved chronic vaginal inflammation in three severe cases. But in the two less severe cases, the improvement was less obvious.
- The positive effect observed did not take place through increase of circulating estrogen level.
- Based on the results of the present study and the effects shown in studies documented in literature, oral

administration of sea buckthorn oil presents a promising alternative for treating chronic vaginal inflammation.

- Clinical trials with larger number of patients are justified to more accurately pinpoint the conditions which may benefit from treatment with sea buckthorn oils.

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