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The impact of oral sea-buckthorn oil on skin, blood markers, ocular, and vaginal health: A randomized control trial

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ABSTRACT

Sea buckthorn have been used for centuries as food and traditional medicine in Asia and Europe. This study evaluated the effects of a nutraceutical consisting of sea buckthorn oil as a functional supplement (Omegia™ sea buckthorn oil). Subjects were randomly divided into two groups and were given capsules containing or without sea buckthorn oil. Skin elasticity, color, collagen, pore, and redness were measured using skin assessment instruments. Blood samples were taken to assess serum antioxidant levels by using ELISA (enzyme-linked immunosorbent assay) kit. Additionally, a questionnaire survey was conducted to gather information on subjects' experiences in eye discomfort and vaginal dryness issues. After 12 weeks, skin parameters showed improvement, and participants reported relief from dry eyes and vulvar issues. This study highlights the potential of Omegia™ supplements demonstrating the ability to delay skin aging, increase high-density lipoprotein cholesterol, and antioxidant enzyme activity when used continuously for a period of 12 weeks.

1. Introduction

Sea Buckthorn, whose scientific name is *Hippophae rhamnoides*, is a species of flowering plant of the Elaeagnaceae family (Wang, Xu et al., 2022, Wang, Zhao et al., 2022). Native to the cold-temperature regions of Asia and Europe, it is also known as seaberry (USDA, 2022) sandthorn, and sallowthorn (USDA, 2023). The berries from sea buckthorn have been used for centuries as food and in traditional medicine and cosmetics in both Asia and Europe (Ma et al., 2022). The fruit, seed, and juice of sea buckthorn have been documented to include more than 190 bioactive nutrients. These include vitamins (A, B1, B2, B6, B9, B12, C, E, K), fatty acids (Omega 3, 6, 7, 9), polyphenols (proanthocyanidins, gallic acid, epicatechin, epigallocatechin), flavonoids (quercetin, isorhamnetin, kaempferol, myricetin), minerals (Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Zn), carotenoids (β-carotene, lycopene, zeaxanthin), terpenes, tannins, organic acids, amino acids, and carbohydrates (Ren et al., 2020).

Additionally, sea buckthorn is the only plant source of the wide range of fatty acids (Solà Marsiñach et al., 2019). Its oil has a rich profile of essential and unsaturated fatty acids, such as Omega 3 (alpha-linolenic acid), Omega 6 (linoleic acid), and Omega 7 (palmitoleic acid, vaccenic acid), and Omega 9 (oleic acid). In particular, its Omega 7 content exceeds that of any other plant (Solà Marsiñach et al., 2019). These fatty acids make sea buckthorn unique and cause it to have numerous health benefits, such as anti-obesity, anti-inflammatory, neuroprotective and great medicinal potential. (Wang, Xu et al., 2022, Wang, Zhao et al., 2022). Sea buckthorn oil is also rich in natural carotenoids, tocopherols, tocotrienols, and plant sterols. The carotenoid concentration in its fruit oil is approximately 0.3 %–0.5 % (Tereshchuk et al., 2022).

Lipids are crucial for maintaining the proper functioning and health of the skin. Free fatty acids, sterols, triglycerides, ceramides, squalene, and some polar lipids are essential elements of the stratum corneum, which forms the skin's barrier structure (Barresi et al., 2021). As the outermost layer of the skin, it protects the underlying tissues from

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transepidermal water loss, irritation, and infection. Phospholipids and sterols are crucial for signal transduction and substance transportation in cell membranes. Free fatty acids, generated by the breakdown of Omega fatty acids, are precursors of the formation of phospholipids, ceramides, and some local hormones that regulate the proliferation and inflammation of skin cells. Hence, an inadequate or unbalanced dietary intake of lipids results in skin dryness, scaling, and inflammation (Shamaprasad et al., 2022). Omega 3 and 6 have been demonstrated to suppress melanin production and reduce UV-induced hyperpigmentation (Choi et al., 2020). Omega 7 inhibits melanogenesis by inhibiting the expressions of tyrosinase, tyrosinase related-protein-2 (TRP-2), and microphthalmia-associated transcription factor (MITF) in human keratinocyte cells (Chou et al., 2020). Omega 7 also promotes collagen synthesis and suppresses inflammation by activating the SIRT1 (Sirtuin 1) pathway in human keratinocyte cells (Song et al., 2018). Omega 9 has been shown to increase the complete oxidation of fatty acids by activating SIRT1-PGC1α in skeletal muscle cells (Lim et al., 2013). The antioxidants in sea buckthorn oil also have a critical role in protecting the skin from aging. Oxidative damage is the primary cause of aging and the development of diseases. Environmental factors such as pollution, UV radiation, and temperature change, continuously put the skin under oxidative stress. Thus, dietary supplementation of antioxidants is critical to modern skin care. Sea buckthorn oil is rich in natural tocopherols (Yao et al., 2021).

Sea buckthorn oil reportedly promotes skin health owing to its nutrient-rich profile. It has also been shown to improve other aspects of health, such as cardiovascular and vaginal health. For example, palmitoleic acid (Omega 7) is reported that can significantly alter the fatty acid content serum by enhancing lipid metabolism in adipose tissue (Cruz et al., 2020). Sea buckthorn oil has been shown to prevent atherosclerosis by reducing triglycerides levels, cholesterol level, blood pressure, inflammation, oxidative stress, and insulin resistance in obese children (Virgolici et al., 2013). It has also been demonstrated to improve cardiovascular risk factors, dyslipidemia, and hypertension in patients with high blood pressure and a high cholesterol level (Vashishtha et al., 2017). While there have been studies on the effects of sea buckthorn oil on skin, eye, and vaginal dryness issues, this study aims to investigate whether oral consumption of sea buckthorn oil can simultaneously address skin and cholesterol levels concerns and alleviate discomfort associated with dry eyes and vaginal dryness.

2. Materials and methods

2.1. Study design

This clinical research was approved by the ethics committee of the Antai Medical Care Corporation Antai Tian-Sheng Memorial Hospital (IRB No. 21–072-B) and registered with clinicaltrials.gov (NCT05872178). In experimental trial settings, subjects are randomly assigned to different groups. In this process, each participant is assigned a unique random number, and they are then allocated to different groups or conditions based on these numbers. Forty healthy subjects were enrolled in this clinical study and randomly assigned to the experimental group (sea buckthorn oil soft capsules, Omegia^{TM} Softgel) or placebo control group, with 20 subjects in each group. Inclusion criteria for subjects were women over 45 years of age. The exclusion criteria were (i) involuntary subjects, (ii) skin disease, autoimmune skin diseases, vasculitis, liver cirrhosis or chronic renal failure, (iii) those with known cosmetic, drug or food allergies, (iv) pregnant women and nursing mothers, (v) those taking chronic disease medication, and (vi) subjects have received laser facial care, fruit acid facial exfoliation, long-term sun exposure, etc. within 4 weeks before the test. Double-blind method: the appearance, shape, and size of the packaging of the placebo and the experimental product are the same; the dosage form and taste of the placebo are similar to those of the experimental group; the daily dose and frequency of each group are the same. Subjects received skin condition checks at weeks 0, 4, and 12, blood tests at weeks 0 and 12, and questionnaires at week 12. One Omegia^{TM} softgel/ day (500 mg sea buckthorn oil in each softgel) or placebo was given to the subjects every day. Subjects are allowed to continue taking their own dietary supplements and have no restrictions on their diet during the study.

2.2. Preparation of Omegia™ sea buckthorn oil

A softgel of supercritical CO_2 extracted blend of sea buckthorn fruit and seed oils (Omegia^{TM}) was provided with 500 mg/dose. The composition of Omegia^{TM} sea buckthorn oil is shown in Table 1. Omegia^{TM} sea buckthorn oil contains fatty acids (Omega 3, Omega 6, Omega 7 and Omega 9) and vitamins (β-carotene and vitamin E). The specification/weight % and result/weight % of Omega 3, Omega 6, Omega 7, and Omega 9 are 13 %/13.2 %, 10 %/12.2 %, 30 %/30.9 % and 18 %/18.1 %, respectively. The specification/mg/100 g and result/mg/100 g of β-carotene and vitamin E are 100/141 and 450/593, respectively.

As shown in Table 2, the composition of Omegia Softgel-Experimental Group (Omegia^{TM} Softgel-B) includes Omegia^{TM} (sea buckthorn oil) (500–540 mg), along with gelatin (95–117 mg), glycerin (57–70 mg), and purified water (95–117 mg) as additional components. The Placebo Softgel-Control Group (Omegia^{TM} Softgel-A) substitutes sea buckthorn oil with palm oil (500–540 mg).

2.3. Skin efficacy assessment

Thirty minutes before every skin test, subjects were instructed to remove the makeup and clean their facial skin. Skin quality testing was performed at 0, 4 and 12 weeks. Then, skin brightness (Chroma Meter MM-500, Minolta, Japan), redness sensitivity index (Chroma Meter MM-500, Minolta, Japan), moisture (Corneometer C0M825, Courage + Khazaka Electronic, Germany) and elasticity (Callegari 1930, Italy), and collagen density content (DermaLab® Series SkinLab Combo, Cortex, Denmark) of each subject's upper cheek were measured. Additionally, skin surface topography including pores and textures on the whole face was analyzed by using VISIA® Complexion Analysis System (Canfield Scientific, Inc., Fairfield, NJ, USA). The VISIA® System ensured consistent positioning of each subject's head with a configurable head support. The photographic images were captured with standard light at 0-degree head positioning. The results were presented as the mean value and the relative percentage (%) to the baseline. The experimental procedure was following previously associated publications (Ho et al., 2022).

2.4. Blood index parameters

Fasting blood from each participant was collected at weeks 0 and 12 for subsequent analysis of their physiological parameters. Blood samples were centrifuged at 2000*g* for 15 min at 4 °C. Collect clear serum samples and store at −80 °C until testing. The values of serum biochemical parameters including catalase and TNF-α were monitored. Other parameters related to serum, including cholesterol, triglycerides, HDL-C,

Table 1
Composition of Omegia™ sea buckthorn oil.

NO.	Fatty Acids	Specification / weight %	Result / weight %
1	Omega 3	13	13.2
2	Omega 6	10	12.2
3	Omega 7	30	30.9
4	Omega 9	18	18.1
NO.	Vitamins	Specification / mg/100 g	Result / mg/100 g
1	β-carotene	100	141
2	Vitamin E	450	593

Table 2
Omegia and placebo softgel compositions.

Item	Omegia™ Softgel -A	Omegia™ Softgel-B
Appearance		
Ingredients	Omegia™ Softgel -A	Omegia™ Softgel-B
Palm Oil	500–540 mg	–
Omegia™ (Sea Buckthorn Oil)	–	500–540 mg
Gelatin	95–117 mg	
Glycerin	57–70 mg	
Purified Water	95–117 mg	

and LDL-C are also monitored. The measurement of Catalase and TNF-α in blood was based on the Enzyme linked immunosorbent assay (ELISA). The ELISA kits were obtained from Cloud-Clone Corp. (US). All experimental procedures were following the recommended protocols provided by the company. Cholesterol, triglyceride, HDL-C and LDL-C were analyzed using an automatic analyzer (Hitachi 7180).

2.5. Questionnaire

After 12 weeks of consumption by the subjects, the improvement of dry eye and vaginal problems was determined by questionnaire. For the questions, they can check the following options: very dissatisfied, dissatisfied, generally satisfied, and very satisfied. Statistical analysis was then conducted.

2.6. Statistical analysis

The experimental data analysis was first computed using the normal distribution and then assessed using the paired *t*-test. A significance level of $p < 0.05$ was considered statistically significant. Statistical significance is denoted as *, indicating $p < 0.05$ compared to week 0 for the group, and #, indicating $p < 0.05$ compared to the placebo at week 0.

3. Results

3.1. Omegia™ Softgel improved skin-aging

Evidence from clinical studies supports the claim that daily oral administration of a sea buckthorn oil supplement as an antioxidant improves skin health in healthy subjects. For an *in vivo* analysis, 40 females (mean age 52.5 years old) were randomly assigned to take soft sea buckthorn oil capsules or placebo soft capsules (one capsule (1 g) per subject per day for 12 weeks).

Consumption of sea buckthorn oil (Omegia™ Softgel, experimental group) for 4 weeks increased the average brightness, moisture and elasticity levels of the skin by 1.2 % ($p < 0.05$), 7.4 % and 1.2 %, respectively from the baseline values; after 8 weeks, the respective increases were 2.2 % ($p < 0.05$), 8.5 % and 2.7 % ($p < 0.05$) (Table 3). Consumption of sea buckthorn oil for 4 weeks reduced the mean redness sensitivity index of the skin of the subjects to 1.1 % lower than the baseline value and consumption for 8 weeks reduced it to 2.2 % lower ($p < 0.05$) (Table 3). Improvements in each of the skin parameters observed at week 4 continued until week 12.

At weeks 4 and 12, the mean levels of texture of the skin were 13.1 % and 14.1 % lower for the subjects in the sea buckthorn oil group than the baseline value, respectively (Table 4), revealing a statistically significant improvement. After 12 weeks of dietary supplementation with sea buckthorn oil, a significant improvement in skin texture relative to the placebo group was identified (-14.1 % vs. −4.1 %, # $p < 0.05$). The mean number level of skin pores in the sea buckthorn oil group at the end of the study was 14.6 % lower than the baseline value (Table 4).

Collagen is an essential structural protein in the extracellular matrix, thus skin integrity and collagen fiber content is related to skin aging. Collagen density may explain the observed improvement in skin pores and texture. Skin collagen density had increased by 3.3 % and 10.0 % after 4 and 12 weeks of sea buckthorn oil consumption ($p < 0.05$), respectively (Table 4). Whereas the placebo group showed some improvement, the sea buckthorn oil group showed greater improvement. The images are representative photographs of the skin pores (Fig. 1A), skin texture (Fig. 1B) and collagen of the skin (Fig. 1C) in subjects who had consumed sea buckthorn oil for 4 weeks and 12 weeks. The images clearly that the consumption of sea buckthorn oil greatly reduced the number of pores and texture of the skin, and significantly increased its thickness and collagen content (yellow-green highlights).

3.2. Omegia™ Softgel regulated Catalase, TNF-α and cholesterol

Increased oxidative stress that is caused by endogenous or exogenous stressors may promote the expression of TNF-α, inhibiting collagen synthesis. Blood was drawn from subjects who had taken soft sea buckthorn oil capsules for 12 weeks to analyze the inflammation in their bodies. Catalase and TNF-α are antioxidant enzymes and pro-inflammatory cytokines, respectively, and are associated with skin aging.

Table 5 shows 12 weeks of consumption of soft sea buckthorn oil capsules significantly increased the amount of catalase levels by 82.8 % (*, # $p < 0.05$) and reduced TNF-α levels by 23 % from their baseline values.

Table 3
Changes of skin brightness, redness sensitivity index, moisture and elasticity in Omegia™ Softgel (experimental) and placebo (control) groups.

Item	Time-Point (W)	Omegia™ Softgel (experimental group)			Placebo (control group)		
		Mean (SEM)	Improve rate %	*p*-Value	Mean (SEM)	Improve rate %	*p*-Value
Brightness	0	59.3 (0.8)	100.0		59.2 (1.1)	100.0	
	4	60.0 (0.9)	101.2	*	59.6 (1.1)	100.6	*
	12	60.6 (0.9)	102.1	*	59.8 (1.1)	100.9	*
Redness sensitivity index	0	8.9 (4.4)	100.0		9.2 (3.8)	100.0	
	4	8.8 (4.3)	98.9		9.2 (3.6)	99.8	
	12	8.7 (4.5)	97.5	*	9.2 (4.0)	99.9	
Moisture	0	36.5 (4.1)	100.0		35.4 (2.6)	100.0	
	4	39.2 (4.2)	107.3		35.4 (3.4)	100.0	
	12	39.6 (4.0)	108.4		35.7 (2.7)	100.8	
Elasticity	0	51.2 (1.6)	100.0		52.2 (1.1)	100.0	
	4	51.8 (1.5)	101.2		52.6 (1.1)	100.9	*
	12	52.6 (1.6)	102.6	*	52.9 (1.0)	101.4	*

* to indicate $p < 0.05$ compared to the baseline measurements (week 0) for the same group and # to indicate $p < 0.05$ compared to the placebo group at week 0.

Table 4
Changes in number of skin pores, skin texture and collagen content of skin in Omegia™ Softgel (experimental) and placebo (control) groups.

Item	Time-Point (W)	Omegia™ Softgel (experimental group)			Placebo (control group)		
		Mean (SEM)	Improve rate %	*p*-Value	Mean (SEM)	Improve rate %	*p*-Value
Pores	0	708.5 (10.2)	100.0		866.3 (10.3)	100.0	
	4	684.1 (10.6)	96.5		827.7 (9.0)	99.3	
	12	605.2 (11.2)	85.4	*	788.0 (10.3)	94.6	
Texture	0	360.5 (14.6)	100.0		616.7 (16.5)	100.0	
	4	313.4 (13.2)	86.9	#	604.5 (16.1)	98.0	
	12	309.8 (14.1)	85.9	*,#	591.2 (16.7)	95.9	*
Collagen content	0	65.7 (6.5)	100.0		73.5 (5.5)	100.0	
	4	67.9 (6.2)	103.3	*	75.2 (5.4)	102.3	*
	12	72.3 (6.0)	110.1	*	76.8 (5.2)	104.4	*

* to indicate $p < 0.05$ compared to the baseline measurements (week 0) for the same group and # to indicate $p < 0.05$ compared to the placebo group at week 0.

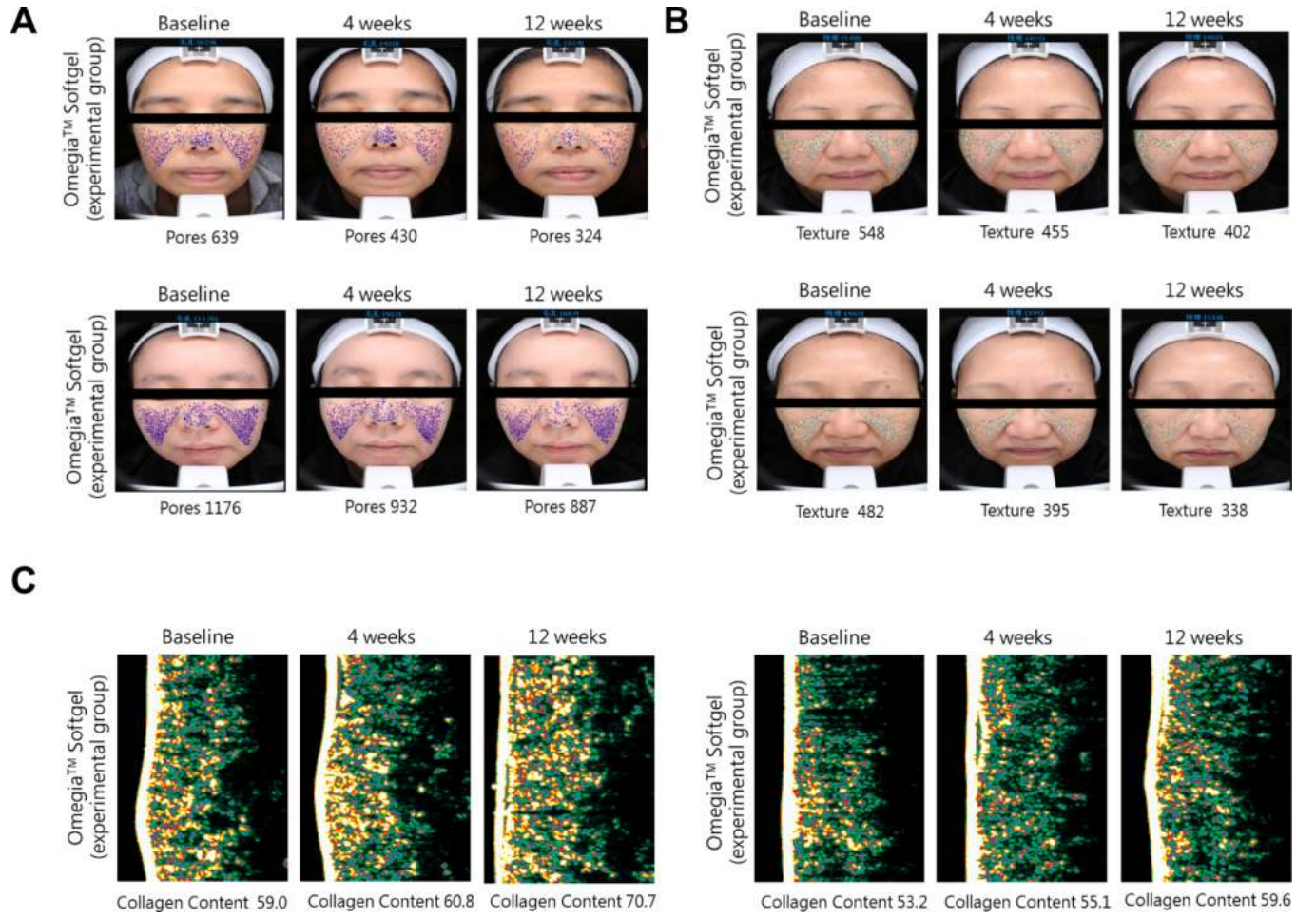


Fig. 1. Omegia™ Softgel (experimental group) improved number of pores in skin, skin texture and collagen content in skin. Having drunk collagen formula for 0, 4 and 12 weeks, (A) skin pores and (B) skin texture were determined by VISIA complexion analysis and (C) collagen density was determined using DermaLab Series SkinLab Combo.

Table 6 shows that taking sea buckthorn oil supplements for 12 weeks had a positive effect on lipid parameters, including a reduction in LDL-C level (-1.8 %), and an increase in HDL-C level (+14.8 %, $p < 0.05$). HDL-C is involved in removing excess cholesterol from the blood and transporting it to the liver for elimination. Elevated levels of HDL-C are generally considered to favor cardiovascular health. The results of this investigation suggest that sea buckthorn oil may have potential as a natural product for improving blood lipid levels and cardiovascular health.

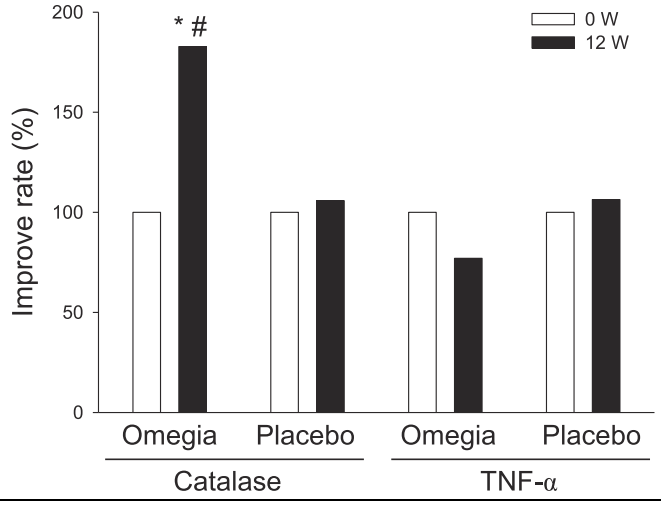
3.3. *Omegia™ Softgel reduce dryness of eyes and vaginal problems*

After 12 weeks of consumption of soft buckthorn oil capsules, reductions in the dryness of eyes and vaginal problems of the subjects were determined using a questionnaire that assessed satisfaction levels. The questionnaire included the options, "very dissatisfied," "dissatisfied," "generally satisfied," and "very satisfied." The results of the questionnaire were statistically analyzed to determine the effect of the sea buckthorn oil supplement on these issues. Besides, we also used a 1 to 5 rating scale to assess participants' level of agreement with eye and

Table 5
Changes in serum catalase and TNF-α levels in Omegia™ Softgel (experimental) and placebo (control) groups.

Item	Time-Point (W)	Omegia™ Softgel (experimental group)			Placebo (control group)		
		Mean (SEM)	Improve rate %	*p*-Value	Mean (SEM)	Improve rate %	*p*-Value
Catalase (ng/ml)	0	14918.3 (14.8)	100.0		18526.8 (8.6)	100.0	
	12	27264.2 (9.5)	182.8	*,#	19604.5 (12.3)	105.8	
TNF-α (pg/ml)	0	94.6 (22.5)	100.0		100.8 (37.1)	100.0	
	12	72.8 (23.6)	77.0		107.3 (27.6)	106.4	

* to indicate $p < 0.05$ compared to the baseline measurements (week 0) for the same group and # to indicate $p < 0.05$ compared to the placebo group at week 0.



vaginal problem statements before and after using the product. In this scale, a rating of 1 represents "no pain," while a rating of 5 represents " severe discomfort" to evaluate 9 eyes problems (dry eyes, itchy eyes, photophobia, blurred vision, epiphora, red eye, foreign body sensation, eye discharge, and pain) and 8 vaginal problems (itching, redness, dryness, vaginal discharge, odor, infection, pain, and dysuria) at 0 and 12 weeks.

The results showed that after 12 weeks of consumption of sea buckthorn oil, eye moisture retention, foreign body sensation, and eye congestion were improved, yielding "satisfied + very satisfied" results from 90 %, 55 %, 65 % and 65 % of respondents, respectively (Table 7). Compared to week 0, subjects in Omegia™ Softgel groups that perceived improvement significant among 7 eyes problems ($p < 0.05$), excluding epiphora and pain (Table 8). In the placebo group, only the dry eyes displayed improvement after 12 weeks. In the vaginal problems study, by week 12, all the means of vaginal problems displayed a decrease in the placebo or Omegia™ Softgel groups (Table 8).

Table 9 shows that after 12 weeks of consuming sea buckthorn oil, participants reported reduced vaginal redness, vaginal odor, vaginal itching, product somatosensory, and vaginal dryness. The percentage of participants who reported being "satisfied or very satisfied" with the reductions were 70 % for vaginal redness, 70 % for vaginal odor, 60 % for vaginal itching, 75 % for product somatosensory, and 65 % for vaginal dryness. Notably, 7 vaginal problems (itching, redness, dryness, vaginal discharge, odor, infection, pain and dysuria) exhibited significantly improvement after using Omegia™ Softgel groups for 12 weeks ($p < 0.05$) (Table 10). While the placebo group showed a significantly greater reduction in redness and vaginal discharge at 12 weeks compared to that at 0 week (Table 10). Both of the improvement of eyes and vagina problems did not reach significance between the placebo group and Omegia™ Softgel groups at 12 weeks.

4. Discussion

Sea buckthorn oil contains a wide range of fatty acids that contribute to numerous health benefits, including anti-obesity, anti-inflammatory, neuroprotective effects, and significant medicinal potential. This study highlights the potential of Omegia™ supplements in delaying skin aging, increasing high-density lipoprotein cholesterol, and enhancing antioxidant enzyme activity when used continuously for a period of 12 weeks.

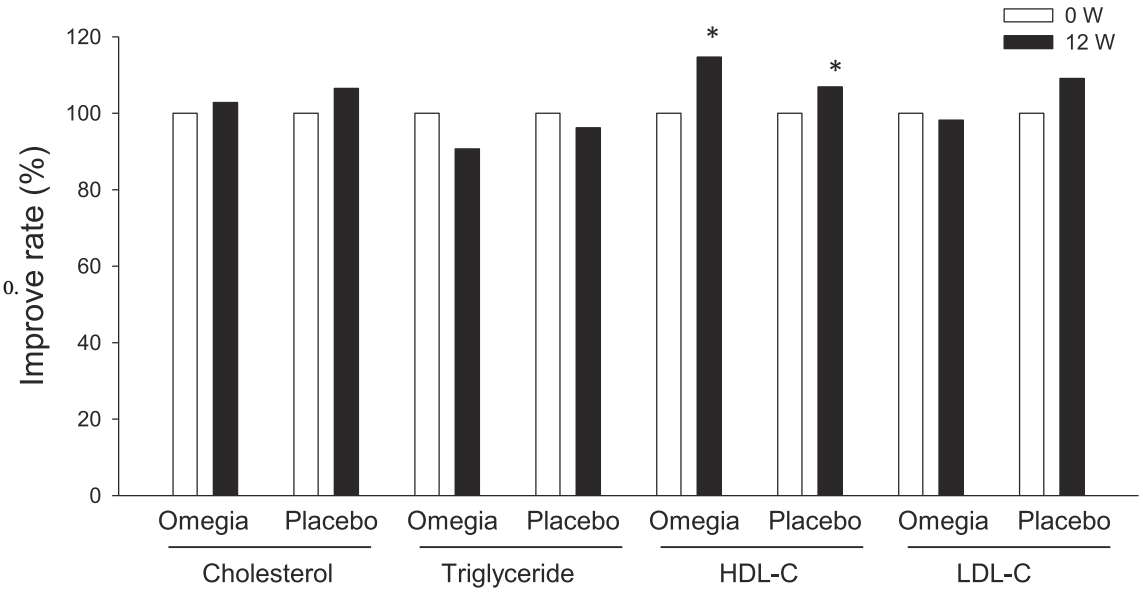
We observed that the participants in the Omegia™ Softgel group showed significant improvements in skin brightness, elasticity, texture, collagen, redness (sensitivity index) compared to the baseline values by the fourth week and the improvement in texture showed a significant difference compared to the placebo group. Collagen is a structural protein that is found in the skin, bones, and connective tissues of the body. It is responsible for maintaining the strength, elasticity, and integrity of these tissues. There are some studies showing that sea buckthorn oil may have a positive effect on collagen production in the body, and that the oil is able to stimulate collagen production in human skin cells in vitro (Lin et al., 2017). Oral dietary supplementation with sea buckthorn fruit and seed oil has been shown to improve skin hydration and elasticity and reduce wrinkles in healthy female participants. These results are attributed to the fatty acids and antioxidants in the oil (Zielińska and Nowak, 2017; Pundir et al., 2021).

Furthermore, we also found that dietary supplementation with Omegia™ may significantly increase levels of catalase (an antioxidant enzyme), reduce levels of TNF-α (an inflammatory marker), and elevate levels of HDL-C, a type of cholesterol that promotes heart health. Sea buckthorn fruit and seed oil alleviate symptoms of atopic dermatitis, such as skin redness, inflammation, and eczema. Sea buckthorn oil improves atopic dermatitis-like skin lesions via inhibition of NF-κB and STAT1 activation in NC/Nga mice (Cui et al., 2011). These improvements are positively correlated with the increase in unsaturated fatty acids levels in the plasma lipids of patients (Chen et al., 2022). The

Table 6
Changes in serum lipid parameters in Omegia™ Softgel (experimental) and placebo (control) groups.

Item	Time-Point (W)	Omegia™ Softgel (experimental group)			Placebo (control group)		
		Mean (SEM)	Improve rate %	*p*-Value	Mean (SEM)	Improve rate %	*p*-Value
Cholesterol	0	185.9 (3.7)	100.0		184.1 (4.1)	100.0	
(mg/dl)	12	191.1 (4.9)	102.8		196.0 (4.6)	106.5	
Triglyceride	0	159.0 (12.5)	100.0		138.8 (12.2)	100.0	
(mg/dl)	12	144.2 (12.4)	90.7		133.6 (15.2)	96.2	
HDL-C	0	54.7 (3.2)	100.0		57.2 (4.6)	100.0	
(mg/dl)	12	62.8 (2.2)	114.7	*	61.1 (4.3)	106.9	*
LDL-C	0	97.0 (4.8)	100.0		93.0 (7.0.3)	100.0	
(mg/dl)	12	95.3 (5.7)	98.2		101.5 (6.8)	109.1	

* to indicate $p < 0.05$ compared to the baseline measurements (week 0) for the same group and # to indicate $p < 0.05$ compared to the placebo group at week



efficacy of this supplementation may be attributed to its high content of Omega 7. In Omegia™ Softgel, Omega 7 is the most abundant component, accounting for 30.9 % of the formulation. Previously, many reports demonstrated that Omega-7 regulated oxidation and inflammation response via catalase, NF-κB, TNF-α and IL1-1β in H_2O_2-treated HaCaT cells (Song et al., 2018). Besides, it also can degrade MMP-1 protein and enhance elastin protein expression to maintain collagen levels (Weimann et al., 2018). Omega 7 inhibits inflammation and promotes

Table 7
Assess participants' satisfaction with the product's effectiveness in improving eye issues using a questionnaire survey, and calculate the percentage of different levels of satisfaction.

No.	topic	Very dissatisfied	dissatisfied	Ordinary	Satisfy	Very satisfied
1	Eyes moisturizing improvement	0 %	0 %	10 %	40 %	50 %
2	Foreign body sensation improvement	0 %	0 %	45 %	20 %	35 %
3	Bloodshot eyes improvement	0 %	0 %	35 %	25 %	40 %
4	Eye discharge improvement	0 %	0 %	35 %	40 %	25 %

Table 8
The mean values of the participants' agreement scores with eyes problem statements were calculated for both time points.

Score	PLACEBO			Omegia™ Softgel			*p*-Value
	0 WEEK Mean	12 WEEK Mean	*p*-Value	0 WEEK Mean	12 WEEK Mean	*p*-Value	
Dry eyes	2.25	2.30	0.330	2.75	2.20	0.000*	0.783
Itchy eyes	1.95	2.00	0.330	2.40	2.05	0.021*	0.870
Photophobia	1.85	2.00	0.083	2.25	2.15	0.042*	0.622
Blurred vision	2.15	2.35	0.042*	2.50	2.05	0.004*	0.358
Epiphora	1.85	2.00	0.083	2.55	2.05	0.056	0.862
Red eye	2.15	2.35	0.042*	2.60	2.30	0.000*	0.887
Foreign body sensation	2.25	2.35	0.163	2.05	1.90	0.021*	0.224
Eye discharge	2.10	2.25	0.083	1.90	1.80	0.010*	0.208
Pain	1.70	1.75	0.330	1.75	1.60	0.083	0.542

Table 9
Assess participants' satisfaction with the product's effectiveness in improving vaginal issues using a questionnaire survey, and calculate the percentage of different levels of satisfaction.

No.	topic	Very dissatisfied	dissatisfied	Ordinary	Satisfy	Very satisfied
1	Vulva redness improvement	0 %	0 %	30 %	30 %	40 %
2	Vaginal odor improvement	0 %	0 %	30 %	30 %	40 %
3	Vaginal itching improvement	0 %	0 %	40 %	10 %	50 %
4	Product somatosensory	0 %	0 %	25 %	25 %	50 %
5	Vaginal dryness improvement	0 %	0 %	35 %	35 %	30 %

Table 10
The mean values of the participants' agreement scores with vaginal problem statements were calculated for both time points.

Score	PLACEBO			Omegia™ Softgel			*p*-Value
	0 WEEK Mean	12 WEEK Mean	*p*-Value	0 WEEK Mean	12 WEEK Mean	*p*-Value	
Itching	1.90	1.75	0.083	2.45	1.85	0.000*	0.725
Redness	1.70	1.50	0.042*	2.15	1.60	0.002*	0.647
Dryness	1.60	1.55	0.330	2.10	1.70	0.008*	0.484
Vaginal discharge	2.00	1.80	0.042*	2.25	1.80	0.004*	1.000
Odor	1.75	1.70	0.330	2.50	2.05	0.004*	0.214
Infection	1.65	1.50	0.083	1.95	1.75	0.042*	0.241
Pain	1.75	1.60	0.083	1.85	1.70	0.083	0.673
Dysuria	1.55	1.50	0.330	1.85	1.55	0.010*	0.796

collagen synthesis through SIRT1 activation (Song et al., 2018). Omega 7 oil increases telomerase activity and anti-inflammatory effect and accelerates healing of grafted burn and donor site wounds (Weimann et al., 2018; Niimi et al., 2021). The new study revealed that analyzing sea buckthorn oil using different instruments yields varied results. For instance, GC–MS displayed the hydrolyzed content of omega fatty acids, while qNMR and FTIR indicated the content of triacylglycerols (TAGs) (Gore et al., 2023). When incorporating TAGs through dietary intake, it may assist in moisturizing, preventing dry skin, and reducing skin erythema and sensitivity. In vitro studies have shown that sea buckthorn oil can protect cell membranes from oxidative damage, promote tissue regeneration, reduce skin dryness, reduce inflammation, and inhibit lipid oxidation (Gęgotek et al., 2018; Dudau et al., 2021; Yao et al., 2021). Sea buckthorn oil had a beneficial effect on atopic dermatitis -like skin lesions, partially via inhibition of the helper (Th)2 cell-attracting chemokines thymus and activation-regulated chemokine (TARC) and macrophage-derived chemokine (MDC) in inflamed skin. Sea buckthorn oil inhibited IFN-γ/TNF-α-Induced NF-κB, JAK/STAT1, p38-MAPK activation in HaCaT cells (Hou et al., 2017).

Based on the questionnaire survey results, participants who consumed Omegia™ Softgel experienced improvements in dry eye syndrome, with reduced eye irritation, decreased eye redness, and less secretion. Furthermore, the serum test results revealed a significant increase in the activity of the antioxidant enzyme catalase after 12 weeks of Omegia™ Softgel supplementation compared to the baseline and placebo group. Additionally, the inflammatory marker TNF-α showed a decrease in the serum. These experimental findings suggest that Omegia™ Softgel may potentially protect the eyes by enhancing the activity of the antioxidant enzyme Catalase and suppressing the release of TNF-α. Sea buckthorn oil has been shown to stimulate the regeneration of the mucous membranes that cover the respiratory, digestive and genitourinary tracts, as well as the inner surfaces of the eyes (Smida et al., 2019). Sea buckthorn oil is also used as a natural remedy for eye problems, including dry eyes and age-related macular degeneration. Research has found that sea buckthorn oil is a natural source of antioxidants that may help protect the eyes from oxidative stress and inflammation. Sea buckthorn oil exerts protective effects against light-induced retinal degeneration by improving retinal oxidative stress (GSH-Px, CAT, T-AOC and MDA), inhibiting pro-inflammatory (IL-1β and IL-6) and angiogenic cytokines (VEGF), and inhibiting retinal cell apoptosis (Bax, Bcl2 and caspase-3) (Wang et al., 2016). After sea buckthorn oil treatment, it can suppress hyperglycemia, water intake, and reduce the level of sorbitol in the lens of the eyes (Dupak et al., 2022).

In our questionnaire feedback, most of subjects satisfy that Omegia™ Softgel can improve vaginal health and relieve vaginal dryness, redness, vaginal odor and itching. The references of sea buckthorn oil also support the results. Sea buckthorn oil reduced vaginal itching, burning, and leakage in patients with Sjogren's syndrome (Larmo et al., 2014). Oral administration of sea buckthorn oil has been shown to improve vaginal endometrial integrity, vaginal dryness, elasticity, and pH in postmenopausal women (Larmo et al., 2014). Vaginal gel containing sea buckthorn oil has been used in postmenopausal women to improve vaginal dryness, vaginal itching, burning sensation, dyspareunia, and vaginal pH (De Seta et al., 2021). Because of high in fatty acids in sea buckthorn oil, such as linolenic acid and palmitoleic acid, they may benefit cell barrier health and suppleness (Ciesarová et al., 2020). Several researches indicated that the atrophic vaginal epithelium improvement of sea buckthorn oil has been attributed to sitosterol, tocotrienols carotenoids and tocopherols. *Candida* infection is a serious concern in women's health, and an overgrowth of *Candida* can lead to severe itching, swelling, and sensitivity in the reproductive organs. Carrot extract containing carotenoids has been found to have inhibitory effects against *Candida* species such as *C. albicans*, *C. glabrata*, *C. parapsilosis*, and *C. tropicalis* (Askari et al., 2023). Research has inferred that sea buckthorn oil has estrogenic properties and may improve vaginal health and relieve vaginal dryness (Larmo et al., 2014).

In conclusion, the results of this study suggest that sea buckthorn oil supplements may have significant benefits for skin dermatological, ocular, and vaginal health. These effects could be due to the high Omega 7 content in Omegia™. However, more research must be conducted to confirm these findings and to determine the mechanisms that underlie the observed effects. Therefore, the study aims to investigate the daily health benefits of sea buckthorn oil, promoting people well-being and reducing the risk of diseases.

Ethical Statement

All authors assure that the manuscript "Sea Buckthorn Oil Improves Skin, Blood Index, Ocular Health, and Vaginal Health: A 12-Week Randomized, Double-Blind, Crossover, Placebo-Controlled Trial" is original work and cited resources correctly in the paper. The paper has

not been published before or being considered for publication elsewhere. All author finished the paper personally and their contributions also be credited.

Inclusion of identifiable human data EDIT

No potentially identifiable human images or data is presented in this study.

Studies involving animal subjects

No animal studies are presented in this manuscript.

Studies involving human subjects

The studies involving human participants were reviewed and approved by Kaohsiung Medical University Hospital. The patients/participants provided their written informed consent to participate in this study.

Consent for publication

All the authors of this manuscript have read it and consented for its publication.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author/s.

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CRediT authorship contribution statement

Leong-Perng Chan: Funding acquisition, Project administration, Investigation, Writing – original draft. **Tung-Wen Yen:** Investigation, Software. **Ya-Ping Tseng:** Visualization, Investigation, Conceptualization, Methodology, Formal analysis. **Tina Yuen:** Investigation, Data curation. **Michael Yuen:** Investigation, Software. **Hywel Yuen:** Investigation, Data curation. **Chia-Hua Liang:** Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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