

November 2013



In Brief

1

Encapsulated L10 is getting a new name! We are renaming Encapsulated L10 to EL25. This change will reduce confusion between the L10 products. More information will be sent out in the coming weeks.

2

We will be redesigning the Astareal.se website in the coming months. If you think there is anything you could benefit from on our new site, please get in contact and let us know.

3

An interesting read regarding the US market and companies that import illegal forms of astaxanthin and who have not filed a successful NDI notification - <http://www.naturalproductsinsider.com/news/2013/11/repurges-fda-to-stop-illegal-ndi-copycats.aspx>

Winter is well and truly around the corner! The days are rapidly becoming colder and darker and forecasts predict the first snowfall within the next week. Soon Gustavsbergs Hamn (harbor), located a short distance from AstaReal's HQ, will ice over and be covered with snow.

Those who are keen skiers eagerly await the winter months and hope for a long season with good conditions. AstaReal is a long-term supplier and supporter of the Swedish Ski Team (Svenska Skidförbundet). The Cross Country Team has been supplementing with Astaxin astaxanthin since 1995.

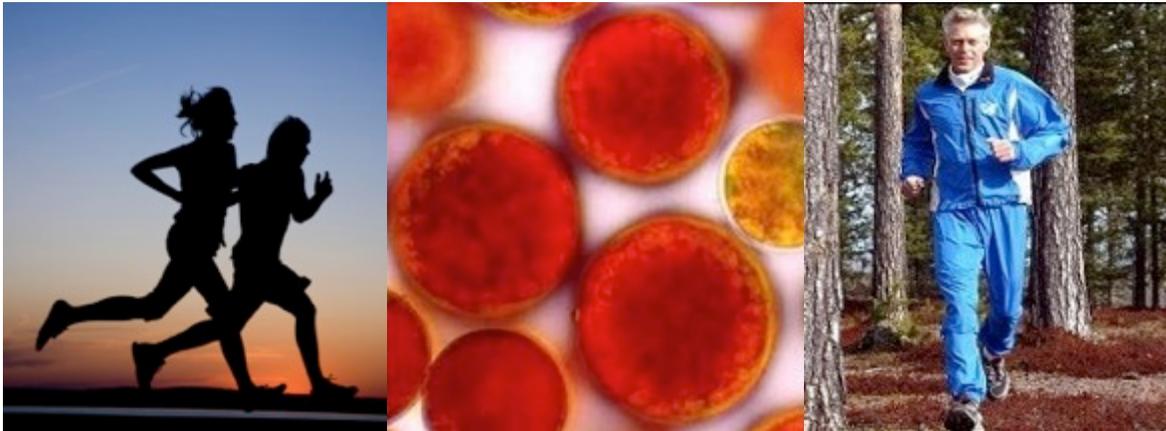
Winter sports demand endurance, and with the start of the ski season and the Winter Olympics fast approaching, we thought it would be a great time to take an in-depth look at the benefits astaxanthin has on muscle performance as well as muscle health.



AstaReal

Natural Astaxanthin

Boosts Muscle Performance



Summary

Oxidative stress is significantly implicated in the development of muscle pain, weakness and fatigue and occurs due to the disturbance of the balance between Reactive Oxygen Species (ROS) and antioxidant defences. AstaReal® contains a high concentration of the potent antioxidant astaxanthin from the alga *Haematococcus pluvialis*. Results from both human and model studies show that astaxanthin increases muscle endurance, lowers lactic acid and may also prevent muscle atrophy with aging. The effects of astaxanthin on muscle health are attributed by its ability to protect membranes from oxidation, thereby enhancing mitochondrial function, reducing inflammation and reducing muscle damage. Strong, healthy muscles play a vital role in achieving an active and healthy lifestyle which can be supported and improved through the use of AstaReal® astaxanthin.





Oxidative stress increases with age and physical activity

Oxidative stress occurs due to an imbalance between reactive free radicals and antioxidant defense and is exacerbated through physical activity. Sport and exercise generate more free radicals as a result of increased stressors on muscle fibers and with increased metabolism (1). Although endogenous antioxidants are increased directly after intensive exercise, protection against oxidative stress is not sufficient if left until the recovery stage (2). Furthermore, low levels of available antioxidants are hypothesized as a main factor driving muscle atrophy and a mechanism by which muscle mass wastage occurs during the aging process. Muscle atrophy leads to body weakness and can cause aging individuals to be more prone to falls and injuries as well as age-related illnesses made worse by inactivity (3).

“Up to 5 % of the total oxygen consumed by mitochondria will result in a free radical. Intense training leads to higher oxygen consumption and therefore can increase the generation of free radicals up to 100 times”

Negative effects of oxidative stress on muscles

Oxidative stress causes damage to proteins, lipids, DNA and alters the function of muscle cells, impacting muscle health and performance (1). Furthermore, it triggers inflammation by activating pro-inflammatory cytokines, leading to muscle pain, stiffness and increased chance of injury. Oxidative stress causes damage to mitochondria membranes, leading to a reduction in its capacity to generate energy. The mitochondria are referred to as the powerhouse of the cell, providing as much as 95 percent of our body's energy, primarily by the burning of carbohydrates and fats. As a consequence of reduced mitochondrial function, the muscles will be supplied with less energy, which can lead to muscle fatigue and muscle atrophy in aging (1,3).

Oxidation of the red blood cell membranes combined with decreased levels of mobility, can reduce the body's ability to transport oxygen to muscles. It has been demonstrated that physical activity increases oxidation in cell membranes (4, 5) and impaired mitochondrial function can also result in lowered aerobic capacity, and increased levels of lactic acid build up and consequent exhaustion. In addition, increased oxidative stress can alter muscular contraction and damage enzymes important for the function of aerobic and anaerobic pathways, resulting in declined muscle power as well as fatigue (1).



The antioxidant power of AstaReal®

Clinical studies have shown that AstaReal®, containing the potent antioxidant astaxanthin from the alga *Haematococcus pluvialis*, has benefits on muscle function and endurance. Astaxanthin, part of the carotenoid family, is found in marine species such as salmon and crustaceans. Astaxanthin is a fat-soluble antioxidant with a unique structure that enables it to span across the entire membrane and provide protection in a way that no other antioxidant can (Figure 1) (6). Nishida *et al* (7) found that astaxanthin had the greatest capacity to quench singlet oxygen as compared with several other antioxidants (Figure 2). In other *in vitro* systems, astaxanthin has shown antioxidant capacity up to 6,000 times stronger than Vitamin C, 500 times more efficient than vitamin E, 10 times stronger than β -carotene (8). Unlike many other antioxidants, astaxanthin has been classified as a pure antioxidant and does not show any pro-oxidative effects (9).

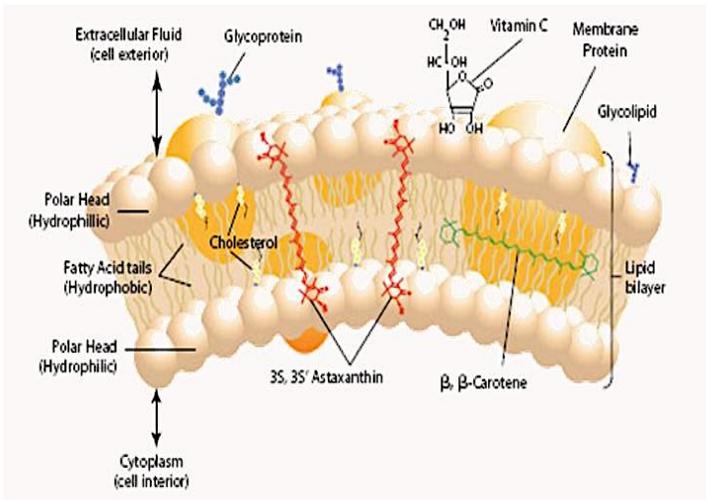


Figure 1. The molecular structure of astaxanthin in the cell membrane. Astaxanthin stays both in and outside the cell membrane as compared to β -carotene and Vitamin C, which can only be position inside or outside the lipid bilayer.

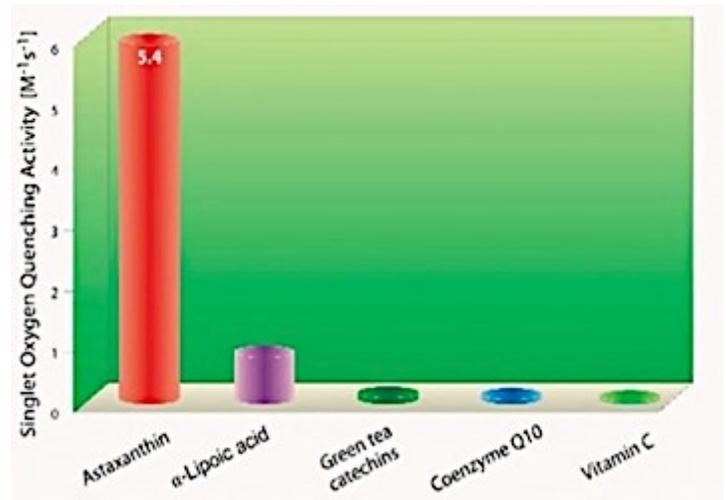


Figure 2. Capacity of different antioxidants to quench the free radical single oxygen (7).

AstaReal® enhances muscle endurance

A randomized, double blind study has shown that AstaReal® increases muscle endurance (10). In a study of 42 healthy men supplemented with 4 mg astaxanthin per day for 6 months undertaking standardized exercise tests, it was demonstrated that the average number of squats (knee bends) performed increased only in the astaxanthin treated group at three months, and after six months significant improvements were observed (Figure 3). In addition, Sawaki *et al*, demonstrated that AstaReal®, with a daily astaxanthin dose of 6 mg per day for 4 weeks, resulted in lower levels of lactic acid during a 1200 meter sprint (Figure 4)(11). The formation of lactic acid is a result of insufficient oxygen to muscles and leads to fatigue, as such decreased levels of lactic acid improves endurance.

In a study looking at the effects of astaxanthin on cycling time trial performance, Earnest *et al* tested 21 competitive cyclists following 28 days supplementation of 0 (placebo) or 4mg of astaxanthin per day. The testing was by no means easy on the subjects and consisted a 10 hour fast followed by a 2 hour constant intensity pre-exhaustion ride at 5% below VO_{2max} with lactic acid stimulation (12).

After 5 minutes of rest the participants then began a 20km time trial. The overall results showed significant improvements in the 20km time trail times, with the astaxanthin group reducing times on average by 121 seconds whilst the placebo group show no significant change. A significant increase in power output in the astaxanthin group was recorded, whilst the placebo group did not show any significant increase in power.

The effect of AstaReal® on muscle endurance is further supported by studies on mice. Ikeuchi *et al*, found that mice supplemented with astaxanthin for 5 weeks could swim for a significantly longer time before exhaustion compared to the placebo group and those supplemented with other antioxidants (Figure 5) (13). In the astaxanthin group, blood lactate concentration was significantly lower than in the control group.

Meanwhile, muscle and liver glycogen were higher for the astaxanthin group. These results were reinforced by another study by Aoi *et al*, which demonstrated comparable results (14). When comparing endurance (running), the total time taken to reach exhaustion for mice within the astaxanthin group was notably longer than those within the control group.

Furthermore, plasma lactate was significantly increased in the control group as a result of exercising, whilst astaxanthin was shown to inhibit the increase of plasma lactate levels. Additionally, astaxanthin increased muscle glycogen and increased fat utilization (Figure 6). Better fat utilization during exercise contributes to reduced levels of lactic acid, whilst also being beneficial to increased weight loss.

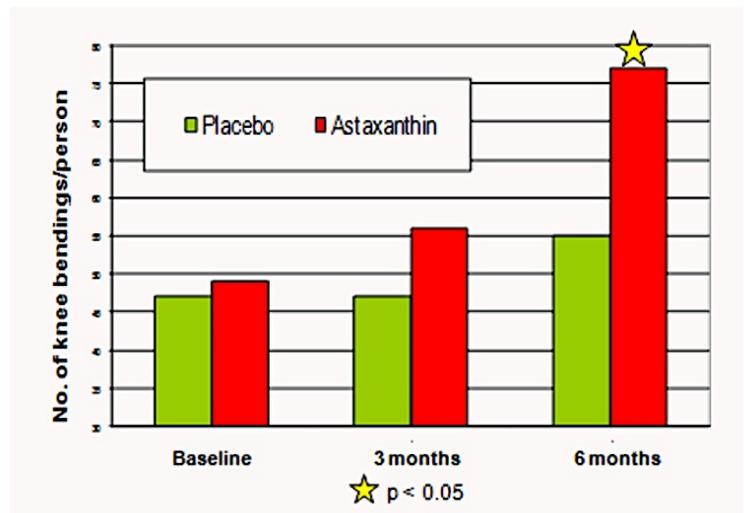


Figure 3. Number of knee bends in healthy young men receiving placebo or 4mg of astaxanthin per day (10).

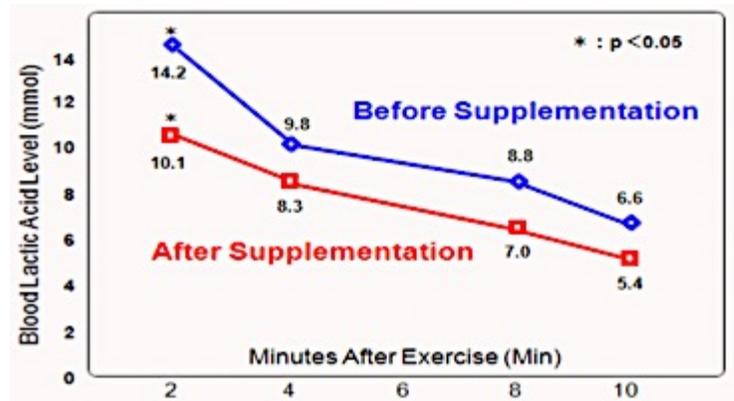


Figure 4. The amount of lactic acid after a 1200m run before and 4 weeks after 4mg/day of astaxanthin (11).

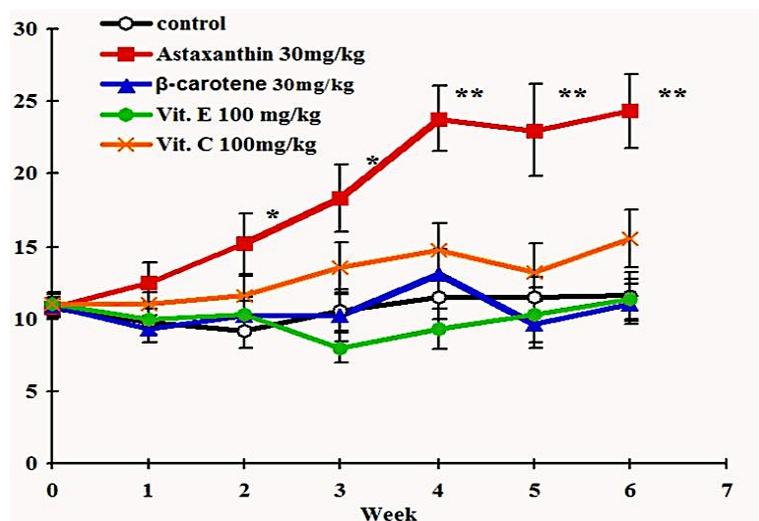


Figure 5. Effects of different antioxidants on swimming time (13).

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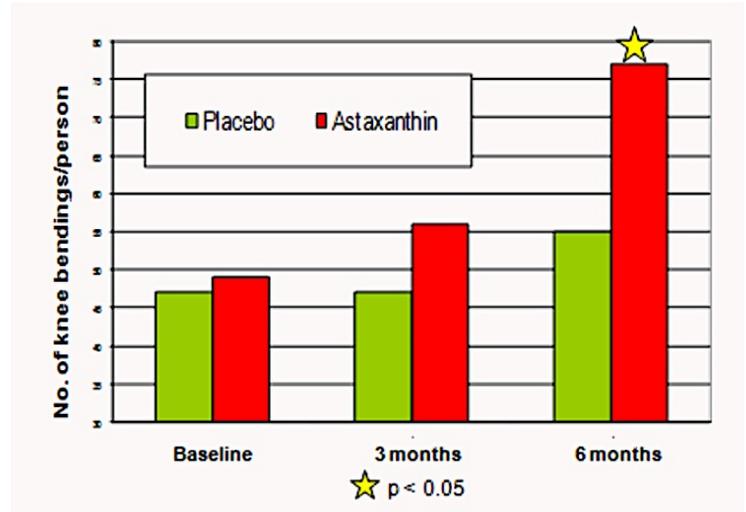


Figure 3. Number of knee bends in healthy young men receiving placebo or 4mg of astaxanthin per day (10).

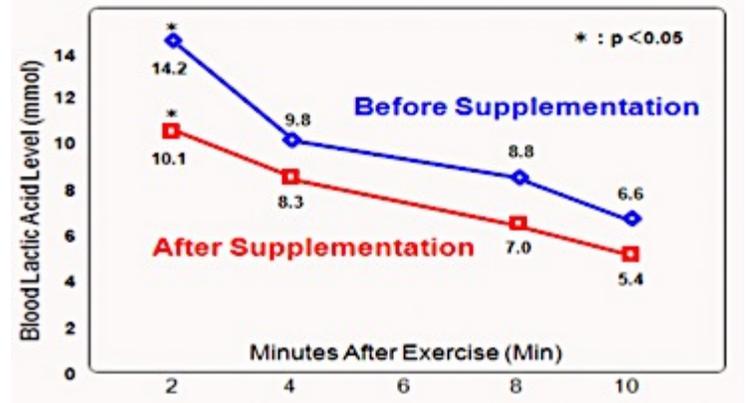


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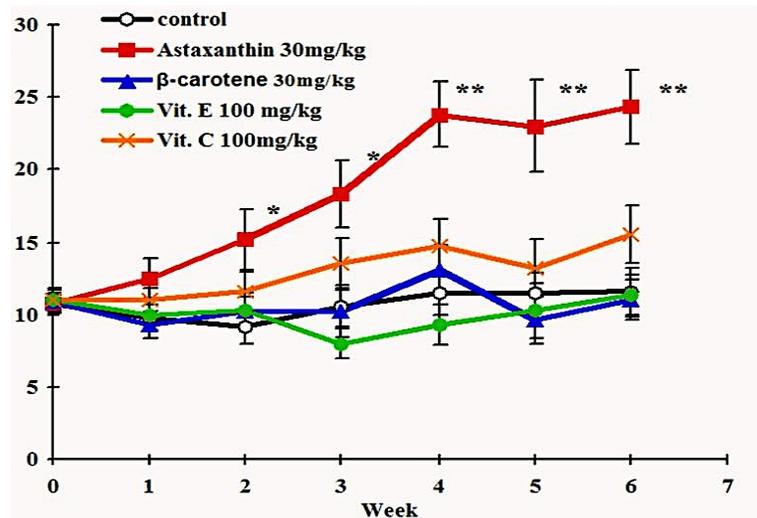


Figure 5. Effects of different antioxidants on swimming time (13).

AstaReal® increases fat utilization during exercise

A randomized, double blind study on humans has confirmed that AstaReal® increases fat utilization during exercise (15). In the study, 32 individuals were supplemented with 2 x 6 mg of astaxanthin per day, or placebo, for 6 weeks. The participants were instructed to undertake 40 minutes of continuous exercise three times per week during the six week period. After 6 weeks, the astaxanthin group had a significant reduction in body fat percentage, whereas there was no difference in the placebo group. These results indicate that astaxanthin increases muscle endurance and reduces lactic acid during intensive training by promoting the use of fat and over glycogen stores.

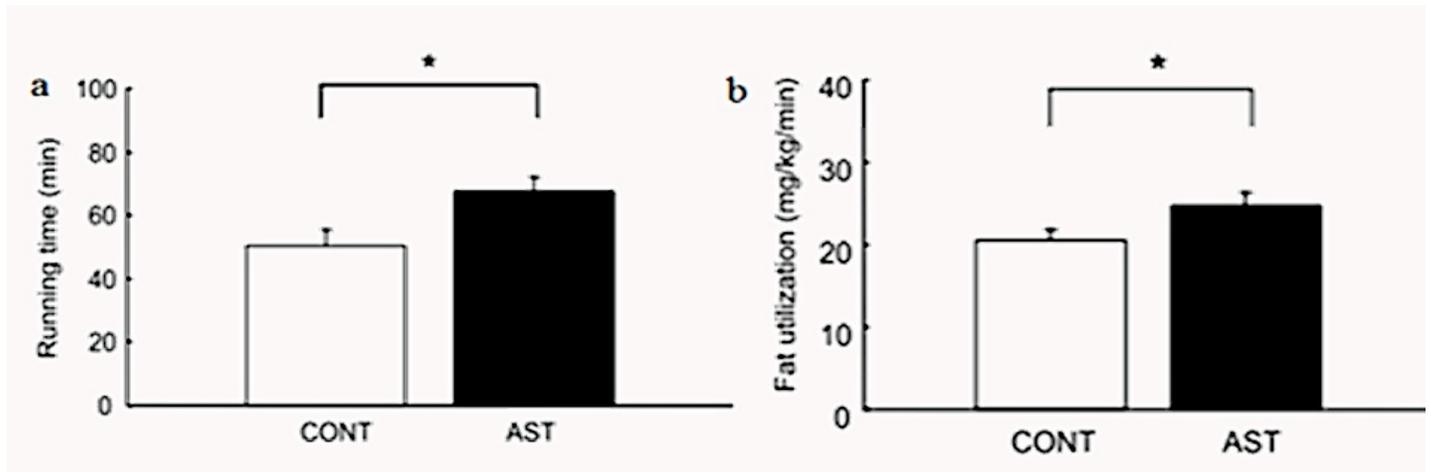


Figure 6. Effects of astaxanthin compared to placebo in mice on a) running time and b) fat utilization * $p < 0.05$ (13).

Improved quality of red blood cells and enhanced mitochondrial function

Respiration is one of the key ways a cell gains useful energy to fuel cellular activity. Aerobic respiration requires oxygen in order to generate ATP. Insufficient oxygen levels lead to anaerobic metabolism and subsequently results in increased muscle fatigue and lactic acid.

In a 2011 randomized, double blind study on humans, Nakagawa demonstrated that astaxanthin reduces oxidation of red blood cells suggesting that astaxanthin improves oxygen transportation to muscles (17). In the study, a total of thirty healthy subjects received 0 (placebo), 6 or 12 mg of astaxanthin per day during a 12 week period. In the supplemented subjects, both blood plasma and red blood cells showed increased concentrations of astaxanthin

Cell membrane oxidation of red blood cells was significantly reduced for both the 6 and 12mg astaxanthin groups compared to that of the placebo group (Figure 7). Furthermore, Wolf *et al* demonstrated that astaxanthin stimulates mitochondrial respiration by maintaining a higher membrane diffusion rate, as such allowing increased oxygen uptake (18) and improves energy availability to muscles. These results indicate that astaxanthin boosts aerobic power by increasing oxygen transportation to muscles and enhancing the capacity of mitochondria.

Reduced oxidation and inflammation in muscles

Not only does astaxanthin protect mitochondria and red blood cells from oxidation, it also protects muscle cells from damage. In a study on mice, it was found that exercise increased oxidation and inflammation in muscles, however supplementation with AstaReal® astaxanthin was shown to significantly lower muscle damage (19) (Figure 8). The anti-inflammatory effect of astaxanthin has further been demonstrated in by Park *et al* in a human study (20). In the randomized, double blind, placebo controlled study, 42 subjects were supplemented with 0 (placebo), 2 mg or 8 mg of astaxanthin for an 8 week period. The groups treated with astaxanthin had significantly reduced DNA damage as a result of oxidation and plasma C-reactive protein. C- reactive protein increases in blood indicating inflammation. According to these research results, astaxanthin may lower muscle pain, stiffness and fatigue by reducing inflammation and oxidation in muscles.

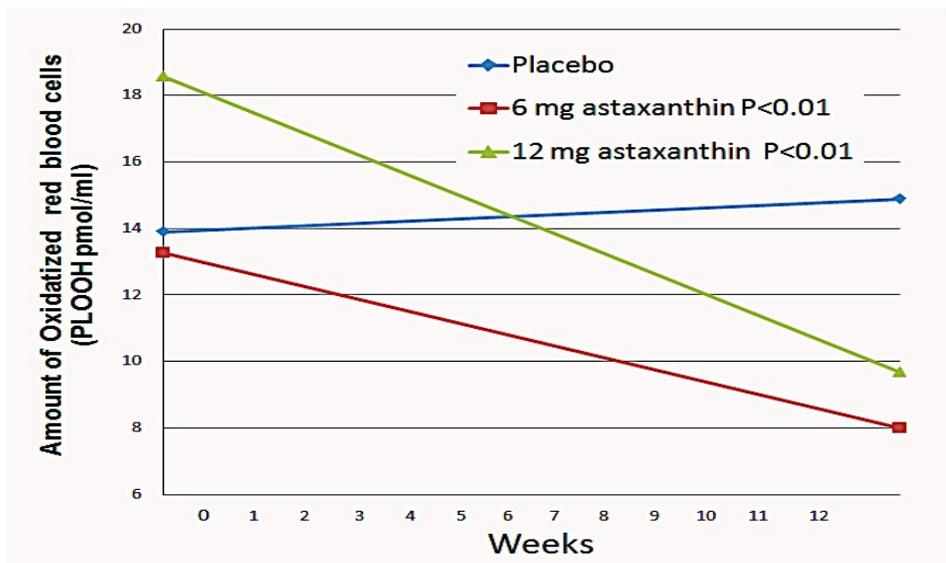


Figure 7. Changes in oxidation of red blood cells before and after 12 weeks of treatment. PLOOH = Phospholipid hydroperoxides in the red blood cells (16).

“Astaxanthin reduces inflammation in muscles by inhibiting free radicals in the cell membrane that otherwise trigger NF-kB. NF-kB is a transcription factor that activates pro-inflammatory cytokines which cause inflammation (21)”



Figure 8. Cross section picture on heart muscle and leg muscle. Exercise increased muscle damage and the cell membranes are destroyed, which is showed in black, meanwhile intake of astaxanthin reduced muscle damage (18).

Decreased risk for muscle atrophy

Due to astaxanthin's ability to protect muscle cells from damage, astaxanthin may assist in preventing muscle weakness in aging. In a study on mice, long-term dietary astaxanthin intake was found to prevent muscle atrophy by reducing oxidative stress and degenerative proteins (22). Forty-five week old mice were supplemented with astaxanthin or placebo during a one year period. After the treatment period, the soleus muscle weight was significantly higher for the astaxanthin group compared to placebo. The levels of degenerative proteins were also significantly lower compared to the placebo group. The results indicate that astaxanthin increases muscle mass by protecting muscle cells from damage. In addition, astaxanthin may prevent muscle atrophy by improving the function of mitochondria since dysfunction is described as a major factor (3,17).



Conclusion

There is a growing interest in the power of astaxanthin among researchers, and new findings about muscle health and endurance are constantly being published. So far, the research on astaxanthin shows impressive results for muscle health and endurance, due to its ability to protect cells and membranes from oxidative damage. The results indicate that AstaReal®, with natural astaxanthin, improves muscle endurance and lowers lactic acid by improving fat utilization, mitochondrial function and by reducing oxidation of red blood cells and muscle damage. In addition, studies demonstrate that astaxanthin decreases inflammation, which may reduce muscle pain and potentially prevent muscle atrophy. The effects of astaxanthin have wide appeal as we recognize more and more the importance of healthy and strong muscles in achieving an active lifestyle and a good quality of life.



AstaReal

Idrottsvägen 4

SE-134 40 Gustavsberg

Sweden

Phone +46 (0) 8 5701 395

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AstaReal® Natural Astaxanthin Products

The majority of all clinical studies on astaxanthin's effect on muscle endurance and performance are made using products produced by AstaReal (Sweden)AB. AstaReal is produced by cultivating the microalgae *Haematococcus pluvialis* indoors which enables the highest and purest form of natural astaxanthin available on the market.

AstaReal® is available in different forms to be used in nutraceuticals, animal feed and cosmetics.

AstaReal® A1010 – powder, homogenized and dried biomass containing 5% astaxanthin.

AstaReal® L10 – oleoresin, supercritical extract of the biomass containing 10 % astaxanthin.

Encapsulated AstaReal® EL25– water dispersible formulation with 2,5 % astaxanthin content.



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Idrottsvägen 4

SE-134 40 Gustavsberg

Sweden

Phone +46 (0) 8 5701 395