

## **Novel Forms of Creatine; Are They Superior to Monohydrate?**

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### INTRODUCTION

Creatine (methylguanidine-acetic acid) is one of the most extensively studied dietary supplements available today. It is a naturally occurring nitrogenous compound synthesized from the amino acids Glycine, Arginine, and Methionine and is present in relatively large quantities in most animal flesh such as fish and red meat. In humans, the majority (~95%) of creatine is stored as phosphocreatine within muscle tissue, while much lesser amounts are present in the brain, liver, kidneys, and testes [1]. In the laboratory, creatine is synthesized from the reaction of N-methylglycine (also known as Sarcosine) and cyanamide [2].

A French scientist, Michel-Eugene Chevreul, is credited as being the first to discover creatine in 1832 after extracting it from meat. Shortly thereafter, Juston von Liebig validated that creatine is a normal constituent of animal flesh and its respective content within muscle cells positively correlates with the physical activity demands of the animal from which it comes. For the remainder of the 1800's creatine research was limited, as extraction of the compound proved a costly procedure [1]. Nevertheless, these early studies laid the foundation for what was to come at the turn of the century.

Studies continued throughout the early 1900's with researchers discovering the existence of phosphocreatine, and creatine kinase as well as the fact that creatine supplementation in animals increased muscle creatine content [1]. In 1923, Chanutin provided the first review of the fate of ingested creatine in man, describing the actions of tissue retention and influences upon creatinine production [3].

There are anecdotal reports that creatine has been used by Eastern European athletes as early as the 1960s to increase exercise performance [1]. By the 1980's this speculated benefit became evident to researchers through anecdotal reports from subjects using creatine supplements to prevent gyrate

atrophy. In this trial, patients received creatine for one year to reduce atrophy of the choroid and retina in the eye. As the trial progressed, subjects reported the impression of increased strength during treatment, as well as one subject reporting decreasing his 100 m sprint time by 2 seconds (although these variables were not measured outcomes in the trial) [4]. It was not until 1992 that the first study directly assessing the potential ergogenic effects of creatine was performed. This study completed by Harris et al. proved that a "loading" phase (20 grams for 4-5 days) of supplemental creatine in humans can increase intramuscular creatine stores by up to 20% [5]. Soon thereafter, the supplement experienced an explosion of popularity and widespread use, likely due in large part to Olympic and professional athletes of the 90s citing their use of it in training such numerous gold medal winners from the '92 Olympics and professional baseball players [1]. This increase in popularity was met with an increase in research on the topic and today there are over 1000 peer reviewed scientific studies in regards to creatine supplementation. After over a century of use and research, creatine as a sports supplement is one of if not the most scientifically validated, safe, and effective ingredient in the sports nutrition industry.

With the continuous growth of the dietary supplement and chemical synthesis industry, an increased demand has continually been met with an array of creatine supplements available for purchase on the market. It is important to note that all of the previously mentioned creatine studies were performed on creatine monohydrate, which consists of creatine bound to one molecule of water. This was the original form consumed by athletes and rigorously tested by researchers. Today, there exist an abundance of new and novel forms of creatine available that all promise to improve upon the supposed flaws of the monohydrate compound. These flaws have been subjectively reported as: limited bioavailability, bloating/malabsorptive symptoms, lack of response to supplementation, and poor aqueous solubility. To address these and other issues, supplement companies have created alternative variations of creatine that can be separated into six categories: Creatine Salts (creatine pyruvate, creatine hydrochloride, di- or tri- creatine malate, creatine gluconate, creatine nitrate, creatine orotate, potassium creatine chelate, sodium creatine chelate, and magnesium creatine chelate), Buffered Creatine (Kre-Alkalyn), Polyethylene Glycosylated Creatine (PEG), Creatine Esters (creatine ethyl ester), and Creatine Alcohols (creatinol-O-phosphate). Each of these variations have their own unique chemical properties that are purported to improve the biological activity of the compound. More importantly, little scientific

evaluation of these alternative forms appear to be present, leaving athletes and consumers uncertain about which leads to the greatest increases in performance and which is the most well tolerated form. The purpose of this review was to analyze the literature on novel forms of creatine and determine if the evidence currently available refutes or supports the use of alternative forms of creatine as compared to the most commonly consumed and studied form; creatine monohydrate.

## CREATINE MONOHYDRATE

As encompassing all of the available literature on creatine monohydrate itself could span a textbook itself, only the most pertinent and comprehensive studies have been included in this review (mainly studies pertaining to common myths about creatine, and meta analyses).

Since the first study performed investigating the relationship between creatine supplementation and exercise performance up to the trials of today, monohydrate powder dominates the literature. In an excellent review of the trials that have been completed, a leading authority in creatine research, Dr. Richard Kreider, has concluded, "of the approximately 300 studies that have evaluated the potential ergogenic value of creatine supplementation, about 70% of these studies report statistically significant results while remaining studies generally report non-significant gains in performance" [6]. A 2003 meta analysis done by Branch on the effects of creatine supplementation in regards to body composition and performance discovered that effect size was significantly greater for changes in lean body mass, as well as upper body and repetitive bout laboratory based exercise. This analysis pooled 96 peer reviewed studies in which a total of 1,847 subjects were randomized, blinded, and placebo controlled [7]. Numerous smaller meta analyses have been performed which have all come to the same conclusions; creatine ingestion improves maximal effort, high intensity short duration exercise in healthy individuals and those with muscular dystrophies [8-9]. Furthermore, these benefits accompany improvements in lean mass and occur in the absence of serious adverse events (headache, GI distress, and skin rash were reported by a small amount of subjects on one of the studies) [10].

The drawback to these meta analyses is that they have typically only included acute supplementation trials. Therefore, data on the safety and efficacy of long term supplementation must be

addressed. Vandenberghe et al. observed the effects of a 4 day loading phase (20g) followed by a 65 day maintenance period of 5 grams per day during 10 weeks of training in healthy, sedentary college aged women. Compared to the placebo group, the creatine group increased maximal strength 20-25% and fat free mass by 60%. The creatine group also maintained training adaptations (muscle strength) to a greater extent during 10 weeks of detraining [11]. Another study performed by Volek and colleagues examined 12 weeks of creatine supplementation in 19 resistance trained athletes. The subjects were also given a 7 day loading phase of 25 g/day, followed by a 77 day maintenance phase of 5g/day. After 12 weeks, the creatine group experienced significantly greater increases in body and fat free mass compared to placebo without the occurrence of negative side effects. Additionally, the creatine group significantly increased one rep max for the bench press and squat, greater increases in all muscle fiber isoforms, muscle fiber cross sectional areas, and exercise volumes [12]. Finally, Willoughby and Rosene found that 6 grams of creatine/day supplemented for 12 weeks led to the same aforementioned results; significantly greater total body and fat free mass, 1 rep max strength, and myofibrillar protein content in comparison to controls [13]. These reports support the notion that creatine supplementation not only positively influences short term outcomes, but also long term adaptations to exercise. More importantly, it does so without the occurrence of serious adverse events.

Regardless of the lack of reported side effects since the advent of creatine use, the long term safety remains a debated topic. Oftentimes those in opposition of creatine supplementation cite the potential negative effects upon the kidneys as well as an increased risk of dehydration and muscle cramps. To date, these concerns have not been validated in the literature, and the few reports that have attempted to make these associations have led to premature and sensationalized media conclusions. For example, a 1998 case study published in *The Lancet* reported that a 25 year old male using creatine who possessed focal segmental glomerulosclerosis (scar tissue in the “filters” of the kidneys) and relapsing steroid responsive nephritic syndrome (high protein excretion in urine that favorably responds to corticosteroid treatment) experienced impaired renal function that was alleviated upon cessation of creatine use [14]. This led to numerous media allegations that creatine can impair kidney function despite erroneously attempting to apply the results of the case study to healthy populations, which have never displayed impairments in renal stress with creatine use [6, 15-17]. Furthermore, a recent case report

described a 20 year old man with a single kidney and slightly decreased glomerular filtration who was supplemented with creatine for 35 days (20g/day loading phase for 5 days followed by 5g/day maintenance for 30 days). As expected, serum creatinine increased and creatinine clearance decreased, but all further measures of kidney function were not adversely affected or impaired such as proteinuria, albuminuria, serum urea, or electrolyte levels [18].

In regards to creatine and muscle dehydration, an excellent review of the available literature has been performed by Dalbo et al. This publication examined all of the studies pertaining to the effects of creatine on fluid volume, fluid distribution, thermoregulatory responses, and supplementation in controlled hot or humid conditions as well as during exercise in dehydrated individuals. Of the 12 studies reviewed, not one suggested that creatine increases the risk of dehydration or muscle cramps. Many of them actually suggested that it may decrease the risk as the creatine groups in many studies increased total body water, lowered core body temperature during exercise, and improved plasma volume (improved hydration) [19].

Finally, there are a number of long term trials that have observed the effects of creatine supplementation in athletes, infants with creatine synthesis deficiency, and patients for 3 years or greater and have not reported any side effects [1, 6, 15]. Additionally, the individuals participating in the previously cited trial on low dose (1.5-3 g/day) creatine for gyrate atrophy have been monitored since 1981 without the occurrence of any significant adverse effects [4].

In contrast to the wide array of studies available on creatine monohydrate, the literature pertaining to alternative forms is relatively non-existent. Before discussing these alternatives, a background on the physiology of creatine supplementation will be given. This will aid in explaining the rationale for creatine as well as the possible basis for novel creatine usage.

### BRIEF PHYSIOLOGY OF CREATINE INGESTION

Dietary or supplemental creatine is absorbed intact from the intestinal tract into the blood similar to other amino acids and short peptides. Contrary to numerous marketing claims, creatine is not destroyed or degraded by the highly acidic environment of the stomach and appears to be absorbed

completely [1, 3, 20]. Once in the bloodstream, creatine is delivered to numerous tissues including the heart, brain, testes as well as the skeletal muscles which appear to have the highest affinity for plasma creatine [6]. There exist two isoforms of plasma creatine transporters which are both sodium and chloride dependent; CreaT1 and CreaT2. CreaT1 is exclusive to skeletal muscle while CreaT2 is located primarily in the testes [21]. The possibility may exist that the CreaT1 transporter possesses a higher affinity for exogenous creatine, which may explain the greater degree of creatine that is deposited within skeletal muscle in comparison to other tissues. This suspicion is yet to be confirmed in the literature.

Insulin and GLUT4 also appear to have additive effects upon creatine absorption into muscle, with studies that have provided carbohydrate and Alpha Lipoic Acid in addition to creatine resulting in greater intramuscular creatine stores [6]. Furthermore, response to creatine supplementation varies among individuals. It has been concluded that those with lower initial intramuscular creatine stores, greater percentage of type 2 muscle fibers, greater muscle cross sectional area, and greater fat free mass generally respond better to supplementation [21].

Once in the cell, creatine is rapidly phosphorylated by creatine kinase which subsequently traps it within the cell membrane. This is the fate of about 60-70% of total muscle creatine, with the remaining stored as free creatine. Inside the muscle cell, creatine acts as an osmolyte as well as an ATP buffer, pulling water into the cell and storing increased amounts of phosphocreatine to replete ADP during high intensity activities (a.k.a substrate level phosphorylation) [6, 19]. Essentially, novel forms of creatine aim to capitalize on one or all of these four mechanisms mentioned: Absorption, transport, tissue saturation, or contribution to ATP production.

### CREATINE SALTS

The premise behind the combination of creatine and organic acids is to provide additive ergogenic effects and improvement of biochemical properties such as aqueous solubility. One potential drawback to this practice though, is that the incorporation of additional compounds will ultimately yield less pure creatine on a gram per gram basis. Additionally, the dose of the added salt must also be significant enough to provide marked physiological benefit. For example, creatine monohydrate is 87.9% pure creatine,

whereas creatine malate, citrate, pyruvate, orotate, and gluconate are 74.7%, 66%, 60%, and 40.2% respectively[22]. Creatine salts have been available since the early 90s [1]; as such there have been some scientific evaluations into their efficacy.

**Table 1** Creatine content of different forms of creatine

Form of creatine	Creatine content (%)	Difference in CM (%)
Creatine anhydrous	100.0	+13.8
CM	87.9	0
Creatine ethyl ester	82.4	-6.3
Creatine malate (3:1)	74.7	-15.0
Creatine methyl ester HCl	72.2	-17.9
Creatine citrate (3:1)	66	-24.9
Creatine malate (2:1)	66	-24.9
Creatine pyruvate	60	-31.7
Creatine $\alpha$ -amino butyrate	56.2	-36.0
Creatine $\alpha$ -ketoglutarate	53.8	-38.8
Sodium creatine phosphate	51.4	-41.5
Creatine taurinate	51.4	-41.6
Creatine pyroglutamate	50.6	-42.4
Creatine ketoisocaproate	50.4	-42.7
Creatine orotate (3:1)	45.8	-47.9
Carnitine creatinate	44.9	-49.0
Creatine decanoate	43.4	-50.7
Creatine gluconate	40.2	-54.3

Adapted from: Jager, R., et al., *Analysis of the efficacy, safety, and regulatory status of novel forms of creatine*. *Amino Acids*, 2011. 40(5): p. 1369-83.

Creatine pyruvate is a combination of creatine bound to pyruvic acid. Pyruvic acid is an intermediate in glycolysis that has been shown to benefit endurance performance in rats. Therefore, the idea is that combining the two will provide a synergistic effect greater than that of either compound alone. A study performed by Van Schuylenbergh et al. analyzing the effects of creatine pyruvate supplementation (7g/day for 7 days) in endurance athletes was not shown to benefit endurance or sprint performance in trained cyclists [23]. Another study done on Olympic canoeists found that lactate concentrations decreased and paddling speed increased with the addition of 7.5 grams of creatine pyruvate for 5 day [22]. Finally, a randomized double blinded and placebo controlled trial compared the effects of creatine pyruvate supplementation compared to triscreatine citrate and placebo in healthy young athletes. In this study, four weeks of supplementation was found to improve maximal intensity handgrip exercise in comparison to placebo, unfortunately, no comparison to monohydrate was made [24].

Creatine citrate is another combination of creatine and an energy producing metabolic intermediate. Citric acid is the starting compound of the krebs cycle, an important component of the

aerobic ATP producing biochemical pathways. Theoretically, the combination of creatine and citrate would therefore lead to increased exercise endurance in addition to the benefits of creatine alone. Creatine citrate studies have shown similar outcomes to those done on pyruvate, showing a loading phase of 20 grams per day to benefit anaerobic working capacity in healthy active women, and raise ventilator threshold during intense activity [25]. The issue with the application of these studies is that none of them have compared the salt groups to a monohydrate group; therefore a gap remains in the literature before any distinct benefit above that of monohydrate can be supported. Recent work performed by Jager et al. directly comparing isomolar amounts (in regards to creatine) of creatine monohydrate, pyruvate, and triscreatine citrate which showed that the pyruvate salt led to slightly higher serum levels of creatine [20]. It must be noted that this study only examined the kinetics after one dose and only had 6 subjects. Furthermore, the authors concluded that this slight difference was unlikely to confer any tangible advantage [20].

To date, there have not been any published trials performed on creatine hydrochloride, gluconate, nitrate, orotate, or potassium/sodium chelate. In the pharmaceutical industry, hydrochloride is typically bound to amines to increase aqueous solubility and is a process that typically allows the substance to be absorbed more rapidly within the GI tract. It is important to note, though, that this practice has not been shown to react positively with all compounds, and in certain cases the base compound alone has been shown to possess superior solubility [26]. Creatine hydrochloride, patented by Promera Health is marketed as a superior form of creatine as it is said to possess these previously mentioned traits of HCL bound amines; increased aqueous solubility and absorption rates. Because of these purported traits it is suggested that it only requires microdosing in comparison to creatine monohydrate to attain the same benefits [27]. There are not any studies currently published to validate these claims.

In the chemical synthesis industry, orotate is commonly used as a bioavailability enhancer and bound to minerals such as calcium, magnesium, potassium, zinc, etc...[28] MAN Sports, the manufacturer who holds a patent on creatine orotate, claims that the addition of orotic acid further improves upon the ergogenic effects of creatine through maintaining intracellular ATP stores, elevating

glycogen stores, and acting as a pH buffer and cell volumizer [29]. To date, none of these claims have been validated by peer reviewed scientific literature in humans.

Creatine nitrate is relatively new to the market as are numerous new nitrate bound amino acid formulas. The purported benefit behind the supplementation of nitrates is that they will lead to a subsequent increase in Nitric Oxide (NO) production, thus creating vasodilation and improving exercise performance through improved blood flow to active muscles. Though nitrate supplementation has recently been shown to reduce submaximal exercise oxygen demands as well as enhance exercise tolerance [30-31], no studies have directly analyzed the effects of creatine nitrate supplementation.

Gluconic acid is a naturally occurring intermediate in glucose metabolism that is typically used as a carrier in mineral nutrition. It is uncertain as to why creatine gluconate is purported to enhance exercise performance other than the previously established trials which have shown glucose administration in addition to creatine to provide additive effects upon tissue creatine uptake. No trials exist that have analyzed the implementation of creatine gluconate in humans.

Finally, chelates form natural complexes within the body between metal ions and amino acids preventing the chelated minerals from being "pulled away" by other elements or ions present in the system. A good example of the biological importance of this is the structure of hemoglobin. Hemoglobin is a chelate containing a central iron ion tightly bound to surrounding nitrogens. This interaction prevents the iron from dislodging when it interacts with molecular oxygen, allowing hemoglobin to act as an oxygen carrier between tissues [32]. To date, sodium and potassium creatine chelates have not been studied in humans. There are, however, two studies that have analyzed the effects of magnesium creatine chelate in athletes. A 2003 study done by Brilla et al., compared the effects of creatine magnesium chelate (5 g creatine chelated with 800 mg magnesium), creatine plus magnesium oxide (5 g creatine powder mixed with 800 mg magnesium oxide powder), and a maltodextrin placebo in healthy 19 to 24 year old subjects. Both creatine groups increased peak torque, power, and total body water compared to placebo but the magnesium chelate group experienced significantly greater increases in intracellular water and peak torque [33]. It is important to note that the p value for peak torque was .06 in the creatine + magnesium group and .04 in the creatine mg chelate group so these are not likely to be differences that would be

noticeable in the real world. A more recent study by Selsby et al. analyzed the effects of a low dose (2.5 g) creatine, creatine Mg chelate (2.5 g), and placebo group on improvements in 1 rep max and total work performed in 31 college age men. Compared to the placebo, both creatine groups significantly increased total work performed but there were no differences between groups on any other variables measured [34]. As the effects of creatine chelate supplements are not yet definitive, more work needs to be done to determine if a greater ergogenic benefit exists with their use.

### BUFFERED CREATINE

Kre-Alklyn is a combination of alkaline powders and creatine formulated with the intent of increasing the basicity of the resulting mixture to within the range of 7-14 on the pH scale. The claim is made that creatine is rapidly converted to creatinine in acidic environments, thus raising the pH of creatine before it interacts with the acidic environment of the stomach will allow it to resist conversion to creatinine, allowing greater creatine to reach systemic circulation [35]. It is important to note that creatine has been shown in numerous published studies to clear the stomach and be absorbed intact; thus these claims are not supported by the existing literature [1,3,20]. Furthermore, there are yet to be any peer reviewed studies published on Kre-Alklyn or its effectiveness in humans.

### CREATINE ESTERS

Esterification is another process typically used in the pharmaceutical industry to increase the bioavailability of drugs with notoriously poor absorption. Spillane et al. published the first review critically assessing the kinetics of creatine ethyl ester supplementation in 30 young, healthy males. In this study, the creatine ethyl ester group did not outperform the creatine monohydrate group OR the maltodextrin placebo. Furthermore, creatinine values were highest in the ethyl ester supplemented group without significant increases in serum or muscle creatine levels [36]. The authors concluded that creatine ethyl ester is likely degraded to creatinine within the GI tract as it is unstable in low pH ranges, previous work supports this conclusion [37].

### CREATINE ALCOHOL

Creatinol-O-Phosphate is not actually creatine in a technical sense but is purported to act as its precursor, being metabolized within the body to form creatine [38]. A single study done in the seventies provided female patients with intramuscular and intravenous doses of creatinol and measured changes in handgrip strength. Creatinol administration did lead to significantly improved handgrip strength [39] but there exist numerous issues with attempting to apply these findings to athletic populations. Most notably, that there was not a control or monohydrate group in the study and they did not orally ingest the supplement, rather, had injections.

### POLYETHYLENE GLYCOSYLATED CREATINE (PEG)

Polyethylene glycosylation is believed to positively alter permeability coefficients within the GI tract and muscle membrane, leading to enhanced absorption and tissue deposition [40]. PEGylation has been shown to positively alter many of the chemical properties of numerous pharmaceuticals, increasing their solubility, half-lives, and resistance to alteration due to pH or temperature change [41]. It is interesting to note that it is also the major component in over-the-counter laxatives due to its water absorbent capacities [42].

PEGylated creatine is marketed as being superior to monohydrate in that smaller doses can be used to create the same ergogenic effects. PEG creatine has been analyzed in two recent studies involving healthy college aged males. It is important to preface the results by noting that both of these studies were funded by GNC, the major producer of PEG creatine. The first study, done by Herda et al. compared the effects of 5 grams of creatine to two different doses of PEG creatine (2.5 grams and 1.25 grams). The authors concluded that PEG creatine may be as efficacious as creatine monohydrate with smaller doses [40], but if you analyze the data yourself you can see that while both groups had statistically significant changes compared to baseline, the monohydrate group showed trends for greater improvements in nearly all of the variables measured (see below).

**TABLE 2.** Mean difference values for all the dependent variables from pre- to postsupplementation for the creatine monohydrate (CM), small-dose polyethelene glycosolated creatine (PEG<sub>1,25</sub>), and moderate-dose polyethelene creatine (PEG<sub>2,50</sub>).

	CM	PEG <sub>2,50</sub>	PEG <sub>1,25</sub>
Body mass (kg)	*1.0	*0.4	*0.4
Countermovement vertical jump (cm)	*2.3	*2.0	*3.3
Countermovement vertical jump (cm·kg <sup>-1</sup> )	*0.017	*0.008	*0.001
Anaerobic peak power (W)	*73.7	*42.6	*54.2
Anaerobic peak power (W·kg <sup>-1</sup> )	*0.839	*0.534	*0.635
Anaerobic mean power (W)	*40.2	14.2	7.0
Anaerobic mean power (W·kg <sup>-1</sup> )	0.441	0.789	0.051
Bench press 1 RM (lbs)	*13.1	*6.0	*5.3
Leg press 1 RM (lbs)	*52.3	*54.3	*31.3
Bench press repetitions to failure	*2.6	*1.7	*1.2
Leg press repetitions to failure	*4.5	*5.0	*2.7

RM = repetition maximum.

\*Significant ( $p \leq 0.05$ ) difference from pre- to post-supplementation.

Adapted from: Herda, T.J., et al., *Effects of creatine monohydrate and polyethylene glycosylated creatine supplementation on muscular strength, endurance, and power output*. *J Strength Cond Res*, 2009. 23(3): p. 818-26.

The second study recently published in the *Journal of Strength and Conditioning Research* simply compared a PEG creatine group to a placebo group [43]. Both groups were untrained prior to the study. Obviously, the outcome was that the addition of PEG creatine improved 1 rep max strength, but without the comparison to a monohydrate group, this study does not provide much in terms of supporting data.

## CONCLUSION

The studies that have been performed on creatine monohydrate do not support the need for novel formulations nor do they support any of the arguments the supplement industry continually uses to substantiate their statements. Ultimately all types of creatine aim to accomplish the same goal; increase plasma creatine as much as possible, saturate muscle creatine stores, and produce significant increases in strength and power. If we revisit the analysis that has been done by Scocch et al. which has determined the major factors that dictate a positive response to creatine supplementation (lower initial intramuscular creatine stores, greater percentage of type 2 muscle fibers, greater muscle cross sectional area, and greater fat free mass) we can speculate that if an individual does not respond to creatine monohydrate,

they will not likely respond to other variations. In other words, the limiting factors appear to be within the individual, not the properties of the compound.

Although the aqueous solubility of creatine can be improved, and plasma creatine may be slightly increased with novel forms of creatine, these have not proven to lead to any measureable differences in exercise performance when compared to monohydrate. Creatine bound to metabolic intermediates may confer some additional endurance exercise benefits but it must be stressed that this process leads to less pure creatine on a gram per gram basis.

It is clear that more work must be done to determine if there are any advantages to novel forms of creatine. At this point the monohydrate variety remains the gold standard. Alternative forms that possess some slight supporting evidence include creatine chelate, PEG creatine and certain creatine salts. These alternates have not been shown to be superior to monohydrate in ANY of the trials performed but may offer some alternative benefits such as: decreased GI symptoms and slightly increased intracellular water retention. It must be considered, though, that all alternative forms are typically accompanied with a greater price tag. It is ultimately your decision as the consumer if these possible minor benefits are worth the added expense.

### ***Brief Author Biography***

Ben Esgro is a Certified Sports Nutritionist (CISSN) through the International Society of Sports Nutrition and Certified Strength and Conditioning Specialist (CSCS) through the NSCA. He holds a Bachelor of Science Degree in Nutrition with a minor in Exercise Science from West Chester University and is pursuing a Masters in Sports Nutrition at Marywood University. Ben is the owner of De Novo Nutrition ([www.denovonutrition.com](http://www.denovonutrition.com)) and is also a competitive Natural Bodybuilder and Powerlifter. He can be contacted at [besgro@gmail.com](mailto:besgro@gmail.com).

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