The bioavailability of coenzyme Q_{10} supplements available in New Zealand differs markedly

In New Zealand, at least 10 brands of coenzyme Q_{10} (CoQ_{10}) supplement are available over the counter from health food shops, pharmacies, and the Internet. These products claim that supplementation with coenzyme Q_{10} increases energy, wellbeing, stamina and muscle performance, strengthens the heart, and scavenges free radicals. The evidence for these effects is equivocal and well-controlled studies are needed. It is also necessary to confirm the bioavailability of the available CoQ_{10} supplements.

Coenzyme Q_{10} is an essential cofactor in the mitochondrial electron transport chain and also acts as an antioxidant, sparing, the α-tocopheroxyl radical.[1] In mammals, CoQ_{10} is synthesised in all cells—and the diet is also a source, with meat being the biggest contributor.[2]

It is unlikely that many healthy New Zealand adults are frankly deficient in CoQ_{10}, but CoQ_{10} deficiency has been associated with various diseases including Alzheimer's disease and Parkinson's disease. It is also possible that diseases producing oxidative stress may result in CoQ_{10} depletion. HMG-CoA reductase inhibitor (statin) therapy also decreases CoQ_{10} synthesis[3] and causes a potential CoQ_{10} deficiency, due to inhibition of the common biosynthetic pathway for cholesterol and CoQ_{10}. Thus, CoQ_{10} is relevant to at least 100,000 New Zealand patients currently on statin therapy.

The available CoQ_{10} supplements have different formulations, which may affect absorption.[4–6] In particular, supplements in which CoQ_{10} is dispersed in oil generally have higher bioavailability than those formulated as dry powder tablets.[4,6]

Therefore we have compared the bioavailability of seven different coenzyme Q_{10} supplement brands, and provide a basis for selecting brand(s) for clinical use.

Ten healthy adult male volunteers were enrolled in a study approved by the Canterbury Ethics Committee. Participants were excluded if they had taken CoQ_{10}, any vitamin supplements, or medications within the previous 4 weeks. The mean age was 24.2 years (range 21–28 years), the mean height was 179.8 cm (range 173–187 cm), and the mean weight was 71.8 kg (range 60–100 kg). The study was completed between November 2003 and January 2004.

Baseline blood samples were obtained after a 10-hour overnight fast, and CoQ_{10} supplements were administered as a single nominal dose of 150 mg, with supplement brands given in a different randomised order for each participant and a 1-week washout period between trial days. After administration of the supplement, a standardised vegetarian breakfast and lunch were provided, containing approximately 3 μg of coenzyme Q_{10}.[2] Lunch was provided as a takeaway package, and participants were permitted to leave the study centre after breakfast. A second blood sample was collected after 6 hours.

The brands investigated were selected because they are 'popular' brands that contain differing excipients and are outlined in Table 1, which also shows the measured CoQ_{10} content (n=6 capsules or tablets).

Table 1. The excipients, formulation, and actual CoQ$_{10}$ content of the seven CoQ$_{10}$ supplement brands investigated for bioavailability

Brand	Excipients	Capsule/tablet type	% Yield CoQ$_{10}$ per capsule/tablet
Q-Gel	Vitamin E, Annato seed extract, Biosolv® base (lecithin, polysorbate, sorbitin monoleate, and medium chain triglycerides)	Softules containing liquid dispersion	137 ± 4
Radiance	Rice bran oil, lecithin, selenium, and vitamin E	Softgels containing liquid dispersion	125 ± 4
Blackmores	Soy lecithin	Capsules containing liquid dispersion	121 ± 8
Solgar	Vegetable cellulose, vegetable magnesium stearate, and silica	Vegetable capsules containing dry powder	130 ± 15
Kordel's	Evening primrose oil and salmon oil	Capsules containing liquid dispersion	127 ± 7
Thompson's	Vegetable oil	Vegetarian capsules containing liquid dispersion	121 ± 6
Good Health	Glucose, sucrose, magnesium stearate, calcium phosphate, and natural orange flavour	Chewable tablets	100 ± 7

Table 2. The median change in CoQ$_{10}$ after supplementation with the different brands

| Brand	Total CoQ$_{10}$ (µmol/L)	CoQ$_{10}$ to LDL cholesterol ratio (µmol/L)	CoQ$_{10}$ to total cholesterol ratio (µmol/L)
Q-Gel	0.586 (0.349–1.424)	0.275 (0.218–0.500)	0.125 (0.100–0.225)
Radiance	0.321 (0.218–1.118)	0.140 (0.120–0.373)	0.065 (0.048–0.210)
Blackmores	0.229 (0.109–0.531)	0.130 (0.072–0.253)	0.045 (0.028–0.090)
Solgar	0.203 (0.094–0.295)	0.075 (0.048–0.188)	0.045 (0.020–0.075)
Kordel's	0.177 (0.102–0.274)	0.075 (0.050–0.173)	0.040 (0.018–0.078)
Thompson's	0.173 (0.106–0.442)	0.080 (0.060–0.150)	0.028 (0.060–0.073)
Good Health	0.139 (0.105–0.297)	0.095 (0.040–0.165)	0.040 (0.018–0.053)

Values shown are median values, with brackets showing the inter-quartile range.

Blood specimens were collected and lithium heparin plasma was stored at -80°C until analysis. CoQ_{10} was analysed using a method similar to that used by Tang et al.[7] The within- and between-run coefficients of variation (CV) for the CoQ_{10} assay are approximately 3.3%. Plasma lipids were determined by routine clinical methods. The differences between CoQ_{10} supplements were tested using either the non-parametric Friedman test or Wilcoxon signed-rank test (as appropriate), with statistical significance inferred when $p < 0.05$. All CoQ_{10} supplement brands tested contained at least the claimed CoQ_{10} (Table 2).

Mean baseline lipids (±SD) for all participants were 4.81±1.04, 2.78±0.75, 1.18±0.30, and 1.28±0.44 mmol/L for total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides respectively. Mean baseline CoQ_{10} (±SD) was 0.85±0.25 µmol/L. During the trial there was no significant change in baseline levels of CoQ_{10}, direct LDL cholesterol, HDL cholesterol, triglycerides, or total cholesterol, thus confirming that the wash-out period was sufficient.

There was no significant effect of CoQ_{10} supplementation on total cholesterol ($p=0.539$), triglycerides ($p=0.128$), or direct LDL and HDL cholesterol ($p=0.910$ and 0.587 respectively).

Figure 1: The change in coenzyme Q_{10} concentration for individual participants and all supplement brands (n=7). Horizontal lines show median increase in CoQ_{10} for each participant
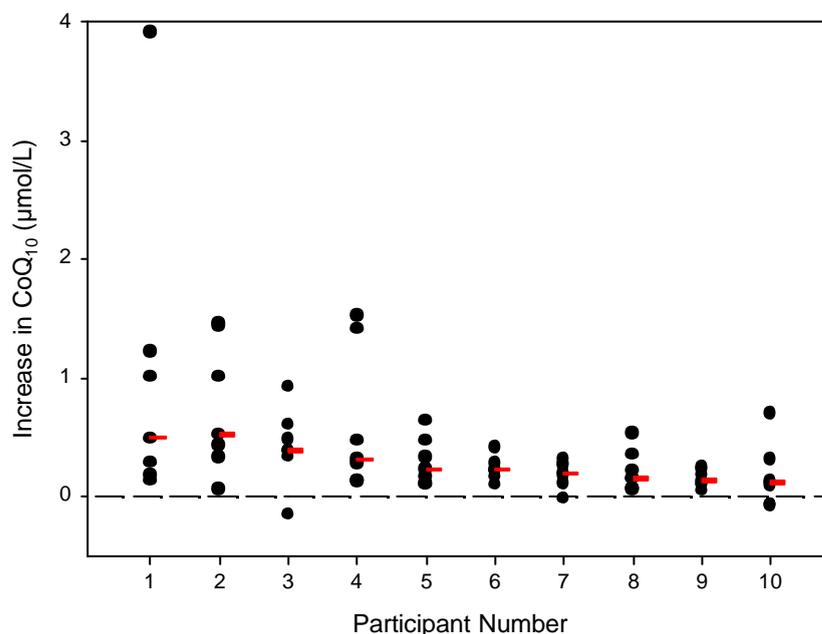
There was a significant difference ($p=0.003$) in CoQ_{10} absorption between the 10 participants (Figure 1). Some participants efficiently absorbed CoQ_{10} from most

brands of the supplements, while others showed inefficient absorption. There was no correlation (p=0.56) between baseline CoQ_{10} levels and absorption of CoQ_{10}.

There was a significant difference in bioavailability between the seven CoQ_{10} brands (p<0.001), with Q-Gel being significantly better than any other supplement (p=0.013). This is summarised in Table 2.

There was a significant difference in the delta CoQ_{10} to direct LDL cholesterol and CoQ_{10} to total cholesterol ratios between the supplement brands (p=0.001 for both), thus mirroring the differences in total CoQ_{10} (Table 2).

There was a significant correlation between baseline LDL concentrations and change in CoQ_{10} (p=0.004; R=+0.343), between total cholesterol levels and change in CoQ_{10} (p=0.004; R=+0.338), and also between baseline triglycerides and change in CoQ_{10} (p=0.035; R=+0.253). Therefore, higher LDL cholesterol or triglyceride concentrations may aid absorption of CoQ_{10}. There was no correlation between HDL cholesterol, weight, or body mass index and mean CoQ_{10} absorption.

Although there are many different CoQ_{10} supplements available, there are little data on the prevalence and effect(s) of CoQ_{10} deficiency, or the benefits of CoQ_{10} supplementation. It is also necessary to confirm that the available CoQ_{10} supplements do in fact increase CoQ_{10} levels before advocating clinical use or attempting clinical trials.

There is also controversy about whether plasma (and hence dietary) CoQ_{10} is delivered to the mitochondria, but it is much easier to measure plasma levels than tissue level, and it is often assumed that tissue levels mirror those of plasma. However, Niklowitz et al[8] found a positive correlation between CoQ_{10} in plasma and platelets, which contain mitochondria, implying that raising plasma levels of CoQ_{10} by diet and supplementation also raises tissue levels.

CoQ_{10} supplementation is well tolerated and dosages as high as 1200 mg/day have been administered with minimal side effects.[9]

We found important differences in the bioavailability of these supplements. However, the mean increase in plasma total CoQ_{10} of 0.41 µmol/L equates to about 0.7 mg of CoQ_{10} being absorbed into the blood from the 150 mg supplied. This can be compared to the normal diet in which CoQ_{10} is limited to about 3 to 5 mg per day, mainly via the consumption of meats rather than fruits and vegetables.[2]

Because CoQ_{10} is lipid soluble, it is likely that administration as a dispersion (or solubilised) in oil will aid absorption, as found in our study. The high bioavailability of Q-Gel compared to other coenzyme Q_{10} supplement brands supports the findings of Chopra et al[5] who found the absorption of Q-Gel to be 319% better than that from a standard softgel capsule containing Q_{10} in oil, after 3 weeks of a daily 120 mg dose. Chopra et al[5] also found the absorption from powder-filled hardshell capsules and powder-based tablets to be higher (125% and 128% respectively) than that from a standard softgel capsule.

Miles et al[4] found the increase of plasma total CoQ_{10} by 'solubilised' supplemental CoQ_{10} to be 858%–1058% higher than that from a dry powder formulation. Furthermore, Wahlqvist et al[6] found that the bioavailability of CoQ_{10} in a complex micelle emulsion (in a soft gelatine capsule) was 927% higher than a crystalline

CoQ_{10} supplement with magnesium stearate (as an excipient and a hard gelatine capsule).

Thus it is clear that there are important differences. There is at least a four-fold variation in the increase in plasma CoQ_{10} achieved by different supplements, and some people get no increase when they take the less effective supplements at typical doses.

The high bioavailability of Q-Gel may be due to the presence of both non-ionic surfactants and the natural surfactant lecithin. The Radiance and Blackmores brands showed the next highest bioavailability, and these brands also contain lecithin.

Significant between subject differences in absorption have been previously reported,[10–12] and highlight a need for monitoring of CoQ_{10} levels during supplementation. There was no correlation between weight, body mass index or baseline CoQ_{10} and CoQ_{10} absorption—hence there are no simple clinical indicators that accurately predict response to different supplement formulations. Therefore, monitoring of plasma CoQ_{10} concentration appears to be the only method to estimate CoQ_{10} absorption.

There are important differences in bioavailability between the available CoQ_{10} supplements and also significant inter-individual differences. We therefore recommend monitoring of plasma CoQ_{10} levels during supplementation, and that differences in bioavailability are considered when selecting a supplement. In this study, the Q-gel brand showed significantly better bioavailability than the six other CoQ_{10} supplements tested.

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