

Article

A Stable Lycopene–Micronutrient Matrix for Male Reproductive Nutrition: Formulation Characterization and Human Evidence on Sperm Quality

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Abstract: Oxidative conditions around sperm cells and the availability of several micronutrients are relevant to membrane integrity, motility and morphology. We examined the formulation performance of the BCLC® low-moisture, lycopene-centered multinutrient tablet and reviewed human evidence most directly related to its reproductive-nutrition rationale. The daily two-tablet dose supplies 4.5–5.5 mg lycopene, 9.5–10.5 mg zinc, 28–32 µg selenium, vitamin C 75–85 mg, vitamin E 10–13 mg, folic acid 180–220 µg, vitamin D3, B vitamins, taurine and pumpkin seed extract. After accelerated storage, lycopene retention was 89.6%, the optimized tablet had the lowest appearance color change (ΔE 2.3) among the tested formulations, and lycopene content RSD was 3.8%. Randomized studies of lactycopene or lycopene at 14–25 mg/day have reported changes in selected sperm-motility, morphology or oxidative-stress endpoints, while the large MOXI multicomponent trial found no broad improvement in semen or pregnancy outcomes. The formulation data define a stable exposure platform for testing discrete semen-quality and redox endpoints with the complete BCLC® matrix.

Keywords: lycopene; male reproductive health; sperm motility; sperm morphology; oxidative stress; zinc; selenium; antioxidant nutrition.

Introduction

Male reproductive health is influenced by multiple biological and environmental factors, and semen-quality measures provide practical intermediate endpoints for nutritional studies. Oxidative stress is a recurring issue in male-infertility research because spermatozoa contain membranes rich in polyunsaturated fatty acids and have limited cytoplasmic antioxidant capacity. This vulnerability is relevant to membrane integrity, motility, morphology and sperm DNA quality and provides a biological rationale for examining antioxidant and micronutrient strategies [1].

Micronutrient intervention studies illustrate both the plausibility and the heterogeneity of this approach. Selenium supplementation has been evaluated for sperm motility in subfertile men [2], and selenium combined with N-acetyl-cysteine has been studied for semen parameters in infertile men [3]. Folic acid plus zinc sulfate has been tested in male-factor subfertility [4], while vitamin E has been examined in relation to sperm lipid peroxidation and motility [5]. Oral antioxidant treatment has also been evaluated against sperm DNA fragmentation [6]. A controlled selenium study in healthy men further illustrates that nutrient response can depend on baseline status and dose rather than simply increasing with intake [7].

Lycopene is of particular interest because it is a lipid-soluble carotenoid with singlet-oxygen-quenching activity and can be incorporated into a broader antioxidant-nutrient matrix. In a 12-week randomized study, lactycopene at 14 mg/day was evaluated for sperm motility and morphology in healthy men [8]. A separate randomized trial investigated lycopene at 25 mg/day in men with oligozoospermia, including semen parameters and seminal oxidative-stress measures [9]. Tomato-juice exposure has also been evaluated in men with infertility [10]. In contrast, the multicenter MOXI trial found no broad improvement in semen or pregnancy-related outcomes with a multicomponent antioxidant intervention [11]. Earlier preliminary work additionally examined oral lycopene in idiopathic male infertility [12].

The broader evidence base is therefore not uniform. A Cochrane review of antioxidants for male subfertility [13], a systematic review examining antioxidant types and doses [14], and a network meta-analysis of randomized trials [15] describe substantial variation in interventions, semen phenotypes, comparators and outcome definitions. Differences in nutrient form, dose, baseline nutritional status and the selected reproductive endpoint make direct extrapolation from one study to another difficult. A formulation-specific investigation should therefore distinguish product performance from biological efficacy and define the exposure actually delivered before reproductive outcomes are interpreted.

The BCLC® composition places lycopene together with zinc, selenium, vitamins C and E, folate, vitamin D3, B vitamins, taurine and pumpkin seed extract in a low-moisture tablet. For this type of multinutrient matrix, stability is not a secondary manufacturing detail. Lycopene degradation, uneven distribution of low-dose micronutrients or visible matrix change can introduce variation in the dose that is eventually compared with the human evidence. Demonstrating content retention, tablet-to-tablet uniformity and appearance stability therefore provides a necessary formulation-level basis for later reproductive evaluation.

The present study was designed to characterize the BCLC® tablet as a defined exposure platform and to place that platform within the human evidence most directly relevant to lycopene and antioxidant nutrition in male reproductive health. We measured lycopene retention after accelerated storage, content uniformity and surface color change, and then integrated these formulation findings with human studies addressing semen-quality and redox endpoints. The objective was to establish whether the formulation is sufficiently stable and reproducible to support a focused clinical study using prespecified semen-quality, oxidative-stress and nutrient-exposure outcomes.

Materials and Methods

Reproductive-nutrition composition

Two tablets constitute the daily dose. The formulation contains lycopene, zinc, selenium, vitamins C and E, folate, vitamin D3, B vitamins, taurine and pumpkin seed extract; the complete dose architecture is listed in Table 1.

Table 1. Daily active-component architecture of the BCLC® formulation.

Active component	Daily dose (2 tablets)
Vitamin C	75–85 mg
Vitamin E	10–13 mg
Vitamin D3	9–11 µg
Vitamin B1	1.8–2.2 mg
Vitamin B2	1.8–2.2 mg
Vitamin B6	1.8–2.2 mg
Vitamin B12	2.5–3.5 µg
Nicotinamide	15–17 mg
Pantothenic acid	4.5–5.5 mg
Folic acid	180–220 µg
Zinc	9.5–10.5 mg
Selenium	28–32 µg
Lycopene	4.5–5.5 mg
Pumpkin seed extract	110–130 mg

Active component	Daily dose (2 tablets)
Taurine	90–110 mg

Formulation-performance endpoints

Lycopene retention was measured after 3 months of accelerated storage. Lycopene content uniformity was expressed as RSD across randomly selected tablets. Instrumental surface color difference (ΔE) was used to track appearance stability. These measurements describe whether the carotenoid-containing matrix remained chemically and physically consistent during storage.

Clinical evidence integration

The literature set covered four clinical contexts: randomized lactolycopene supplementation in healthy men [8]; randomized lycopene supplementation in men with oligozoospermia [9]; tomato-juice exposure in men with infertility [10]; and the multicenter MOXI antioxidant trial in male-factor infertility [11]. Nutrient-specific selenium, zinc/folate and vitamin E trials and earlier lycopene data were also reviewed for dose and endpoint context [2]–[7], [12].

Results

Lycopene and appearance stability

After 3 months of accelerated storage, the optimized BCLC® tablet retained 89.6% of lycopene. Surface color difference was ΔE 2.3. Comparator values were 4.9 for ordinary lycopene plus direct mixing, 7.4 for the iron/copper comparator, 3.8 for one-time mixing with the same lycopene microcapsule, 4.2 for ordinary lycopene with staged mixing, and 4.6 for the higher-moisture comparator. Lycopene content RSD was 3.8%.

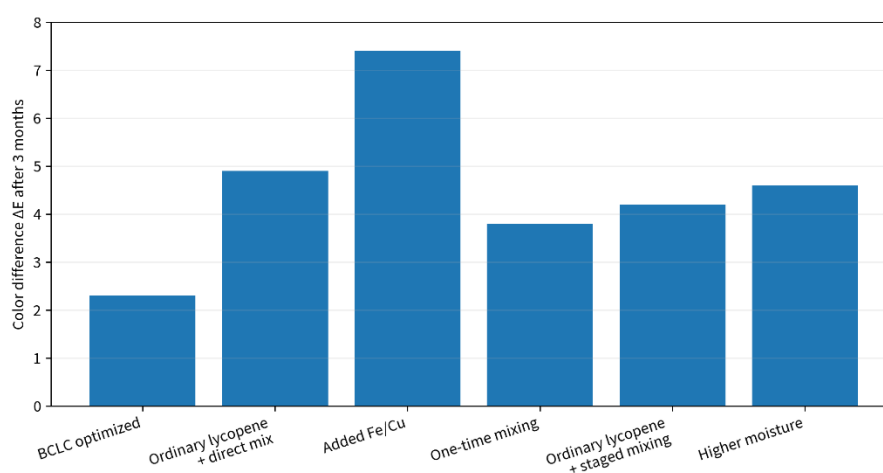


Figure 1. Tablet surface color difference (ΔE) after 3 months of accelerated storage. Lower ΔE indicates less visible color drift and is used here as a formulation-stability indicator, not as a biological efficacy endpoint.

Human reproductive evidence

Table 2. Representative human evidence relevant to lycopene and antioxidant nutrition in male reproductive health.

Study	Design / population	Intervention	Endpoints	Main observation
Williams et al., 2020	60 healthy men; double-blind randomized placebo-controlled; 12 wk	Lactolycopene 14 mg/day vs placebo	Sperm motility and morphology	Fast progressive sperm and normal morphology improved with lactolycopene.
Nouri et al., 2019	44 men with oligozoospermia; randomized,	Lycopene 25 mg/day vs placebo	Semen parameters, seminal	Several semen parameters and total antioxidant capacity

Study	Design / population	Intervention	Endpoints	Main observation
Yamamoto et al., 2017	double-blind, placebo-controlled; 12 wk		oxidative stress	improved within the lycopene group; study size was modest.
	Men with infertility and low concentration and/or motility; dietary intervention	Tomato juice as a lycopene-containing food	Seminal plasma lycopene, sperm parameters	Tomato juice increased lycopene exposure and was associated with improvement in selected sperm-motility measures.
Steiner et al., 2020 (MOXI)	Couples with male-factor infertility; multicenter randomized placebo-controlled trial	Multicomponent antioxidant supplement vs placebo	Semen parameters, DNA fragmentation, pregnancy/live birth	No broad improvement in semen parameters or pregnancy/live-birth outcomes was observed.

Discussion

The optimized tablet combined 89.6% lycopene retention with ΔE 2.3 and a lycopene content RSD of 3.8%. These are formulation measurements rather than reproductive outcomes, but they reduce an important source of experimental noise: variation in the carotenoid dose caused by degradation or poor tablet-to-tablet distribution.

The lycopene-specific studies point most consistently to semen-quality endpoints. Williams et al. reported improved fast progressive sperm and normal morphology after 14 mg/day lactolycopene for 12 weeks in healthy men [8]. Nouri et al. studied 25 mg/day in men with oligozoospermia and reported changes in semen variables and seminal antioxidant status [9]. Tomato juice increased lycopene exposure and was associated with selected motility changes in the dietary study by Yamamoto et al. [10]. An earlier preliminary trial also evaluated oral lycopene in idiopathic male infertility [12]. The doses and study populations were not identical to the BCLC® formulation, which supplies 4.5–5.5 mg lycopene per day.

Antioxidant evidence becomes less uniform as the intervention broadens. The MOXI trial did not show broad improvement in semen parameters, DNA fragmentation or pregnancy/live-birth outcomes with its multicomponent supplement [11]. Systematic reviews likewise describe marked variation among antioxidant types, doses, semen phenotypes and outcome definitions [13]–[15]. This makes motility, morphology, total motile sperm count, seminal redox measures and nutrient exposure more useful early endpoints than assuming a common effect on every reproductive outcome.

Several components of the BCLC® matrix have their own male-reproductive literature. Selenium supplementation has been examined in subfertile men and in combined selenium/N-acetyl-cysteine regimens [2], [3], while folic acid plus zinc was tested in fertile and subfertile men [4]. Vitamin E has been studied in relation to sperm lipid peroxidation and motility [5], and oral antioxidant treatment has been evaluated against sperm DNA fragmentation [6]. A controlled selenium study in healthy men also illustrates that response can depend on baseline status and dose rather than simply increasing with intake [7]. These studies do not reproduce the BCLC® combination; they help define which biological measurements are reasonable for a formulation-specific trial.

Current Scope and Future Directions

A prospective BCLC® study could enroll men with a defined semen-quality phenotype and measure the same formulation-specific dose throughout the intervention. Repeated semen analyses, seminal oxidative-stress markers, plasma lycopene and baseline zinc/selenium status would allow responder patterns to be examined before moving to couple-level outcomes. The trial duration should be long enough to capture changes across a spermatogenic cycle and should prespecify motility and morphology endpoints rather than rely on a composite antioxidant claim.

Conclusion

The BCLC® low-moisture multinutrient tablet retained 89.6% of lycopene after accelerated storage, showed ΔE 2.3, and maintained a lycopene content RSD of 3.8%. Human lycopene studies have reported changes in selected sperm-quality and redox endpoints, whereas broader antioxidant trials show substantial heterogeneity. The complete tablet can therefore be evaluated as a defined formulation, with semen quality, redox status and nutrient exposure measured directly.

REFERENCES

- [1] K. Tremellen, "Oxidative stress and male infertility – A clinical perspective," *Hum. Reprod. Update*, vol. 14, no. 3, pp. 243–258, 2008, doi:10.1093/humupd/dmn004.
- [2] R. Scott, A. MacPherson, R. W. Yates, B. Hussain, and J. Dixon, "The effect of oral selenium supplementation on human sperm motility," *Br. J. Urol.*, vol. 82, no. 1, pp. 76–80, 1998, doi:10.1046/j.1464-410x.1998.00683.x.
- [3] M. R. Safarinejad and S. Safarinejad, "Efficacy of selenium and/or N-acetyl-cysteine for improving semen parameters in infertile men: a double-blind, placebo controlled, randomized study," *J. Urol.*, vol. 181, no. 2, pp. 741–751, 2009, doi:10.1016/j.juro.2008.10.015.
- [4] W. Y. Wong, H. M. W. M. Merkus, C. M. G. Thomas, R. Menkveld, G. A. Zielhuis, and R. P. M. Steegers-Theunissen, "Effects of folic acid and zinc sulfate on male factor subfertility: a double-blind, randomized, placebo-controlled trial," *Fertil. Steril.*, vol. 77, no. 3, pp. 491–498, 2002, doi:10.1016/S0015-0282(01)03229-0.
- [5] S. A. Suleiman, M. E. Ali, Z. M. Zaki, E. M. el-Malik, and M. A. Nasr, "Lipid peroxidation and human sperm motility: protective role of vitamin E," *J. Androl.*, vol. 17, no. 5, pp. 530–537, 1996, doi:10.1002/j.1939-4640.1996.tb01830.x.
- [6] E. Greco, M. Iacobelli, L. Rienzi, F. Ubaldi, S. Ferrero, and J. Tesarik, "Reduction of the incidence of sperm DNA fragmentation by oral antioxidant treatment," *J. Androl.*, vol. 26, no. 3, pp. 349–353, 2005, doi:10.2164/jandrol.04146.
- [7] W. C. Hawkes and P. J. Turek, "Effects of dietary selenium on sperm motility in healthy men," *J. Androl.*, vol. 22, no. 5, pp. 764–772, 2001, doi:10.1002/j.1939-4640.2001.tb02579.x.
- [8] E. A. Williams, M. Parker, A. Robinson, S. Pitt, and A. A. Pacey, "A randomized placebo-controlled trial to investigate the effect of lactolycopene on semen quality in healthy males," *Eur. J. Nutr.*, vol. 59, no. 2, pp. 825–833, 2020, doi:10.1007/s00394-019-02091-5.
- [9] M. Nouri et al., "The effects of lycopene supplement on the spermatogram and seminal oxidative stress in infertile men: a randomized, double-blind, placebo-controlled clinical trial," *Phytother. Res.*, vol. 33, no. 12, pp. 3203–3211, 2019, doi:10.1002/ptr.6493.
- [10] Y. Yamamoto et al., "The effects of tomato juice on male infertility," *Asia Pac. J. Clin. Nutr.*, vol. 26, no. 1, pp. 65–71, 2017, doi:10.6133/apjcn.102015.17.
- [11] A. Z. Steiner, K. R. Hansen, K. T. Barnhart, et al., "The effect of antioxidants on male factor infertility: the Males, Antioxidants, and Infertility (MOXI) randomized clinical trial," *Fertil. Steril.*, vol. 113, no. 3, pp. 552–560.e3, 2020, doi:10.1016/j.fertnstert.2019.11.008.
- [12] N. P. Gupta and R. Kumar, "Lycopene therapy in idiopathic male infertility – A preliminary report," *Int. Urol. Nephrol.*, vol. 34, no. 3, pp. 369–372, 2002, doi:10.1023/A:1024483520560.
- [13] W. de Ligny, R. M. Smits, R. Mackenzie-Proctor, V. Jordan, K. Fleischer, J. P. de Bruin, and M. G. Showell, "Antioxidants for male subfertility," *Cochrane Database Syst. Rev.*, no. 5, Art. no. CD007411, 2022, doi:10.1002/14651858.CD007411.pub5.
- [14] A. Majzoub and A. Agarwal, "Systematic review of antioxidant types and doses in male infertility: Benefits on semen parameters, advanced sperm function, assisted reproduction and live-birth rate," *Arab J. Urol.*, vol. 16, no. 1, pp. 113–124, 2018, doi:10.1016/j.aju.2017.11.013.
- [15] L. Su, H. Qu, Y. Cao, J. Zhu, S.-Z. Zhang, J. Wu, and Y.-Z. Jiao, "Effect of antioxidants on sperm quality parameters in subfertile men: A systematic review and network meta-analysis of randomized controlled trials," *Adv. Nutr.*, vol. 13, no. 2, pp. 586–594, 2022, doi:10.1093/advances/nmab127.