

International Journal of Applied and Traditional Medicine, 2026, 1-6
https://publishingjournals.org/ijatm
Volume: 3 | Number: 3 (2026) July

Fruit-Derived Vitamin C and Polyphenols in Cardiometabolic Nutrition: Formulation Stability, Glycemic Evidence, and Vascular Relevance

Yassine Igoundaz
National Laboratory of Medicine LLC

Declan Walsh
National Laboratory of Medicine LLC

Connor Price
National Laboratory of Medicine LLC

***Correspondence :** Yassine Igoundaz

Received: 18-05-2026
Accepted: 19-06-2026
Published: 21-07-2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/ 4.0/

Open Access

Abstract

The NVTIA® fruit-derived vitamin C-polyphenol powder was characterized for composition and storage performance and then compared with human cardiometabolic evidence. The optimized formulations contained 16.8-18.4% L-ascorbic acid and 7.9-8.8% corrected total polyphenols. Thirty-day L-ascorbic acid retention was 87.5-89.1%, with 24-hour hygroscopicity of 5.8-6.3%; direct dry mixing or removal of the protective matrix produced lower retention and substantially greater hygroscopicity. In type 2 diabetes, a randomized crossover trial using 1 g/day ascorbic acid improved postprandial and 24-hour glycemia and reduced blood pressure. Meta-analyses report modest average changes in glycemic control, endothelial function, and blood pressure, but individual trials include both positive and neutral results. Phyllanthus emblica studies add a polyphenol-rich fruit context for endothelial and lipid endpoints. The formulation therefore supplies a stable ascorbate-polyphenol exposure for cardiometabolic studies in which baseline phenotype and biochemical exposure are measured directly.

Keywords vitamin C; polyphenols; glucose metabolism; endothelial function; blood pressure; Phyllanthus emblica; cardiometabolic health; antioxidant

Introduction

Ascorbate and fruit polyphenols intersect with glucose and vascular biology through redox-sensitive pathways, nitric-oxide signaling, and postprandial metabolism. Human intervention studies have examined fasting and postprandial glucose, HbA1c, insulin, endothelial function, and blood pressure, with effects varying by disease status, duration, and background treatment [1]-[5].

The formulation combines vitamin-C-rich acerola and Rosa roxburghii with a polyphenol-rich Phyllanthus emblica fraction. Because ascorbate is readily oxidized and fruit powders can be hygroscopic, the amount remaining after manufacture and storage is part of the exposure definition, not a separate manufacturing detail.

We compared three optimized formulations with process variants using L-ascorbic acid content, corrected total polyphenols, accelerated-storage retention, and hygroscopicity. Clinical studies were then considered by endpoint and population so that vitamin C or amla effects reported elsewhere were not assigned directly to the complete NVTIA® powder.

Materials and Methods

Finished-powder L-ascorbic acid, corrected total polyphenols, 30-day accelerated-storage retention, and 24-hour hygroscopicity were compared across the three optimized formulations and seven process comparators. Values were interpreted descriptively because replicate-level biological variance was not available for these formulation metrics.

Human evidence was selected for postprandial or 24-hour glucose, HbA1c, fasting insulin, blood pressure, endothelial function, lipid profile, and oxidative or inflammatory biomarkers. Phyllanthus emblica trials were retained because that fruit is part of the composite formulation. Individual trial conditions were preserved rather than averaged into a new effect estimate.

Results

The three optimized powders contained 16.8-18.4% L-ascorbic acid and 7.9-8.8% corrected total polyphenols. Thirty-day retention was 88.1%, 89.1%, and 87.5%, with hygroscopicity of 5.8%, 6.1%, and 6.3%. The no-protective-matrix and direct-dry-mix comparators showed 75.3% and 77.2% retention with hygroscopicity of 13.6% and 12.8%. The no-low-oxygen comparator retained 73.8%.

Table 1. Selected composition and storage-performance metrics.

Condition	L-ascorbic acid (%)	Polyphenols (%)	30-d retention (%)	Hygroscopicity (%)
Optimized 1	17.6	8.2	88.1	5.8
Optimized 2	18.4	7.9	89.1	6.1
Optimized 3	16.8	8.8	87.5	6.3
No low-O2 control	14.9	7.7	73.8	8.9
No protective matrix	15.8	8.0	75.3	13.6
Dry-mixed fruit powders	16.2	8.1	77.2	12.8

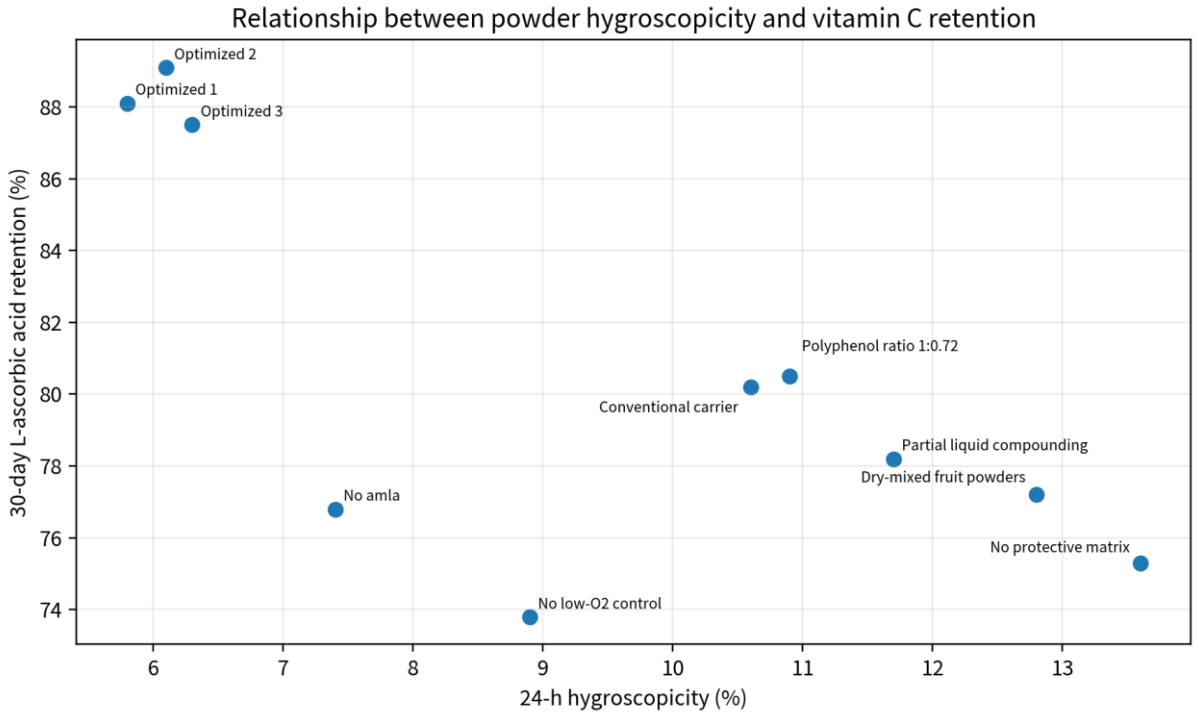


Figure 1. Relationship between 24-h hygroscopicity and 30-day L-ascorbic acid *retention.*

Mason et al. studied 31 adults with type 2 diabetes in a randomized crossover trial. Four months of 2 × 500 mg/day ascorbic acid improved postprandial and 24-hour glycemia and reduced blood pressure relative to placebo [1]. Their later GRADE-assessed review found short-term improvements in several glycemic and blood-pressure outcomes, with heterogeneity across trials [2]. Nosratabadi et al. pooled 22 RCTs involving 1,447 participants with type 2 diabetes and reported reductions in HbA1c, fasting insulin, and fasting glucose [3].

Vascular findings are similarly dependent on population. Ashor et al. reported an overall improvement in endothelial function across 44 randomized vitamin C trials, with larger effects in higher-risk groups [4]. Blood-pressure meta-analysis also found modest average reductions [5]. Phyllanthus emblica trials in type 2 diabetes and metabolic syndrome reported improvements in endothelial or selected oxidative, inflammatory, and lipid markers [6], [7]. Upadya et al. found reductions in total cholesterol, triglycerides, LDL-C, VLDL-C, and atherogenic index in dyslipidemia [8]. In healthy adults, Kapoor et al. reported changes in vascular and oxidative-stress measures after amla exposure [9]. A 150-participant add-on trial in essential hypertension did not show an additional blood-pressure or arterial-stiffness benefit [10].

Clinical Evidence Synthesis

Table 2. Summary of human cardiometabolic evidence for vitamin C and Phyllanthus emblica.

Study	Design / population	Intervention	Main outcome	Interpretation
Mason et al., 2019 [1]	Randomized crossover; 31 adults with type 2 diabetes	1 g/day ascorbic acid for 4 months	Improved postprandial/24-h glycemia and reduced BP	Direct human evidence for glycemic and vascular intermediate endpoints
Mason et al., 2021 [2]	GRADE systematic review/meta-	Oral vitamin C	Short-term improvements in several glycemic	Supports context-dependent

Study	Design / population	Intervention	Main outcome	Interpretation
	analysis; T2D RCTs		and BP outcomes	metabolic relevance
Nosratabadi et al., 2023 [3]	Meta-analysis; 22 RCTs, 1,447 T2D participants	Vitamin C supplementation	Reduced HbA1c, fasting insulin and fasting glucose	Quantitative support for glycemic modulation
Ashor et al., 2014 [4]	Meta-analysis; 44 randomized trials	Vitamin C	Overall improvement in endothelial function; stronger in higher CVD risk	Supports vascular redox mechanism
Usharani et al., 2019 [7]	Randomized double-blind placebo trial; metabolic syndrome	P. emblica 250 or 500 mg twice daily	Improved endothelial function and selected oxidative/inflammatory/lipid markers	Relevant polyphenol-rich fruit evidence
Upadya et al., 2019 [8]	Multicenter RCT; 98 patients with dyslipidemia	Amla extract 500 mg twice daily for 12 weeks	Lower TC, TG, LDL-C, VLDL-C and AIP vs placebo	Supports complementary lipid context
Shanmugarajan et al., 2021 [10]	Randomized double-blind placebo trial; 150 patients	P. emblica 500 mg twice daily as add-on	No additional BP or arterial-stiffness benefit	Defines a clinically relevant boundary and phenotype dependence

Discussion

The optimized powders occupied a distinct low-hygroscopicity/high-retention region. That matters because vitamin C degradation changes the dose available for any downstream metabolic comparison. A study that begins with the same nominal gram amount can still deliver a different ascorbate exposure if storage and water uptake are poorly controlled.

The human data do not support a single cardiometabolic response. Dakhale et al. found lower fasting and post-meal glucose and HbA1c when vitamin C was added to metformin in type 2 diabetes [11]. Afkhami-Ardekani and Shojaoddiny-Ardekani reported dose-dependent changes in glucose, insulin, and lipids over six weeks, with the 1000-mg dose producing the clearer signal [12]. Darko et al., however, found no improvement in blood pressure, oxidative stress, or endothelial function after 1.5 g/day for three weeks in type 2 diabetes [13]. A 2024 trial in metabolic syndrome likewise found no reduction in CRP or several inflammatory markers with a high-vitamin-C micronutrient formula, although some metabolic indices improved [14].

These differences make exposure measurement especially useful. Vitamin C pharmacokinetics are saturable and dose dependent, and plasma concentration is influenced by baseline status and repeated intake [15]. For the present powder, plasma ascorbate and selected polyphenol metabolites can be measured alongside continuous glucose monitoring, fasting insulin, ambulatory blood pressure, or flow-mediated dilation. The formulation variable then becomes part of the observed exposure rather than an assumption based on label

dose.

Research Scope and Future Directions

A formulation-specific randomized study could select one metabolic phenotype in advance rather than combining healthy and high-risk participants. Plasma ascorbate, a defined polyphenol-metabolite panel, and one primary cardiometabolic endpoint would keep the design interpretable. Continuous glucose monitoring or ambulatory blood pressure can then provide repeated measures without requiring a large set of loosely related outcomes.

Conclusion

The optimized fruit-derived powder contained 16.8-18.4% L-ascorbic acid and 7.9-8.8% corrected total polyphenols, with 87.5-89.1% L-ascorbic acid retention after 30 days and substantially lower hygroscopicity than several comparators. Human vitamin C and Phyllanthus emblica trials show glycemic, endothelial, lipid, and blood-pressure signals in some metabolically compromised populations together with neutral findings in others. The stable ascorbate-polyphenol matrix provides a defined exposure for direct cardiometabolic testing rather than an assumed extension of single-ingredient trials.

References:

[1] S. A. Mason, B. Rasmussen, L. J. C. van Loon, J. Salmon, and G. D. Wadley, "Ascorbic acid supplementation improves postprandial glycaemic control and blood pressure in individuals with type 2 diabetes: findings of a randomized cross-over trial," Diabetes Obes. Metab., vol. 21, pp. 674-682, 2019, doi: 10.1111/dom.13571.

[2] S. A. Mason et al., "Effects of vitamin C supplementation on glycemic control and cardiovascular risk factors in people with type 2 diabetes: a GRADE-assessed systematic review and meta-analysis of randomized controlled trials," Diabetes Care, vol. 44, no. 2, pp. 618-630, 2021, doi: 10.2337/dc20-1893.

[3] S. Nosratabadi et al., "The effects of vitamin C supplementation on glycemic control in patients with type 2 diabetes: a systematic review and meta-analysis," Diabetes Metab. Syndr., vol. 17, Art. no. 102824, 2023, doi: 10.1016/j.dsx.2023.102824.

[4] A. W. Ashor, J. Lara, J. C. Mathers, and M. Siervo, "Effect of vitamin C on endothelial function in health and disease: a systematic review and meta-analysis of randomised controlled trials," Atherosclerosis, vol. 235, no. 1, pp. 9-20, 2014, doi: 10.1016/j.atherosclerosis.2014.04.004.

[5] S. P. Juraschek, E. Guallar, L. J. Appel, and E. R. Miller III, "Effects of vitamin C supplementation on blood pressure: a meta-analysis of randomized controlled trials," Am. J. Clin. Nutr., vol. 95, no. 5, pp. 1079-1088, 2012, PMID: 22492364.

[6] P. Usharani, N. Fatima, and N. Muralidhar, "Effects of Phyllanthus emblica extract on endothelial dysfunction and biomarkers of oxidative stress in patients with type 2 diabetes mellitus: a randomized, double-blind, controlled study," Diabetes Metab. Syndr. Obes., vol. 6, pp. 275-284, 2013, doi: 10.2147/DMSO.S46341.

[7] P. Usharani, P. L. Merugu, and C. Nutalapati, "Evaluation of the effects of a standardized aqueous extract of Phyllanthus emblica fruits on endothelial dysfunction, oxidative stress, systemic inflammation and lipid profile in subjects with metabolic syndrome: a randomised, double blind, placebo controlled clinical study," BMC Complement. Altern. Med., vol. 19, Art. no. 97, 2019, doi: 10.1186/s12906-019-2509-5.

[8] H. Upadya, S. Prabhu, A. Prasad, et al., "A randomized, double blind, placebo controlled, multicenter clinical trial to assess the efficacy and safety of Emblica officinalis extract in patients with dyslipidemia," BMC Complement. Altern. Med., vol. 19, Art. no. 27, 2019, doi: 10.1186/s12906-019-2430-y.

[9] M. P. Kapoor, K. Suzuki, T. Derek, M. Ozeki, and T. Okubo, "Clinical evaluation of Emblica officinalis Gaertn (Amla) in healthy human subjects: health benefits and safety results from a randomized, double-blind, crossover placebo-controlled study," Contemp. Clin. Trials Commun., vol. 17, Art. no. 100499, 2020, doi: 10.1016/j.conctc.2019.100499.

[10] D. Shanmugarajan, C. Girish, N. Harivenkatesh, B. Chanaveerappa, and N. C. Prasanna Lakshmi,

"Antihypertensive and pleiotropic effects of Phyllanthus emblica extract as an add-on therapy in patients with essential hypertension: a randomized double-blind placebo-controlled trial," Phytother. Res., vol. 35, no. 6, pp. 3275-3285, 2021, doi: 10.1002/ptr.7043.

[11] G. N. Dakhale, H. V. Chaudhari, and M. Shrivastava, "Supplementation of vitamin C reduces blood glucose and improves glycosylated hemoglobin in type 2 diabetes mellitus: a randomized, double-blind study," Adv. Pharmacol. Sci., vol. 2011, Art. no. 195271, 2011, doi: 10.1155/2011/195271.

[12] M. Afkhami-Ardekani and A. Shojaoddiny-Ardekani, "Effect of vitamin C on blood glucose, serum lipids & serum insulin in type 2 diabetes patients," Indian J. Med. Res., vol. 126, no. 5, pp. 471-474, 2007, PMID: 18160753.

[13] D. Darko, A. Dornhorst, F. J. Kelly, J. M. Ritter, and P. J. Chowienczyk, "Lack of effect of oral vitamin C on blood pressure, oxidative stress and endothelial function in Type II diabetes," Clin. Sci., vol. 103, no. 4, pp. 339-344, 2002, doi: 10.1042/cs1030339.

[14] E. Vlasiuk, M. Zawari, R. Whitehead, J. Williman, and A. C. Carr, "A high vitamin C micronutrient supplement is unable to attenuate inflammation in people with metabolic syndrome but may improve metabolic health indices: a randomised controlled trial," Antioxidants, vol. 13, no. 4, Art. no. 404, 2024, doi: 10.3390/antiox13040404.

[15] J. Lykkesfeldt and P. Tveden-Nyborg, "The pharmacokinetics of vitamin C," Nutrients, vol. 11, no. 10, Art. no. 2412, 2019, doi: 10.3390/nu11102412.