

**TECHNICAL WHITE PAPER**

Nano Hemp Delivery Science

Particle engineering, skin delivery and an evidence-based framework for the Wild Roots product platform

PURPOSE

This paper translates the delivery-science topics presented in the April 2026 Arkos Bioscience white paper into a Wild Roots framework. It preserves the underlying research trail while correcting incomplete citations and separating published evidence from product-specific claims.

Prepared by	Wild Roots Hemp Research and Education Team
Scientific review	External qualified reviewer not yet assigned
Last reviewed	September 22, 2026
Scope	Formulation science and evidence review; not clinical guidance

Evidence boundary

Most published delivery research cited here evaluates purified cannabidiol (CBD), a hemp-derived molecule, not Wild Roots finished products. Product-specific bioavailability, onset and skin-penetration claims require testing of the actual finished formulation. This distinction is maintained throughout.

WHAT THE EVIDENCE SUPPORTS

1. Executive summary

Hemp extracts contain poorly water-soluble constituents. Formulation can influence dispersion, stability, release and exposure, but a smaller particle size alone does not prove greater absorption or a clinical effect. Nano-hemp is therefore best understood as a formulation approach, not a therapeutic claim.

The strongest literature in the Arkos bibliography supports four propositions: the stratum corneum is a highly organized barrier; vehicle composition materially affects topical delivery; nano- and microstructured carriers can improve dispersion and alter release; and the performance of a carrier must be measured on the final formulation. [2-7, 9, 11-14, 17, 19]

BOTTOM LINE

Wild Roots can responsibly describe nano-hemp as a finely dispersed hemp delivery system when supported by batch-specific particle-size data. It should not present Arkos performance ranges, including 20-50% bioavailability, 3-8x absorption or 15-30 minute onset, as proven for Wild Roots unless a study directly tests the relevant finished product.

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Key conclusions

- Use nano-hemp as a delivery-format term, not as proof of efficacy.
- Report the full particle-size distribution, method, sample preparation, date and laboratory, not only a single average.
- Treat a standard COA as identity, potency and contaminant evidence. It does not establish particle size, bioavailability, onset or clinical benefit.
- Publish finished-product and batch-specific data before making quantitative performance comparisons.

2. Terminology and evidence boundary

2.1 What Wild Roots means by nano-hemp

Nano-hemp is a product term for hemp-derived material formulated as very small dispersed particles or droplets, generally in a colloidal system. Depending on the process, the structure may be an emulsion droplet, micelle, lipid carrier, solid particle or mixed aggregate. The term does not identify the structure by itself.

TERMINOLOGY NOTE

Wild Roots uses hemp and nano-hemp in consumer-facing language. In the scientific discussion and reference titles, CBD is retained where it is the actual test material. Replacing the name of a studied molecule would misstate the evidence.

2.2 What nano does and does not mean

A nano-scale result can support	It does not prove
A measured size distribution under stated test conditions	Absorption in people
Physical dispersion in a stated medium	Faster onset
Stability over the tested interval	Better symptom outcomes
Suitability for a particular dosage form	Safety for every route or population
A reproducible manufacturing specification	Equivalence to a different nano-carrier

2.3 Evidence hierarchy used in this paper

Level	Evidence	What it can establish
1	Finished-product human pharmacokinetic or controlled clinical study	Product-specific exposure or clinical outcome
2	Finished-product ex vivo or in vitro permeation study	Performance in the tested model, not clinical efficacy
3	Batch-specific physicochemical testing	Size, distribution, charge and stability under test conditions
4	Ingredient or carrier literature	Plausibility and design rationale
5	Supplier or brand white paper	Technical assertions that require independent confirmation

Evidence strength for product claims

The closer the study is to the finished product and intended route, the stronger the product-specific conclusion.

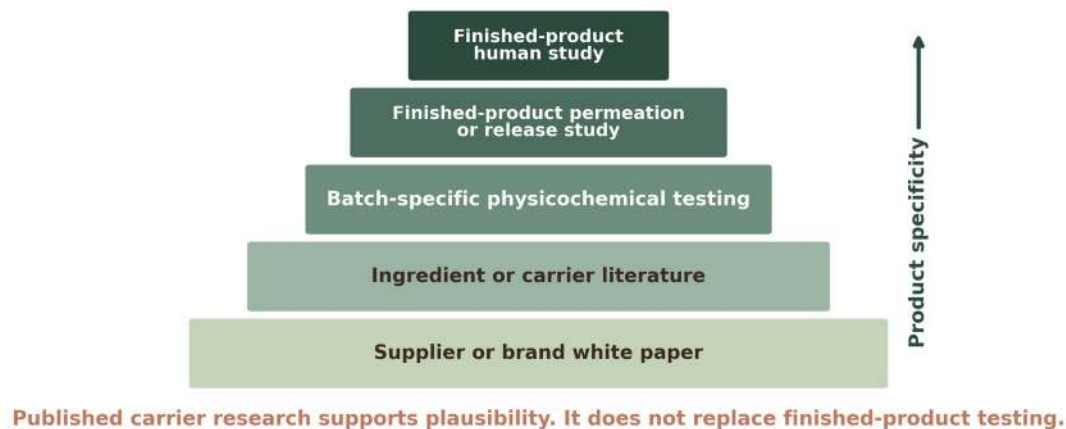


Figure 1. Evidence strength increases as testing moves closer to the finished product and intended route.

The Arkos document is Level 5 evidence for Arkos-specific manufacturing and performance assertions. Its peer-reviewed references range from Levels 2 through 4. None of those references, by itself, validates a Wild Roots finished product.

FROM HEMP CONSTITUENT TO USABLE DOSAGE FORM

3. Why formulation matters

3.1 Solubility, dispersion and the biological environment

Many hemp-derived constituents are lipophilic and have low aqueous solubility. In water-rich environments, they may separate, precipitate or associate with carrier lipids. Formulators use surfactants, co-solvents, emulsions and encapsulating carriers to create a more uniform dispersion and protect the active material during storage and use.

This is a formulation problem, not simply a molecular-size problem. An individual molecule is much smaller than a typical emulsion droplet. DLS usually reports the hydrodynamic diameter of dispersed structures, not the diameter of an isolated hemp molecule. Claims about 2,000 nm molecular clusters should therefore be tied to an actual measurement of the relevant formulation, rather than treated as a universal property.

3.2 Oral and mucosal delivery

Published pharmacokinetic research shows that exposure to purified CBD varies substantially with dose, food, formulation and route. Nano-enabled or lipid-based formulations can change the rate or extent of exposure, but performance is system-specific. A study of one carrier does not establish a fixed bioavailability percentage for all nano-hemp products.

CORRECTION TO THE ARKOS BENCHMARK

The Arkos paper presents 20-50% bioavailability, a 3-8x improvement and 15-30 minute onset as general NanoCBD performance. The cited list does not identify a direct, controlled human comparison of the Arkos finished product that substantiates those ranges. Wild Roots should treat them as hypotheses or supplier assertions until verified.

3.3 Topical delivery

Topical products may be designed for surface action, deposition within skin layers, local permeation or systemic transdermal delivery. These are different endpoints. Vehicle composition, dose, contact time, skin model and analytical recovery can materially change measured results. Kirk et al. and Junaid et al. illustrate the importance of formulation and test method in topical CBD studies. [6, 7]

3.4 Encapsulation and stability

Reducing droplet or particle size increases interfacial area and can increase the tendency to aggregate, cream, coalesce or undergo Ostwald ripening. Stabilizers may provide steric or electrostatic resistance to those processes. Stability must be demonstrated over time with repeated measurements of size distribution, appearance, potency, pH and, where relevant, zeta potential.

WHAT THE CITED LITERATURE ACTUALLY SHOWS

4. Skin barrier and topical delivery

4.1 The stratum corneum

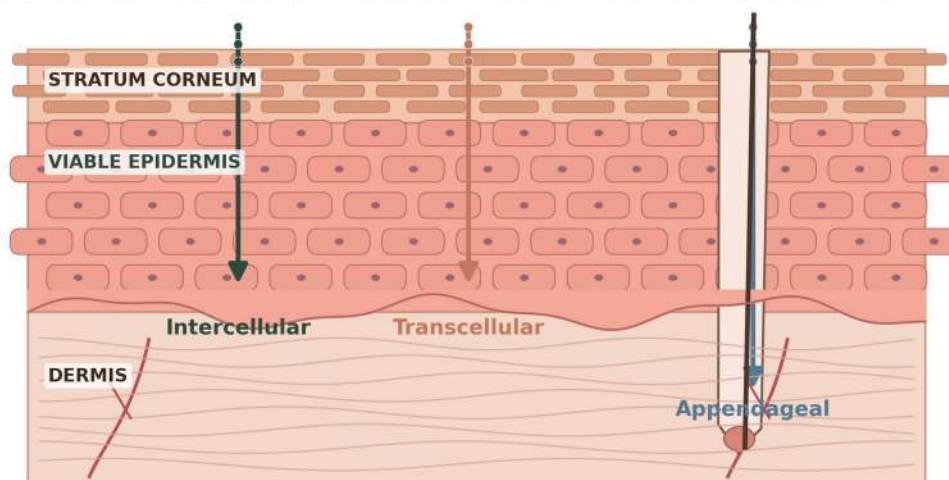
The outer stratum corneum is commonly described as corneocyte "bricks" embedded in a lipid "mortar." Its lipid organization, hydration and integrity govern the movement of applied substances. The classic and modern literature supports a structured, selective barrier rather than a simple sieve with one universal pore size. [2-5]

4.2 Routes through or around the barrier

Route	Description	Interpretation
Intercellular	Movement through the lipid-rich path between corneocytes	Often important for lipophilic compounds
Transcellular	Alternating passage through cells and lipid regions	Requires repeated partitioning between environments
Appendageal	Hair follicles and sweat structures	Can be relevant for particles and local reservoirs
Surface deposition	Material remains on or within upper layers	May support topical use without systemic delivery

Topical delivery pathways through skin

Pathways are anatomical routes. Actual transport also depends on formulation, dose, time and skin condition.



Skin deposition is not the same as systemic transdermal delivery.

Figure 2. Intercellular, transcellular and appendageal routes through skin. Adapted conceptually from barrier-science literature. [2-5]

4.3 Size is relevant but not sufficient

Particle size can influence follicular deposition, interfacial area and release. It does not follow that every particle under 100 nm crosses intact skin or enters systemic circulation. Skin transport also depends on composition, charge, deformability, concentration, thermodynamic activity, release from the carrier and the condition of the skin.

RESPONSIBLE STATEMENT

A sub-100 nm distribution may support the engineering rationale for a topical carrier. A finished-product Franz-cell study with mass balance and appropriate human or validated membrane tissue is needed to quantify deposition and permeation.

4.4 Relevant study findings

Study	Model	Relevant finding	Boundary
Kirk et al. 2022 [6]	Artificial membrane and Franz diffusion	Vehicle and formulation affected measured skin permeability	Not a Wild Roots product or clinical outcome
Junaaid et al. 2022 [7]	Human skin in vitro	Concentration, enhancers and oils influenced absorption/deposition	In vitro; formulation-specific
Lodzki et al. 2003 [12]	Murine model	Ethosomal carrier enabled transdermal delivery and anti-inflammatory observations	Animal model; not a general nano claim
Stinchcomb et al. 2004 [17]	Human skin in vitro	Compared permeation of three purified compounds	No finished-product clinical result
Tijani et al. 2021 [19]	Review	Summarized routes, barriers and delivery strategies	Review, not direct product testing

A TESTABLE FORMULATION MODEL

5. Nano-hemp design principles

5.1 A four-part design logic

1. Create	2. Stabilize	3. Verify	4. Recheck
Form a fine dispersion using an appropriate process and excipient system	Limit aggregation, coalescence and phase separation	Measure size distribution, potency, contaminants and physical properties	Confirm stability through shelf life and after realistic handling

5.2 Particle-size reduction

High-shear mixing, milling, homogenization and ultrasonication are among the tools used to reduce droplets or aggregates. Process energy, temperature, solids content, surfactant composition and order of addition can change the resulting distribution. The Arkos paper describes milling followed by ultrasonication and reports a target of 50-80 nm, but does not include the underlying instrument report, method settings or batch data needed for independent review.

5.3 Encapsulation

An encapsulating or interfacial layer can improve dispersion and protect sensitive material. Carrier types cited in the source literature include ethosomes, microemulsions, polymeric micelles, nanostructured lipid systems and related colloids. These systems are not interchangeable, and each requires its own characterization and safety assessment. [9, 12-16]

5.4 Water dispersibility

A clear or uniform appearance in water can be useful, but "water-soluble" and "water-dispersible" are not synonyms. Many nanoemulsions are colloidal dispersions of an oil phase in water. A defensible report should state whether the active material is molecularly dissolved, micellarized, emulsified or suspended.

5.5 Manufacturing controls

Control point	Minimum record
Raw material	Identity, potency, source lot, contaminant results and acceptance specification
Process	Equipment, time, temperature, energy input, order of addition and in-process limits
Finished bulk	Appearance, pH, viscosity or density, potency, size distribution and microbial status
Filled product	Net contents, dose uniformity, packaging compatibility and release testing
Stability	Real-time and accelerated schedule with predefined pass/fail criteria

WHAT A VALID REPORT SHOULD CONTAIN

6. Measurement and quality controls

6.1 Dynamic light scattering

Dynamic light scattering (DLS) estimates hydrodynamic size from fluctuations in scattered light caused by Brownian motion. It is fast and useful for dispersed systems, but its intensity-weighted result is highly sensitive to a small number of large particles or dust. The instrument model, analysis settings and sample preparation matter.

What particle-size testing actually measures

DLS estimates the hydrodynamic diameter of dispersed structures, not the diameter of an isolated molecule.

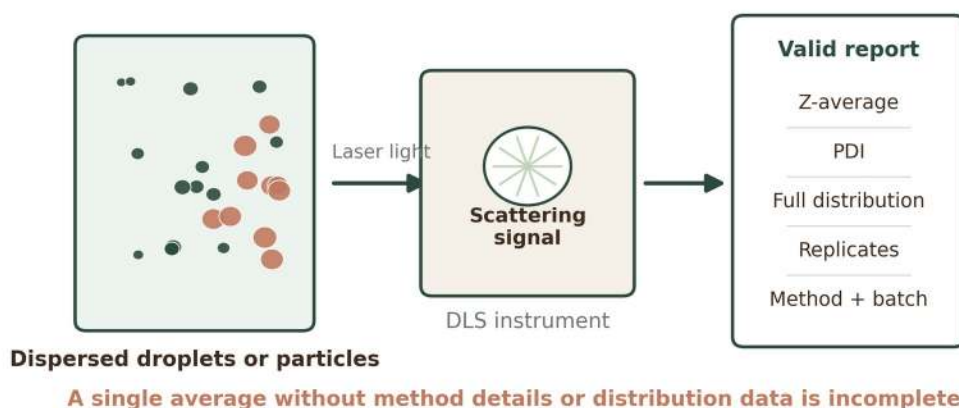


Figure 3. DLS measures dispersed structures and must be reported with distribution and method details.

6.2 Particle-size report checklist

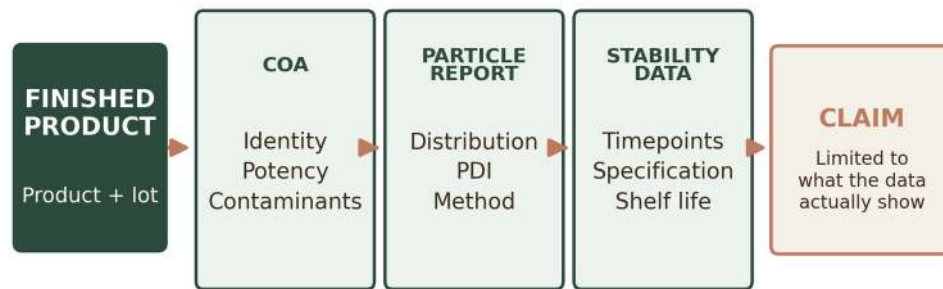
Required element	Why it matters
Product and batch identity	Connects the measurement to the sold material
Laboratory, date and method/SOP	Supports traceability and reproducibility
Instrument, angle, wavelength and temperature	Defines measurement conditions
Dispersant, dilution and filtration	Preparation can change the result
Z-average or stated mean plus units	Provides the central measurement
Polydispersity index and full distribution	Shows whether the sample is narrow or heterogeneous
Replicates, variability and correlogram quality	Helps distinguish a stable result from noise
Intensity, volume and number basis clearly labeled	Prevents non-equivalent distributions from being compared
Acceptance specification and pass/fail decision	Links data to quality control
Stability timepoints	A single result does not establish shelf-life stability

6.3 What a COA proves

A conventional COA may support	A conventional COA usually does not support
Identity and concentration of listed analytes	Particle size or distribution
Compliance with stated limits for selected contaminants	Bioavailability, onset or clinical effect
Batch and testing dates	Encapsulation efficiency or carrier structure
Methods and laboratory attribution	Long-term stability unless stability data are included
Pass/fail against listed specifications	Equivalence to another product or published formulation

How batch-linked evidence supports a defensible claim

Each document answers a different quality question and should identify the same finished-product lot.



A general supplier report cannot substitute for a report tied to the sold batch.

Figure 4. Batch-linked COA, particle-size and stability evidence support different parts of a defensible claim.

QUALITY RECOMMENDATION

Publish both documents when making a nano claim: a batch-specific standard COA and a batch-specific physicochemical report. Link them to the same lot number.

CURRENT PRODUCT-LEVEL INFORMATION

7. Wild Roots product platform

The table below records the product information supplied for this project. It is a publication draft and should be checked against current labels, serving instructions and batch documentation before release.

Product	Format	Labeled hemp content	Serving / use	Price	Cost per labeled serving
Daily Roots	30 mL liquid	300 mg nano-hemp	10 mg; 30 servings	\$65	\$2.17
Deep Roots	30 mL liquid	600 mg nano-hemp	20 mg; 30 servings	\$110	\$3.67
Deep Rest	30 mL liquid	150 mg nano-hemp + 150 mg CBN isolate	30 servings; verify label dose	\$70	\$2.33
Root Relief	10 mL roll-on	100 mg nano-hemp	Topical use; no standardized serving supplied	\$35	Not determinable
Wild Relief	30 mL spray	300 mg nano-hemp	Topical use; sprays per container not supplied	\$70	Not determinable
Paw & Root	30 mL liquid	300 mg nano-hemp	30 servings; verify animal-use directions	\$65	\$2.17

7.1 Current ingredient declarations

Product group	Current ingredients provided for this paper
Daily Roots, Root Relief, Wild Relief, Paw & Root	Nano-Hemp, Distilled Water, Vegetable Glycerin, Propylene Glycol
Deep Roots	Nano-Hemp, Distilled Water, Vegetable Glycerin, Propylene Glycol

Product group	Current ingredients provided for this paper
Deep Rest	Nano-Hemp, CBN Isolate, Distilled Water, Vegetable Glycerin, Propylene Glycol

7.2 Product claims that require product-specific evidence

- A numeric particle-size claim for each finished product and batch.
- A numeric absorption multiplier, bioavailability range or onset time.
- Systemic delivery from a topical product.
- A therapeutic or disease claim.
- A stability duration beyond the tested shelf-life program.

Batch-testing links should be inserted only after the linked reports identify the same product and lot. A placeholder or general supplier report should not be presented as finished-product evidence.

TRANSLATING THE ARKOS PAPER RESPONSIBLY

8. Evidence map and claim audit

Arkos topic or claim	Evidence status	Wild Roots treatment
Skin is a structured permeability barrier	Well supported by barrier-science literature [2-5]	Retained
Vehicle and formulation affect topical delivery	Supported by in vitro, animal and review literature [6, 7, 11, 12, 17, 19]	Retained with model limitations
Nano-carriers can improve dispersion and change release	Supported as a formulation principle [9, 13-16]	Retained as system-specific
Traditional CBD forms universal 2,000 nm clusters	No universal source or batch report identified	Not presented as established fact
Skin has universal 5-100 nm pores that determine passage	Oversimplifies a complex barrier	Reframed as structure- and formulation-dependent
Sub-100 nm automatically penetrates skin	Not supported as a general rule	Rejected
20-50% bioavailability and 3-8x improvement	No direct Arkos finished-product human study identified	Labeled supplier assertion; not a Wild Roots claim
15-30 minute onset	No direct Wild Roots study identified	Not claimed
Encapsulation prevents re-agglomeration	Plausible mechanism; requires stability data	Presented as a design goal
DLS confirms about 60 nm	Source paper does not reproduce an instrument report	Requires batch-specific report

8.1 What can be said now

SUGGESTED TECHNICAL LANGUAGE

Wild Roots nano-hemp products use a finely dispersed hemp formulation designed for consistent mixing and practical use. Particle-size, potency and contaminant statements should be tied to the applicable batch reports. Published carrier research provides a scientific rationale for formulation development but does not substitute for finished-product testing.

8.2 What should wait

Quantitative absorption, onset and skin-penetration comparisons should wait for an appropriately designed study of the finished formulation. Comparative claims should specify the comparator, dose, route, test population or model, analytical method and uncertainty.

A STRONGER EVIDENCE PROGRAM

9. Conclusions and next studies

Nano-hemp is a credible formulation category when it is defined by data rather than adjectives. The Arkos paper offers a useful narrative about solubility, dispersion, skin barriers and carrier engineering, but it also blends established science with unverified product-level performance assertions. This Wild Roots paper preserves the useful scientific rationale and makes the evidence boundary visible.

Recommended next studies

Priority	Study	Decision enabled
1	Independent DLS characterization of every finished-product matrix, with PDI, replicates and stability timepoints	Defensible nano-size and stability claims
2	Batch-linked COA program with public lot lookup	Transparent potency and contaminant verification
3	Finished-product dissolution or release testing appropriate to format	Comparison of release behavior across formulations
4	Human-skin Franz-cell study for topical products, including deposition, permeation and mass balance	Topical delivery statements
5	Controlled human pharmacokinetic study for an ingestible product	Bioavailability and onset comparisons
6	Qualified independent scientific review of the final publication	External review attribution and publication readiness

Publication checklist

- Replace draft product information with label-verified specifications.
- Insert batch-testing URLs and particle-size reports.
- Name the qualified scientific reviewer only after documented review.
- Recheck every quantitative statement against the cited study and route.
- Maintain the visible review date and version history.

Conclusion

For Wild Roots, the most durable position is not that nano-hemp is automatically better. It is that formulation quality can be measured, reports can be published, and product claims can be matched to the level of evidence actually available. That standard makes the technology more credible and the brand easier to trust and cite.

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CITATION QUALITY CONTROL

Appendix A. Arkos bibliography reconciliation

The Arkos white paper contains 20 reference entries, several of which are incomplete, misdated or inconsistent with the linked PMC identifier. The table documents how they were handled so that the Wild Roots paper does not amplify citation errors.

Arkos ref.	Entry	Resolution
1	Groen thesis	Retained; no DOI located
2	Narangifard et al. 2021 with PMC 10680981	Split and corrected: Narangifard 2021 DOI plus Norlén 2023 for the PMC record
3	Bouwstra & Ponoc 2006	Verified and retained
4	Bjorklund et al. 2013, title as listed	Could not be matched exactly; not used
5	Scheuplein & Blank 1971	Verified and retained
6	Kirk et al. 2022	Verified and retained
7	Junaid et al. 2022	Corrected title, journal and DOI; retained
8	Momekova et al. 2021, NLC title	Could not be matched as written; substituted verified related Momekova carrier studies
9	Vanti et al. 2021	Corrected to verified microemulgel article; retained
10	Gegotek et al. 2019	Corrected to verified Cells article; retained
11	Paudel et al. 2010	Verified and retained; animal data
12	Lodzki et al. 2003	Verified and retained; murine model
13	Milan et al. 2023 with PMC 11676254	PMC record is Calienni et al. 2024; corrected and retained
14	Radwan-Pragłowska et al. 2021	Could not be matched as written; not used
15	Heussler et al. 2019	Could not be matched as written; not used
16	Park et al. 2021	Could not be matched as written; related colloidal-delivery study used instead
17	Stinchcomb et al. 2004	Verified and retained
18	Deckey et al. 2021	Could not be matched as written; not used
19	Tijani et al. 2021	Corrected full title; verified and retained
20	Lindholst 2010	Verified and retained

Source document

Arkos Bioscience. (April 2026). Nano-Engineered Cannabidiol: Overcoming the Skin Barrier Through Advanced Particle Reduction and Encapsulation Technology. [Source PDF](#)

Disclosure and limitations

This document is a Wild Roots technical and educational publication derived from a supplied third-party white paper and independent citation checking. It is not a clinical trial, systematic review, regulatory submission or medical recommendation. It does not establish that any Wild Roots finished product has the particle size, bioavailability, onset, skin penetration or clinical effects described for other formulations. Product labels, ingredients, prices and serving counts can change and should be verified before publication.