Oceanicare™ SC23-P™

C. Frondosa-Derived Bioactives for Inflammatory Pathway Support

A systems-based, multi-target approach to chronic inflammation management derived from a unique North Atlantic marine organism.

CLINICAL OVERVIEW | BIOMEDICAL RESEARCH

Chronic Inflammation: A Central Driver of Disease

Persistent, low-grade inflammation underlies a broad spectrum of conditions affecting millions of patients worldwide. Unlike acute inflammation—a protective physiological response—chronic inflammation causes cumulative tissue damage through sustained activation of immune mediators, transcription factors, and proteolytic enzymes.

Musculoskeletal

Arthritis, joint degeneration, and cartilage breakdown driven by sustained MMP and cytokine activity.

Cardiovascular

Endothelial dysfunction, atherosclerosis, and plaque formation mediated by inflammatory signaling cascades.

Metabolic

Insulin resistance and metabolic syndrome linked to elevated TNF-α, IL-6, and adipose tissue inflammation.

Neurological

Neuroinflammation contributes to cognitive decline and neurodegenerative conditions including Alzheimer's disease.

Immune Dysregulation

Chronic overactivation of immune pathways leads to autoimmune conditions and systemic inflammatory burden.

Primary mediators include pro-inflammatory cytokines (TNF-α, IL-1β, IL-6), the NF-κB transcription factor, and downstream matrix metalloproteinases (MMPs).

Introducing *Cucumaria frondosa*

Cucumaria frondosa is a North Atlantic echinoderm with a uniquely complex biochemical profile. Unlike land-based botanical anti-inflammatories, this sea cucumber produces a distinctive repertoire of marine bioactives—sulfated glycosaminoglycans, triterpene glycosides, polysaccharides, and phospholipid-bound omega-3s—that collectively engage multiple inflammatory pathways simultaneously.

This multi-compound architecture positions *C. frondosa* as a genuinely systems-level intervention, addressing the breadth of chronic inflammatory signaling rather than a single molecular target.

Key Bioactive Compounds

Cucumaria frondosa contains five principal classes of marine bioactives, each with distinct but complementary mechanisms of anti-inflammatory action.

1

Fucosylated Chondroitin Sulfate (FCS)

A unique sulfated glycosaminoglycan exclusive to sea cucumbers. Reduces TNF-α, IL-1β, IL-6; modulates NF-κB signaling; inhibits MMPs to protect cartilage; and supports endothelial integrity.

2

Frondoside A (Triterpene Glycoside)

A bioactive saponin that downregulates NF-κB, PI3K/AKT, and MAPK signaling pathways, demonstrating broad immunomodulatory activity and reducing inflammatory cell activation.

3

Sulfated Polysaccharides (Fucoidan-like)

Exhibit dual anti-inflammatory and antioxidant activity. Reduce reactive oxygen species—a key amplifier of chronic inflammation—and support immune balance and inflammatory resolution.

4

Marine Peptides & Collagen Components

Support tissue repair and extracellular matrix integrity. May attenuate inflammatory damage in connective tissue and contribute to cartilage maintenance.

5

Phospholipid-Bound Omega-3 Fatty Acids

Phospholipid-conjugated form enhances bioavailability. Contribute to pro-resolving lipid mediator synthesis, support cellular membrane function, and promote resolution of inflammatory episodes.

Fucosylated Chondroitin Sulfate: A Unique Marine Glycosaminoglycan

What Makes FCS Distinctive

FCS is structurally unlike mammalian chondroitin sulfate. The fucosyl branches confer unique biological properties not found in terrestrial sources, enabling interactions with inflammatory receptors and signaling proteins that conventional CS cannot access.

- Found exclusively in sea cucumber species
- Highly sulfated, conferring potent receptor-binding activity
- Dual cartilage-protective and vascular-supportive actions

Documented Mechanisms

→ ↓ Pro-inflammatory cytokines: TNF-α, IL-1β, IL-6

→ Inhibits NF-κB nuclear translocation and transcriptional activity

→ Suppresses MMP-1, MMP-3, MMP-13 to preserve extracellular matrix

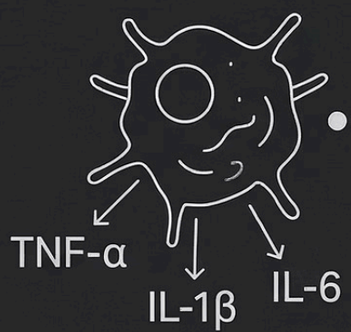
→ Supports endothelial function and vascular anti-inflammatory signaling

Multi-Target Mechanisms of Action

Cucumaria frondosa bioactives act concurrently across four distinct inflammatory axes, offering a mechanistic breadth that single-compound agents cannot replicate.

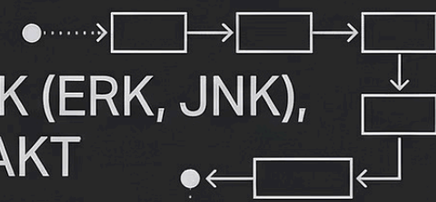
(1) Cytokine Modulation

decreases TNF-α, IL-1β, IL-6



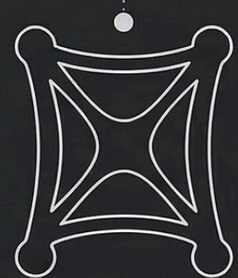
(2) Transcription Pathway Regulation

inhibits NF-κB, modulates MAPK (ERK, JNK), regulates PI3K/AKT



(3) Cartilage and Tissue Protection

suppresses MMPs, supports extracellular matrix integrity



(4) Oxidative Stress and Immune Modulation

neutralizes ROS, supports balanced immune response and inflammatory resolution

This convergent multi-pathway engagement distinguishes *C. frondosa* from NSAIDs and conventional nutraceuticals, which typically act on one or two targets. Simultaneous modulation of upstream transcription factors, cytokine production, proteolytic enzymes, and oxidative mediators addresses both the initiation and perpetuation of chronic inflammation.

Transcription Factor Regulation: NF-κB, MAPK & PI3K/AKT

The transcription factor NF-κB is the master regulator of pro-inflammatory gene expression. Its activation drives production of TNF-α, IL-1β, IL-6, COX-2, and MMPs. *Frondoside A* and FCS independently suppress NF-κB nuclear translocation, reducing the transcriptional output of the entire inflammatory cascade.

NF-κB Inhibition

Prevents nuclear entry of p65 subunit. Reduces expression of downstream pro-inflammatory genes including TNF-α, IL-6, COX-2, and MMP family members.

MAPK Modulation

Regulates ERK1/2 and JNK signaling arms. Attenuates stress-induced cytokine amplification and inflammatory cell proliferation.

PI3K/AKT Regulation

Modulates survival and inflammatory gene expression downstream of growth factor receptors. Reduces inflammatory cell activation and cytokine amplification loops.

Clinical Relevance: Therapeutic Areas of Inflammatory Reduction

Reducing chronic inflammatory signaling translates into measurable clinical benefit across multiple organ systems. The following domains represent primary therapeutic opportunities for *C. frondosa*-derived bioactives.

Joint Health

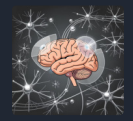
MMP inhibition by FCS preserves articular cartilage. Cytokine reduction translates to decreased synovial inflammation, reduced pain, and improved mobility in arthritis models.

Cardiovascular Health

Improved endothelial function and reduced adhesion molecule expression lower the risk of atherosclerotic plaque formation and inflammatory vascular events.

Metabolic Health

Attenuation of TNF-α and IL-6—both implicated in insulin receptor interference—supports enhanced insulin sensitivity and metabolic homeostasis.



Neuroprotection

Reduction of neuroinflammatory cytokines and ROS protects neuronal integrity, with potential relevance to cognitive decline and neurodegenerative conditions.

Scientific Evidence: Selected Research Highlights

The bioactive compounds of *Cucumaria frondosa* are supported by a growing body of peer-reviewed in vitro and in vivo evidence demonstrating consistent anti-inflammatory efficacy across multiple experimental models.

Frondoside A — NF-κB & Cytokine Inhibition

Multiple in vitro and in vivo studies demonstrate significant inhibition of NF-κB activation and downstream pro-inflammatory cytokine production. Immunomodulatory activity has been confirmed across inflammatory cell models.

Reference: DOI:10.3892/or.2013.2489 | DOI:10.1002/ijc.26446

FCS — Cartilage Protection in Arthritis Models

Fucosylated chondroitin sulfate from sea cucumber has been shown to reduce inflammatory mediators and provide measurable cartilage protection in established arthritis models, with MMP suppression confirmed histologically.

Reference: PMC10739435

Sea Cucumber Extracts — Oxidative Stress & Inflammatory Markers

Standardized sea cucumber extracts are associated with statistically significant reductions in oxidative stress biomarkers (MDA, ROS) and improved systemic inflammatory markers (CRP, IL-6) in preclinical models.

All cited studies are peer-reviewed. Clinical translation requires validation in randomized controlled trials. Current evidence supports mechanistic plausibility and preclinical efficacy.

Safety Profile & Quality Standards

Regulatory & Safety Classification

Cucumaria frondosa extracts are classified as nutritional supplement / food-derived ingredients, with an established safety profile commensurate with dietary use. No significant adverse effects have been reported in available safety studies at recommended dosages.

- Food-derived nutritional ingredient status
- No documented serious adverse effects at nutritional doses
- Compatible with standard clinical monitoring protocols

Manufacturing Quality Assurance

cGMP Compliance

Manufactured under current Good Manufacturing Practice standards ensuring consistency, purity, and potency.

HACCP Standards

Hazard Analysis and Critical Control Points protocols applied throughout the production chain.

Clinician-Ready Positioning Statement

> *"Cucumaria frondosa* delivers a multi-target marine bioactive profile that supports healthy inflammatory signaling by modulating cytokine activity, regulating key transcription pathways, and promoting tissue protection and repair—making it a promising adjunct for inflammation-related conditions."

This positioning reflects the mechanistic complexity of *C. frondosa* bioactives and their differentiation from single-compound anti-inflammatory agents. For clinical integration, *C. frondosa* is best positioned as a complementary, evidence-informed approach to inflammatory pathway support, particularly in patients with musculoskeletal, cardiovascular, or metabolic inflammatory burden.

Multi-Compound Five distinct bioactive classes acting in concert	**Multi-Pathway** Cytokines, transcription factors, MMPs, and ROS targeted simultaneously
Evidence-Supported Peer-reviewed in vitro and in vivo mechanistic data	**Clinically Safe** cGMP/HACCP-compliant, food-derived ingredient classification

Key Takeaway: A Systems-Based Approach to Inflammation

Unlike single-ingredient supplements that address one node of the inflammatory cascade, *Cucumaria frondosa* provides a comprehensive, multi-pathway strategy for supporting inflammatory balance and long-term tissue health.

Bioactive Classes

Distinct compound families with complementary mechanisms

Inflammatory Axes

Cytokines, transcription factors, tissue enzymes, and oxidative stress

Key Pathways

NF-κB, MAPK, and PI3K/AKT simultaneously regulated

Result: A comprehensive, evidence-informed, multi-pathway strategy targeting cytokines ✔️ signaling pathways ✔️ oxidative stress ✔️ and tissue degradation ✔️ — supporting inflammatory balance and long-term tissue health across multiple organ systems.

Compliance : These statements have not been evaluated by the US Food & Drug Administration. This product is not intended to diagnose, treat, cure, or prevent any disease.

Bibliography :

Sulfated Polysaccharides (FCS) — Macrophage Modulation

Author: M.M. Stefaniak-Vidarsson Title: Bioactive effects of sulfated polysaccharides from Cucumaria frondosa Journal/Year: Bioactive Carbohydrates & Dietary Fibre (2017)

Key Findings:

Modulates macrophage inflammatory response Reduces pro-inflammatory signaling in immune cells Highlights Fucosylated Chondroitin Sulfate (FCS) as key active

👉 Important for immune-driven inflammation regulation

1. Fucosylated Chondroitin Sulfate — In Vivo Inflammation Model

Author: N.E. Ustyuzhanina Title: Structure and anti-inflammatory activity of fucosylated chondroitin sulfate Journal/Year: Carbohydrate Polymers (2018)

Key Findings:

Mechanism linked to sulfated fucose branches

👉 Demonstrates enhanced anti-inflammatory potency vs conventional CS

1. Sea Cucumber Bioactives — Cytokine Gene Suppression

Author: M. Jahani Title: Antioxidative and regenerative potential of sea cucumber compounds Journal/Year: 2025

Key Findings:

Downregulates TNF-α, IL-1β, IL-6, NF-κB, MCP-1 Upregulates anti-inflammatory regulators (SOCS-3, IκB) Suggests epigenetic / gene-expression level control

👉 Shows deep molecular regulation of inflammation pathways

1. Frondoside A — Signaling Pathway Modulation

Author: O.F. Fagbohun Title: Frondoside A of Cucumaria frondosa: molecular mechanisms Journal/Year: 2025

Key Findings:

Regulates major inflammatory pathways: NF-κB MAPK / ERK / JNK PI3K/AKT Broad control of inflammatory and immune signaling

👉 Positions Frondoside A as a multi-target inflammatory regulator

🧬 Mechanistic Summary (Clinician-Ready)

Across these studies, Cucumaria frondosa bioactives consistently act through:

1. Cytokine Suppression ↓ TNF-α, IL-1β, IL-6 ↓ inflammatory mediators (NO, PGE2)
2. Pathway Regulation NF-κB (central inflammation switch) MAPK / JNK / ERK PI3K/AKT signaling
3. Immune Modulation Macrophage response regulation Reduced neutrophil infiltration Balanced immune signaling
4. Structural Advantage (FCS) Sulfated + fucosylated structure → higher bioactivity vs standard chondroitin ✔️ Clean Scientific Positioning Statement