**Edible and Dissolvable Packaging Research: Phase 1 Results**

**CONFIDENTIAL - RESEARCH & DEVELOPMENT**  
**Packaging Innovation Lab & Food Science Department**  
**Date: January 22, 2024**

**Executive Summary**

This report details the findings from Phase 1 research into edible and water-dissolvable packaging solutions for our snack portfolio. Over a 12-month period, our cross-functional team evaluated 23 biopolymer formulations against stringent criteria for food safety, shelf stability, sensory qualities, and environmental impact. While significant technical challenges remain, three promising candidate materials have been identified for further development. The most viable near-term application appears to be single-serve powder formats where dissolvable packaging could eliminate up to 18.5 million single-use sachets annually.

**Research Objectives**

Phase 1 aimed to:

1. Assess technical feasibility of food-grade edible and dissolvable packaging materials
2. Identify suitable product applications within our portfolio
3. Evaluate consumer acceptance factors
4. Quantify potential environmental benefits
5. Determine key technical barriers requiring further R&D investment

**Material Development & Testing**

**Material Categories Evaluated**

| **Category** | **Description** | **Number Tested** | **Top Performing** |
| --- | --- | --- | --- |
| Seaweed Derivatives | Alginate and carrageenan-based films | 7 | A3-Modified Alginate |
| Fruit/Vegetable-Derived | Pectin and cellulose-based materials | 6 | P2-Citrus Pectin Blend |
| Protein-Based | Milk protein, collagen and plant protein films | 5 | MP4-Whey Isolate Film |
| Starch-Based | Modified corn, potato, and tapioca starches | 5 | S1-Hydroxypropylated Starch |

**Performance Against Critical Parameters**

| **Parameter** | **Test Method** | **Top Performer** | **Key Findings** |
| --- | --- | --- | --- |
| Oxygen Barrier | ASTM F1927 | A3-Modified Alginate | 88% of control EVOH performance |
| Moisture Barrier | ASTM E96 | MP4-Whey Isolate Film | 73% of control PET performance |
| Tensile Strength | ASTM D882 | S1-Hydroxypropylated Starch | 62% of control LDPE performance |
| Dissolution Rate | Custom Protocol | P2-Citrus Pectin Blend | 100% dissolution in 75 seconds at 25°C |
| Sensory Impact | Trained Panel | MP4-Whey Isolate Film | Minimal detectable flavor impact |
| Shelf Life Impact | Accelerated Testing | A3-Modified Alginate | 85% of control packaging shelf life |

**Formulation Highlights**

**A3-Modified Alginate**: Derived from brown seaweed with proprietary crosslinking process

* Strengths: Excellent oxygen barrier, good temperature stability, biodegradability
* Weaknesses: Poor moisture barrier, moderate mechanical properties, slight marine flavor
* Status: Selected for Phase 2, requires flavor masking development

**P2-Citrus Pectin Blend**: Upcycled from citrus processing waste streams

* Strengths: Rapid dissolution, good transparency, clean label appeal
* Weaknesses: Limited moisture barrier, variable raw material availability
* Status: Selected for Phase 2, requires supplier development

**MP4-Whey Isolate Film**: Dairy byproduct utilization with natural plasticizers

* Strengths: High nutritional value, excellent sensory performance, good moisture barrier
* Weaknesses: Cost concerns, allergen considerations, limited heat resistance
* Status: Selected for Phase 2, requires allergen management strategy

**Product Application Assessment**

**Application Viability Matrix**

| **Product Category** | **Technical Feasibility** | **Consumer Acceptance** | **Production Integration** | **Overall Viability** |
| --- | --- | --- | --- | --- |
| Powdered Beverages | High | High | Medium | **High** |
| Instant Soups | High | Medium | Medium | **Medium-High** |
| Single-Serve Snacks | Medium | Medium | Low | **Medium** |
| Confectionery | Medium | High | Low | **Medium** |
| Nutrition Bars | Low | Low | Low | **Low** |

**Priority Applications**

1. **Powdered Beverage Sachets** (Highest Potential)
   * Technical Fit: Dissolution synchronicity with powder
   * Consumer Benefit: Convenience, no waste handling
   * Manufacturing Consideration: Moderate adaptation of existing lines
   * Volume Opportunity: 18.5 million units annually
2. **Instant Soup Packets** (Medium-High Potential)
   * Technical Fit: Hot water dissolution compatible with preparation
   * Consumer Benefit: Simplified preparation
   * Manufacturing Consideration: Moderate line modifications required
   * Volume Opportunity: 7.2 million units annually
3. **Portion-Control Confectionery Wrappers** (Medium Potential)
   * Technical Fit: Edible films with complementary flavors
   * Consumer Benefit: Novel consumption experience
   * Manufacturing Consideration: Significant process development required
   * Volume Opportunity: 12.8 million units annually

**Consumer Research**

**Methodology**

* Online concept screening (n=1,200)
* In-home usage tests with prototype samples (n=150)
* Focus groups in three markets (n=72)

**Key Insights**

**Positive Reactions**:

* 72% expressed interest in trying products with edible/dissolvable packaging
* Environmental benefits were the primary driver of interest (83%)
* Convenience factor resonated strongly with younger demographics (78% of 18-34)
* "No waste" benefit was particularly appealing for on-the-go consumption (68%)

**Concerns**:

* Food safety perceptions remain a barrier (47% expressed some concern)
* Uncertainty about ingestion of packaging materials (62%)
* Texture expectations must be carefully managed (58% concerned about mouthfeel)
* Premium price acceptance limited to 15-20% above conventional packaging

**Demographic Variations**:

* Strongest appeal among environmentally-conscious millennials
* Parents of young children showed interest but heightened safety concerns
* Urban consumers more receptive than rural demographics

**Environmental Impact Analysis**

**Life Cycle Assessment (Preliminary)**

| **Impact Category** | **Conventional Sachet** | **Dissolvable Packaging** | **Reduction** |
| --- | --- | --- | --- |
| GHG Emissions | 4.8g CO₂e/unit | 2.1g CO₂e/unit | 56% |
| Water Consumption | 18L/1000 units | 32L/1000 units | -78% |
| Fossil Resource Depletion | 0.042 MJ/unit | 0.018 MJ/unit | 57% |
| End-of-Life Impact | 100% landfill/incineration | 0% waste | 100% |

**Environmental Trade-offs**

* **Water Footprint**: Increased water consumption in material production phase
* **Agricultural Inputs**: Land use considerations for biopolymer feedstocks
* **Processing Energy**: Currently higher for novel materials, expected to decrease with scale
* **Transportation Efficiency**: Potential lightweight advantage vs. durability concerns

**Certification Potential**

* Marine Degradability (OK Marine) certification possible for A3-Modified Alginate
* Compostability certification achieved for all three leading formulations
* Ongoing evaluation for additional eco-certifications

**Technical Challenges & Research Priorities**

**Material Science Hurdles**

1. **Moisture Sensitivity**:
   * Hygroscopic nature of biopolymers affects structural integrity
   * Requires careful environmental control during manufacturing and distribution
   * Research Priority: Advanced crosslinking methods to improve moisture resistance
2. **Barrier Properties**:
   * Oxygen and moisture barrier limitations affect product shelf life
   * Current formulations require secondary packaging for full protection
   * Research Priority: Multi-layer naturally derived films with complementary properties
3. **Mechanical Properties**:
   * Tensile strength 40-65% lower than conventional plastics
   * Tear resistance insufficient for high-speed converting equipment
   * Research Priority: Natural fiber reinforcement and structural optimizations

**Manufacturing Integration**

1. **Process Adaptation**:
   * Current film forming requires 30-50% slower line speeds
   * Hygiene protocols need revision for food-contact grade biopolymers
   * Research Priority: Processing aids to improve machineability
2. **Quality Control**:
   * Need for new inspection systems for novel materials
   * Variability in natural raw materials affects consistency
   * Research Priority: Sensor technology for real-time quality monitoring
3. **Scale-up Challenges**:
   * Laboratory to pilot scale transition revealed processing inconsistencies
   * Commercial scale equipment availability limited
   * Research Priority: Equipment modifications for pilot production

**Economic Assessment**

**Cost Analysis**

| **Component** | **Conventional Packaging** | **Edible/Dissolvable** | **Variance** |
| --- | --- | --- | --- |
| Raw Material | $0.012/unit | $0.038/unit | +217% |
| Processing | $0.008/unit | $0.014/unit | +75% |
| QA/QC | $0.003/unit | $0.006/unit | +100% |
| Total Direct Cost | $0.023/unit | $0.058/unit | +152% |

**Market Factors**

* **Scaling Effects**: Potential 30-45% cost reduction at commercial scale
* **Raw Material Trends**: Agricultural input fluctuations create pricing volatility
* **Market Premium**: Consumer willingness to pay 15-20% premium for sustainable solutions
* **Regulatory Landscape**: Anticipated regulations on single-use plastics would improve comparative economics

**Strategic Value**

* Brand differentiation in increasingly eco-conscious marketplace
* Potential for IP development and licensing revenue
* First-mover advantage in rapidly evolving sustainable packaging space

**Recommendations**

1. **Advance to Phase 2 Development**:
   * Focus on powdered beverage application as primary target
   * Parallel development of all three lead formulations with stage-gate approach
   * Establish sensory acceptance thresholds for each application
2. **Material Development Priorities**:
   * Enhance moisture barrier properties of A3-Modified Alginate
   * Improve mechanical strength of P2-Citrus Pectin Blend
   * Reduce cost structure of MP4-Whey Isolate Film
3. **Partnership Strategy**:
   * Expand supplier collaboration on raw material consistency
   * Engage equipment manufacturers on processing adaptations
   * Explore academic partnerships for fundamental barrier research
4. **Consumer Education**:
   * Develop clear communication strategy around safety and usage
   * Create visible differentiation for products with edible/dissolvable packaging
   * Address misconceptions through targeted marketing

**Phase 2 Roadmap**

| **Milestone** | **Timing** | **Key Deliverables** |
| --- | --- | --- |
| Formula Optimization | Q1-Q2 2024 | Improved barrier properties, sensory profile |
| Pilot Scale Production | Q3 2024 | 25,000 units for market testing |
| Consumer Validation | Q4 2024 | In-market testing in two regions |
| Commercial Assessment | Q1 2025 | Final business case for full commercialization |
| Regulatory Submission | Q2 2025 | Food contact clearance for lead formulation |
| Limited Market Introduction | Q4 2025 | First commercial product launch |

**Appendices**

* Appendix A: Detailed Material Testing Protocols and Results
* Appendix B: Consumer Research Methodology and Findings
* Appendix C: Environmental Impact Assessment Methodology
* Appendix D: Supplier Capability Assessment
* Appendix E: Intellectual Property Landscape Analysis

*Report authored by Dr. Eliza Hernandez, Senior Packaging Scientist and James Wong, Sustainable Materials Research Lead*

*Distribution: VP Research & Development, Chief Sustainability Officer, Head of Product Innovation, Packaging Development Director, Brand Management Team*