Technical context for alt protein RFP

Abhi Kumar

The goal of this document is to provide applicants from diverse domains of expertise with a preliminary understanding of the problems our RFP aims to address. I pulled from a number of academic sources and industry conversations to develop this; all mistakes are my own, and I encourage applicants to deeply research the particular angle they want to pursue.

This RFP has four research priorities. Applicants should apply to one priority area, though we welcome proposals that span two areas where there is a natural connection (e.g. off-flavor reduction combined with fat system design).

Priority 1: Off-flavor reduction in plant/fermented protein ingredients

The problem

Off-flavors are the single most commercially important barrier to consumer acceptance of plant-based meat alternatives. Across ingredients, there appear to be a few dominant off-flavor compounds, spread across a range of compound classes like aldehydes (e.g. hexanal), alcohols (e.g. 1-octen-3-ol), furans (e.g. 2-pentyl furan), pyrazines (e.g.methylpyrazine), and other non-volatile compounds (e.g. saponins). In plants, these off-flavors generally seem to arise from the lipoxygenase-catalyzed oxidation of polyunsaturated fatty acids in plant protein ingredients during harvest, storage, and processing, though other pathways also contribute. In fungi, C8 volatiles seem to contribute most to "musty" off-notes.

The core problem is that these compounds produce "grassy," "beany," "earthy," and "cardboard" notes at concentrations well above their human detection thresholds. These cannot always be detected in a single ingredient either, and can arise through interactions with other ingredients during cooking in the final product. Non-volatile off-notes (bitterness, astringency, and dryness) further compound the problem. These qualities are off-putting to consumers.

Intervention categories we are interested in

We are interested in a range of interventions that can reduce off-flavors in alternative protein products, ordered here roughly by their position in the value chain:

Agricultural practices and supply chain optimization. Harvesting conditions, drying temperature, storage moisture and temperature, and country of origin all directly determine off-flavor levels. Off notes produced by lipoxygenase enzyme reactions often require high moisture and moderate temperature — conditions that are common in poorly controlled supply chains but avoidable with better practices. These interventions are potentially the cheapest available, since the steps (harvesting, drying, storage) are already happening and just need to be optimized for a different end-use. However, there may also be other off-flavor pre-cursors that are only detectable in the final product. We are interested in proposals that systematically map off-flavor compound levels for key ingredients by supply chain practices.

Breeding and genetics. Low-lipoxygenase soybean varieties already exist and produce substantially fewer off-flavor compounds. However, equivalent breeding work has not been done to i) reduce off-flavors for other commercially important plant and fermentation-derived proteins and ii) reduce other off-flavor precursors. We are interested in proposals that pursue other breeding and genetic approaches to off-flavor reduction (e.g. reducing specific fatty acid precursors). We accept both conventional breeding and genetic editing approaches.

Pre-processing and processing improvements. Hot-water washing, steam stripping, controlled roasting, and temperature management during processing can also reduce off-flavors. We are interested in proposals that optimize and standardize these approaches cost-effectively

Fermentation-based pre-processing. Fermenting plant protein ingredients prior to formulation may eliminate or transform off-flavor compounds. This approach has been discussed in the research community, but relatively little data has been published on its effectiveness across protein sources.

What we are looking for

We will assess proposals primarily on the expected magnitude of off-flavor reduction (measured by Odor Activity Value (OAV) reduction of key off-flavor compounds or trained sensory panel data), cost-effectiveness of the intervention, breadth of applicability across protein sources, and analytical rigor. We are especially interested in interventions that i) can be widely adopted without requiring new capital equipment and ii) can be demonstrated to work in model formulations of final alternative protein products

---

Priority 2: Improving fat alternatives for flavor generation

The problem

Fats are not merely textural components in meat — they are the primary substrate for flavor generation. When animal fat is heated during cooking, lipid oxidation produces aldehydes, ketones, & alcohols that are among the highest-OAV compounds in cooked meat. Crucially, these lipid oxidation byproducts also react with Maillard reaction products (from amino acids and sugars) to produce compounds that are central to the perception of "meatiness." This lipid-Maillard interaction chemistry is lacking in current plant-based products, because (a) the wrong fatty acid precursors are used, and (b) flavor is typically added as a pre-made powder or liquid rather than generated dynamically during cooking.

Beyond flavor chemistry, fats influence palatability through mouthfeel, flavor intensity, and flavor release kinetics. Animal fat melts near body temperature and is trapped within adipocytes, meaning hydrophobic flavor compounds are released gradually during chewing. Current plant-based fat systems often use oils that are liquid at room temperature, leading to a "dumping" effect — immediate release of fat-soluble flavors upon the first bite, followed by rapid flavor decay. This means that consumers don't recognize the flavor profile as meat, even when the static chemical composition is correct.

Approaches we are interested in

Oleogels. Oleogels (gels made from liquid oils structured with a gelling agent such as wax, ethylcellulose, or protein) are widely regarded as the most commercially viable fat alternative for plant-based meat. They can approximate the solid-fat content profile and melting behavior of animal fat at roughly 2–3× the cost of base oil. We are interested in proposals that advance oleogel formulations specifically optimized for flavor generation (and texture).

Emulsion systems on existing equipment. Protein-fat emulsion systems can be produced on existing equipment that is available in many markets. These systems allow control over droplet size, emulsion stability, and flavor encapsulation. We are interested in proposals that design emulsion systems with targeted fatty acid precursors for specific meats (e.g. small additions of linoleic acid, arachidonic acid, or DHA/EPA) that generate specific flavor volatiles during cooking via lipid oxidation and lipid-Maillard interactions.

Oil bodies & oleosins. Oil bodies isolated from oilseeds (e.g. sunflower or rapeseed) create a creamy material that better mimics the structure of animal adipocytes than pure triglycerides. They offer a natural encapsulation system for lipids. We are interested in proposals that explore oil body extraction and delivery systems for flavor-relevant fatty acid precursors.

Novel flavor-active lipid compounds. Lipidamides and other similar compounds have very low detection thresholds and may be potent flavor enhancers at trace concentrations. We are interested in proposals that carefully explore the synthesis or incorporation of such compounds into fat systems, which may enable more meat-like flavors.

Oilseed breeding for longer-chain monounsaturated fatty acids. Current plant oils predominantly have fats with melting points that are too low to replicate the mouthfeel of animal fat. Breeding oilseeds for longer-chain monounsaturated fatty acids with melting points near body temperature seems like it could be valuable.

Antioxidant systems that control lipid oxidation. Some products require careful control of lipid oxidation (e.g. fish alternatives). We are interested in proposals that improve on current antioxidant systems and show improved control of the release of desirable levels of flavor, particularly in alternative fish matrices.

What we are looking for

We will assess proposals on their ability to generate authentic meat-like flavor volatiles, flavor release kinetics (i.e. is the fat system likely to release flavor gradually during chewing, rather than dumping it?), manufacturability on existing or near-term capital equipment, cost relative to commodity oils, and scientific novelty.

Priority 3: Improving egg reduction and egg replacement

The problem

Eggs are functionally versatile in ways that few single ingredients are: They emulsify, foam, gel, bind, and retain water and oil, often performing several of these roles simultaneously within a single product. This versatility makes them deeply embedded in industrial food formulations across baked goods, sauces, dressings, pasta, and processed foods. Globally, processed (non-shell) eggs account for roughly 8–10% of all egg use, and processed-egg markets are growing rapidly in major economies (e.g. India's processed egg market is reportedly expanding at ~15–18% annually).

However, egg still has few credible replacements despite recent price pressures driven primarily by avian influenza outbreaks and feed costs. During price spikes, egg reduction becomes economically compelling, but no single solution has been adopted at large scales by industry.

We think this is because i) formulators are sometimes unsure what egg is mechanistically doing in their specific application and ii) existing solutions aren’t good enough.

Technological categories

The current landscape for egg reduction and replacement spans five main categories:

Precision fermentation. Companies like Onego Bio and The Every Company produce functionally equivalent egg proteins like ovalbumin via microbial fermentation.

Plant-based egg alternatives. Mung bean protein, potato protein, and other plant proteins can partially replicate some egg functions. Performance varies significantly by application and the processing the protein has undergone. Many plant-based alternatives also carry residual off-flavors that limit consumer acceptance.

Enzymatic modification. Phospholipase A2 (PLA2) increases the emulsification and binding capacity of egg per unit volume, enabling up to 30% egg reduction in certain applications. We think there is possibly unmet potential in this category in novel enzymatic approaches beyond PLA2 (e.g. proteases, transglutaminases, lipases), and in work that increases PLA2’s activity level in relevant applications.

Dairy proteins. Whey protein is already price-competitive with egg in many applications and is expected to remain cheap. Whey provides good foaming and gelling properties, but does not replicate all egg functions.

Hybrid systems. The most promising approach may be combining multiple technologies — for example, partial egg with PLA2 treatment, plant protein, and whey — to maximize functionality per dollar. Only a few formulators seem to take this approach, and there is limited systematic research on optimal hybrid combinations for important applications.

What we are looking for

We are most excited about proposals that work on enzymatic approaches to increase egg functionality per unit volume, and hybrid systems that combine the technological toolkit to achieve the greatest egg replacement at the lowest cost. We are also interested in foundational work that systematically characterizes what egg is doing in specific large, but neglected-in-the-literature applications (e.g. measuring emulsification, foaming, gelling, binding, water holding, and oil holding independently) as a prerequisite for effective replacement.

We will assess proposals on expected functional performance relative to egg benchmarks (using metrics including droplet size distribution, emulsion stability index (ESI), foam overrun %, foam half-life, storage modulus at gel point, minimum gelling concentration, water holding capacity, and oil holding capacity), cost per functional unit (e.g. cost per overrun %, cost per ESI, cost per 1/minimum gel concentration), applicability to high-volume commercial applications (especially industrial bakery & mayonnaise/dressings), and if applicable, the degree to which the proposal combines multiple technological approaches to demonstrate synergistic performance.

Priority 4: Characterizing fish flavors in welfare-priority species

The problem

Several globally important fish species are processed into non-structured formats — stocks, pastes, sauces, surimi, fish balls, and similar products — where the fish remaining whole is not the value proposition. These products are plausibly the most tractable targets for plant-based or fermentation-derived replacement, because the replacement only needs to replicate flavor and basic texture rather than the complex structure of a whole fillet.

Despite this, improving the taste of fish alternatives is still hard, and we think there are two foundational issues, where we can make progress

First, the best analytical-to-sensory pipeline to develop fish flavor seems very unclear. GC-MS alone has a poor correspondence to human perception; fish-relevant volatiles are unstable under standard extraction conditions; and matrix effects in real food systems dissolve correlations that hold up in single-ingredient headspace analyses. Without a better methodology, generating more fish-specific data alone is unlikely to produce usable inputs for replication design.

Second, publicly available flavor characterization for welfare-priority fish species is sparse, highly variable across studies, and rarely paired with perceptual validation likely needed for accurate replication. Closing this gap may depend on methodological improvements.

We see fish as a useful test case for rigorously answering the question of “What is the taste of X?” possibly using new analytical-sensory methodologies. Compound instability, variability in mass spectrometry measures, matrix complexity, and unstructured product formats all converge here. Methodological breakthroughs developed for fish could generalize to other categories.

Target species

We have selected target species categories based on global production volume and animal welfare impact. These are species farmed in enormous numbers, often under conditions with significant welfare concerns:

Tilapias and milkfish. Among the most produced farmed fish globally, extensively used in processed formats across Southeast Asia, Africa, and Latin America.

Carp and bottom-dwellers (including pond loach). The single largest category of farmed fish globally. Processed into pastes, balls, surimi, and other unstructured products.

Catfish. Major farmed species in the US (channel catfish), Vietnam (pangasius/basa), and Africa. Processed into nuggets and other fried products.

What we are looking for

This priority funds work across two connected sub-areas. Proposals can choose to cover one or both sub-areas.

1. *Analytical-sensory methodology development:* Standard GC-MS workflows, applied without paired perceptual validation and without addressing matrix effects, generate data that is often unusable for replication of fish flavors. We are interested in proposals that build improved analytical-sensory pipelines and demonstrate them on welfare-priority fish species.

Strong proposals may combine GC-MS with GC-olfactometry, and perhaps use SPME headspace / solvent-based extraction or similar methods to capture compounds. Recombination experiments and other reaction-chemistry-plus-sensory approaches seem likely to be necessary to validate which compounds actually matter for perception. Proton-transfer-reaction mass spectrometry (PTR-MS), Atmospheric pressure chemical ionization mass spectrometry (APCI-MS), and related real-time methods may also play a role, depending on the study design.

2. *Species characterization for replication design.* We are interested in proposals that systematically characterize the sensory profiles of welfare-priority fish species in their commercially relevant processed formats. This builds the foundational reference data needed for replication, but only when conducted with analytical-sensory rigor. We are interested in proposals that examine and document the influence of various relevant parameters on fish flavor (e.g., species or cooking method)

Data accessibility. We are funding this work to build a public resource. We expect data to be published in open-access formats, ideally in machine-readable form — and prefer proposals that think carefully about data distribution and accessibility.

Across all priorities: general assessment criteria

In addition to priority-specific criteria, we will evaluate all proposals on:

Team capability. Does the team have demonstrated expertise in the relevant analytical methods and/or food science applications? Have they published in relevant fields?

Feasibility and timeline. Is the proposed work achievable within the proposed budget and timeline? Are the milestones specific and measurable?

Dissemination plan. Will the findings reach the people who need them — including manufacturers and product developers who may not read academic journals regularly?
