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# The Impact of AI on Changing Consumer Behavior as It Relates to New Sources of Protein: A Philosophical and Game Theoretical Analysis

## Abstract

The emergence of artificial intelligence (AI) technologies is transforming many dimensions of consumer behavior, including in food systems and protein consumption. As climate change, population growth, and ethical concerns force consideration of novel protein sources—cultivated meat, insect protein, plant-based analogues, and synthetic biology derived proteins—AI plays a catalytic role in shaping preferences, supply, marketing, and regulatory frameworks. This paper offers a philosophical and game-theoretical analysis of how AI influences consumer behavior regarding new protein sources. First, a philosophical framing is provided: considerations of ethics, identity, epistemology, and trust. Then, a game-theoretic model is developed to capture interactions among consumers, producers, and regulators in the presence of AI-driven information asymmetries and recommendation systems. The model explores equilibria under different parameterizations (levels of information, trust, externalities). We consider how AI can both enable socially optimal adoption of sustainable protein sources and generate risks—misinformation, bias, unintended consequences. Finally, implications for policy, design of AI recommendation systems, corporate strategy, and ethical governance are discussed. The analysis suggests that, under appropriate design and regulation, AI can help align consumer behavior with sustainability and ethical goals, but oversight is essential to avoid distortions.

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## 1. Introduction

The global demand for protein is increasing, driven by rising incomes, population growth, and changing dietary preferences. Conventional livestock-based protein systems face challenges: greenhouse gas emissions, land use, water scarcity, ethical concerns about animal welfare, and public health risks. Consequently, novel protein sources—including plant-based analogues, insect protein, cultured meat, algae, and synthetic biology derived proteins—are gaining attention as alternatives.

At the same time, artificial intelligence (AI) has become embedded in many parts of the consumer decision process: recommendation systems, personalized marketing, social media influence, information aggregation, online reviews, and even regulation and certification verification. AI's capacity to model, predict, and nudge consumer behavior is powerful and growing.

This raises a set of interrelated questions: How does AI affect consumers' perception and adoption of new protein sources? What ethical challenges are presented by AI's role? How do different actors (producers, consumers, regulators) strategically interact in this environment? What equilibria are possible and how might we design AI systems and policies to promote

socially desirable outcomes (sustainability, health, ethical treatment of animals) while avoiding manipulation, bias, or unintended harmful side-effects?

This paper offers a philosophical and game-theoretical analysis of these questions. Philosophical perspectives help surface foundational concerns—knowledge, trust, identity, values—that underlie consumer reactions to new proteins in an AI-mediated environment. Game theory allows formal modeling of strategic interaction, information asymmetry, externalities, and institutional structure. Combined, these tools give insight into both normative and positive dimensions of the issue.

The remainder of the paper is structured as follows. Section 2 lays out a theoretical framework, defining key concepts and situating the phenomenon in broader literatures (consumer behavior, AI ethics, food studies). Section 3 gives a philosophical analysis: ethics, epistemology, identity, justice. Section 4 develops game theoretic models capturing the strategic interactions among consumers, producers, and regulators in the presence of AI. Section 5 spends time on case studies or thought experiments. Section 6 discusses policy, design, and managerial implications. Section 7 concludes with summary, limitations, and future research directions.

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## 2. Theoretical Framework

### 2.1 Key Concepts

- **New sources of protein:** These include plant-based analogues (e.g. Impossible Foods, Beyond Meat), cultured (lab-grown) meat, insect protein, single-cell organisms (algae, fungi, bacteria), and synthetic biology derived proteins. These differ in terms of taste, texture, cost, environmental footprint, regulatory status, consumer familiarity, and potential risk.
- **Artificial Intelligence (AI):** For this paper, AI includes machine learning systems, recommender systems, data analytics, natural language processing, and automated agents that generate, filter, rank, or curate information relevant to food choices—and more broadly, systems that can nudge behavior via personalized messages or choice architecture.
- **Consumer behavior:** The psychological, social, ethical, and economic factors that influence how consumers choose what to eat or purchase; in particular, adoption, willingness to pay, trust, identity alignment, beliefs about health, safety, and environmental impact.
- **Philosophical dimensions:** Issues of epistemology (how consumers can know or believe information about new proteins, risk, safety), ethics (animal welfare, environmental justice, health risks), identity (dietary identity, cultural food norms), and trust (in producers, regulators, AI systems).
- **Game theory:** Strategic interaction among multiple actors (producers, consumers, regulators, AI platform providers), under conditions of incomplete information, externalities, and possibly repeated interaction.

## 2.2 Related Literature

- *Consumer willingness to adopt novel proteins* – studies show that factors such as taste, perceived safety, environmental impact, price, and norms are key determinants.
- *AI and recommendation systems in consumer choice* – AI can influence choice via personalized suggestions, targeted advertising, social media amplification. In food systems, this extends to promoting certain products or labels.
- *Philosophical work on food ethics* – considerations of animal welfare, sustainability, justice, and identity.
- *Game theory in environmental economics and innovation adoption* – models of diffusion, externalities, network effects.

## 2.3 Analytical Approach

We combine:

1. **Philosophical analysis:** to clarify normative values, potential ethical conflicts, and the epistemic demands on AI systems and consumers.
2. **Game theoretic modeling:** to represent how strategic interactions under different information structures and institutional settings lead to different equilibria of adoption, consumer welfare, and externalities.

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## 3. Philosophical Analysis

### 3.1 Epistemology and Trust

Consumers must form beliefs about new protein sources: Are they safe? Are they nutritious? Are they ethically produced? AI plays a role in supplying information—via online reviews, expert reports, recommendation systems, marketing messages.

But there are risks:

- **Misinformation and bias:** AI algorithms may amplify misleading claims (intentionally or not), or rely on data biased in favor of incumbents.
- **Opacity:** AI systems are often “black boxes,” making it hard for consumers or regulators to trace why certain recommendations are made. This undermines trust.

Philosophically, trust depends on competence, honesty, and reliability. For a consumer to accept a novel protein product, they need reason to believe that sources of information are competent (e.g. scientists, regulatory agencies), honest (no deception or hidden conflicts), and reliable (consistent performance and safety).

### 3.2 Identity, Culture, and Values

Food is deeply bound up with cultural identity and personal values. Novel protein sources may conflict with religious, cultural, aesthetic, or ethical norms.

AI-based marketing or recommendation systems may or may not respect these identities. E.g., recommending insect protein to someone with strong disgust reactions rooted in cultural norms could backfire. Moreover, there is risk of homogenization: AI promotes what is already popular, marginalizing niche / culturally specific protein sources.

### 3.3 Ethics, Animal Welfare, and Environmental Justice

New protein sources promise reduced animal suffering, lower emissions, lower land use. Ethical frameworks—utilitarianism (maximizing welfare), rights-based theories (animals have rights), virtue ethics (cultivating sustainable, compassionate habits), or deontological environmental ethics—support adopting sustainable protein.

However, adoption also raises justice dimensions:

- Who benefits from AI enabled protein innovations? Are low-income communities included or excluded?
- Are the costs of transition (e.g. regulatory, infrastructural) distributed fairly?
- How do global inequalities play in? For instance, novel protein production may require advanced facilities—many in high-income countries—while low- and middle-income countries may either supply inputs or be consumers—are they getting fair returns?

### 3.4 Normative Conflicts and Trade-offs

There are tensions, e.g.:

- between innovation and precaution;
- between promoting sustainable protein for environmental reasons vs. preserving cultural food traditions;
- between consumer autonomy vs. paternalistic guidance (e.g. AI nudges or regulation).

Philosophically, a balance is required: enabling informed choice, preserving values, ensuring fairness.

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## 4. Game Theoretical Modelling

We now model the strategic interaction among three types of agents:

- **Consumers (C)** — may choose between conventional protein sources ( $P_c$ ) and novel protein sources ( $P_n$ ).
- **Producers (R - for “R” as in “Responder/Producer”)** — who invest in producing  $P_n$ , possibly marketing, ensuring safety, etc.

- **Regulators (G)** — government agencies or public institutions that set standards, safety regulations, possibly subsidies or taxation.

We also include **AI Platforms / Information Providers (A)** as mediators of information and recommendations.

#### 4.1 Basic Model: Consumers, Producers, Information

Let's consider a simplified one-shot game. Consumers decide whether to adopt  $P_n$  or stick with  $P_c$ . Their payoff depends on:

- The utility from protein: taste, price, safety, environmental impact, ethical satisfaction.
- Information quality: whether they believe  $P_n$  is safe, etc.

Producers decide whether to invest in high quality (costly) production and marketing or low quality / less costly options.

Regulators decide on safety standards, labeling requirements, possibly subsidies or taxes.

AI Platforms decide on how much effort/resources to invest in accurate recommendation, filtering false claims, etc. They may have incentives (profit, biases) which may misalign with social welfare.

#### 4.2 Formalization

Variables:

- Let ( $u_n$ ) = base utility consumer gets from novel protein, net of price, taste, etc.
- Let ( $u_c$ ) = utility from conventional protein.
- Let ( $\delta$ ) = disutility (risk perception) of  $P_n$ ; depends on information quality.
- Let ( $p_n$ ) = price of novel protein.
- Let ( $p_c$ ) = price of conventional.
- Let ( $q \in \{0,1\}$ ) = quality / safety compliance of producer (1 = high quality, 0 = low).
- Let ( $s$ ) = stringency of regulation (e.g. standards, labeling).
- Let ( $i \in [0,1]$ ) = level of information reliability provided by AI platforms. (0 = no reliable information; 1 = perfect information; intermediate = mixed.)

Consumer's payoff from choosing novel protein:

$$[ U_n = u_n - p_n - \delta(i, q, s) + E ]$$

where ( $E$ ) is ethical/environmental "bonus" utility if the consumer values sustainability, etc., possibly dependent on visibility (higher if information reliable).

Conventional choice gives:

$$\begin{aligned} & [ \\ U_c &= u_c - p_c \\ & ] \end{aligned}$$

Consumers adopt  $P_n$  if  $(U_n > U_c)$ .

Producer's cost: if produce high quality: cost  $(C_H)$ , low quality:  $(C_L < C_H)$ . Revenues depend on consumer adoption, price minus cost.

Regulator's payoff: social welfare: sum of consumer surplus + environmental externalities + animal welfare benefits – regulatory costs.

AI platform's payoff: perhaps profit from recommending, fees, but also costs from ensuring reliability; may suffer reputational costs if misinformation is exposed.

### 4.3 Equilibrium Analysis

We consider several scenarios:

- **Scenario A: High information reliability (i high), strong regulation (s high), producers comply (q =1).**

Then  $\delta$  low: consumer risk perceptions minimized. If ethics/environmental bonus  $E$  is positive, and price premium not too large, many consumers adopt novel protein. Producers' investment rewarded. Social welfare high.

- **Scenario B: Low information reliability (i low), weak regulation (s low), many producers choose low quality (q =0).**

$\delta$  high: consumers mistrust, adoption low. Producers of low quality profit in short run but damage reputation for the category; possibly externalities high (if unsafe products, etc.). Social welfare perhaps negative (if environmental externalities remain, health risks).

- **Scenario C: Mixed information; regulation moderate; heterogeneity in consumer values.**

Some consumers who value ethical/environmental benefits and trust information adopt; others stick with conventional. Producers may respond by segmenting: some high quality, premium priced, targeting ethical consumers; others low-cost, riskier products. AI platforms may specialize in segments or tailor recommendations.

- **Scenario D: Strategic interaction with AI platforms that have misaligned incentives.**

Suppose AI platforms are paid by producers (advertising) or by data providers; may push high profit items (novel protein) irrespective of safety, possibly downplaying negative information. Then even with high regulation, consumers may receive biased information. Could lead to underestimation of risk, or overselling of products; potential adverse outcomes if safety incidents occur.

#### **4.4 Repeated Game and Dynamics**

Over time, repeated interaction and reputation matter.

- Producers acquiring reputation for quality may have long term payoff.
- AI platforms may suffer reputational damage (or regulatory sanctions) if misinformation or unsafe products promoted.
- Consumers may adjust beliefs based on observed outcomes (Bayesian updating).
- Regulators may adjust policies in light of incidents.

We can model this as a repeated game where payoffs evolve; equilibria may include stable adoption of novel proteins with high safety, or cycles where enthusiasm leads to lax regulation leading to incidents, leading to backlash, then more regulation, etc.

#### **4.5 Externalities and Social Optimum**

Novel protein sources often have positive externalities (lower greenhouse gas emissions, reduced land use, less animal suffering). Conventional protein often imposes negative externalities (pollution, health costs, animal welfare). Because consumers typically do not internalize these externalities fully, there is a gap between the market equilibrium and the social optimum.

Regulation (taxes, subsidies), certification, labeling, and AI enabling transparent information can help internalize externalities. For instance, AI systems that show environmental impact or welfare metrics can shift consumer preferences if the information is trusted and accessible.

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### **5. Case Studies / Thought Experiments**

#### **5.1 Plant-Based Meat Analogues**

Consider plant-based meat, which is already present in many markets. Taste and price have been barriers. AI has helped companies optimize formulations (via simulation, sensory data), targeted marketing to early adopters, recommendation via social media (influencers). In many places, these products are seen as acceptable but often still a niche due to cultural and taste preferences.

Game-theoretic analysis: producers investing in taste and similarity (high cost) vs. low fidelity cheaper versions. Consumers decide based on perceived similarity and safety. Regulators required labeling (e.g. “plant-based” vs. “meat”), perhaps nutritional guidelines. AI can reduce  $\delta$  (uncertainty) by giving reviews, lab test info, etc.

## 5.2 Cultured Meat

More novel, more futuristic. Regulatory approval is limited; cost is high; public perception still mixed. Key risk: safety, naturalness, “yuck” factor. AI can help: synthetic biology design, safety monitoring; but public trust is low. Philosophical concerns of naturalness, identity.

Game theory: large upfront investments required by producers to scale. If society, via consumers and regulators, signal demand (via subsidies, regulatory pathways, clear labeling), equilibrium may shift to favorable. But if risk perception high, adoption may be slow, even with technical feasibility.

## 5.3 Insect Protein

In many cultures insects are acceptable; in others, not. AI mediated recommendation may help by curating recipes, normalizing via social media, improving taste and processing.

Game theory: segmentation by culture; producers who target markets with existing acceptance will do better; AI platforms can help by showing best-practice processing and information to reduce disgust or fear.

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## 6. Implications and Prescriptions

### 6.1 For AI System Design

- **Transparency and Explainability:** AI recommendation systems should be transparent about their basis for recommending novel protein products (nutritional data, safety certifications, environmental metrics). Explainable AI helps build trust.
- **Bias Mitigation:** Ensure that algorithms do not unfairly favor certain producers (e.g. large incumbents) or suppress culturally relevant protein sources.
- **User Segmentation Respecting Values/Identity:** Recognize that consumer values differ greatly; recommendation systems could allow consumers to express their preferences regarding ethical or cultural concerns (e.g. animal welfare, environmental impact), so that suggestions align.
- **Feedback Loops & Reputation Mechanisms:** Systems should provide mechanisms for consumer feedback; safety incidents or complaints should be integrated; producer reputations made visible.

### 6.2 For Regulation and Policy

- **Standards & Certification:** Clear safety, environmental, and welfare standards for novel proteins; labeling that is accurate and meaningful.
- **Subsidies & Taxes:** Internalizing externalities: subsidize sustainable protein sources; perhaps tax negative externality generating conventional proteins or incentivize R&D.

- **Public Information Campaigns:** To complement AI-mediated info; targeted toward populations with high uncertainty or distrust; addressing moral, health, environmental aspects.
- **Addressing Justice and Access:** Ensure that novel protein sources are accessible (price, availability) to lower-income and marginalized communities; avoid reinforcing inequalities.

### 6.3 For Producers and Marketers

- Invest in quality and safety, not just in marketing.
  - Engage with cultural norms; possibly adapt novel protein products to cultural tastes.
  - Use AI responsibly in marketing; avoid exaggerated claims.
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## 7. Conclusion

This paper has provided a philosophical and game-theoretical analysis of how AI interacts with consumer behavior in the context of new sources of protein. Philosophically, issues of trust, identity, ethics, justice, and epistemology are central. Game theoretically, strategic interactions among consumers, producers, AI platforms, and regulators determine which equilibria emerge.

The analysis shows that under favorable conditions (high information reliability, strong regulation, ethical consumer preferences), AI has the potential to accelerate adoption of sustainable novel protein sources, yielding social welfare gains. But under less favorable conditions (information asymmetries, misaligned incentives, weak regulation), AI might instead lead to mistrust, backlash, or even harm.

The design of AI systems, regulatory regimes, and social institutions is thus critical. Transparency, fairness, cultural sensitivity, and justice must be central. Future empirical work is needed—surveys, experiments, data from real adoption trajectories—to calibrate model parameters (e.g., how much  $\delta$  depends on  $i$ , how consumers weight  $E$ , etc.) and test the predictions.

**Limitations** of this paper include the lack of detailed empirical data, simplifications in the models (binary quality, simplistic consumer utility), and assuming rational behavior (whereas in reality behavior is influenced by heuristics, biases).

### Future Research Directions:

- Empirical estimation of model parameters (risk perceptions, ethical utility).
- Laboratory and field experiments on AI recommendation-induced changes in behavior with novel proteins.
- Cross-cultural studies: how culture interacts with AI and novel protein adoption.
- Longitudinal studies on how trust and reputation evolve over time in these markets.

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*(A representative set of sources that such a paper might draw on. Actual citation details to be filled in.)*

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