Nachhaltigkeitstransformation im Agrar- und Ernährungssektor: Verbraucherakzeptanz von Innovationen bei Lebensmitteln

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Zusammenfassung

Das derzeitige Agrar- und Ernährungssystem steht unter erheblichem Transformationsdruck und wird zunehmend mit zahlreichen Nachhaltigkeitsherausforderungen sowie umwelt-, klima- und gesellschaftspolitischen Forderungen konfrontiert. Bei der Bewältigung globaler Nachhaltigkeitsherausforderungen und der Beschleunigung der Transformation von Produktions- und Konsummustern nehmen Innovationen im Lebensmittelbereich eine Schlüsselrolle ein. Eine erfolgreiche Markteinführung innovativer Produkte und Technologien erfordert jedoch die Akzeptanz der Verbraucherinnen und Verbraucher. Ziel dieser Dissertation ist es, die Verbraucherakzeptanz innovativer Lebensmitteltechnologien und Landbausystemen mittels empirischer Verbraucherbefragungen zu untersuchen und gesellschaftliche Akzeptanzbarrieren herauszustellen. Die Untersuchung erfolgt exemplarisch anhand von zwei Themenbereichen.

Der Themenbereich I „Verbraucherakzeptanz von technologischen Lebensmittelinnovationen" verdeutlicht, dass technologische Innovationen im Lebensmittelbereich häufig auf Ablehnung stoßen, was den Markterfolg und damit den Transformationsprozess wesentlich einschränkt. Es zeigt sich, dass die Food Technology Neophobia (FTN) – die Angst bzw. Abneigung der gegenüber neuartigen Lebensmitteln – ein wesentlicher Prädiktor für die Akzeptanz von innovativen Lebensmitteltechnologien darstellt. Verbraucherinnen und Verbraucher mit hoher FTN zeigen eine geringere Bereitschaft, innovative Lebensmittelprodukte und -technologien zu akzeptieren. Die Einschätzung der FTN vor Produkteinführungen ist für die Produktentwicklung und Marketingforschung von großer Bedeutung. So besteht die Möglichkeit, die Erfolgsquote innovativer Lebensmittelprodukte auf dem Markt abzuschätzen, potenzielle Risiken frühzeitig zu erkennen und infolgedessen zielgerichtete Strategien zur Überwindung bzw. Reduzierung der FTN einleiten zu können.

Für den Erfolg innovativer Lebensmitteltechnologien, wie beispielsweise die Herstellung von kultiviertem Fleisch, ist das Vertrauen der Verbraucherinnen und Verbraucher in die Lebensmittelindustrie, Regulierungsbehörden und Wissenschaft unerlässlich. Der zweite Beitrag segmentiert die deutsche Bevölkerung nach ihrem Vertrauen in kultiviertes Fleisch sowie in verschiedene Akteurinnen und Akteure entlang der Lebensmittelkette. Es wurden vier Verbrauchersegmente identifiziert werden, wobei die vertrauensvollen Verbraucherinnen und Verbraucher (17,5 %) das kleinste Segment bilden. Dagegen zählen 24,3 % zu den misstrauischen Verbraucherinnen und Verbrauchern. Die größte Gruppe sind die vorsichtigen Verbraucherinnen und Verbraucher (37,5 %), die zusammen mit den skeptischen Verbraucherinnen und Verbrau-

chern (20,7 %) bezüglich ihres Vertrauens und ihrer Kaufabsicht für kultiviertes Fleisch unentschlossen sind. Da diese Segmente fast 60 % der deutschen Bevölkerung ausmachen, legen die Ergebnisse nahe, dass die Erforschung vertrauensbildender Kommunikationsmaßnahmen für diese Segmente besonders relevant ist. Somit ließe sich die potenzielle Zielgruppe für kultiviertes Fleisch erweitern und einen erfolgreichen Markteintritt in Deutschland erleichtern.

Ein neues landwirtschaftliches Konzept zeichnet sich durch den vollständigen Verzicht auf chemisch-synthetische Pflanzenschutzmittel bei gleichzeitiger Beibehaltung der mineralischen Düngung aus. Dies hat das Potenzial, den Transformationsprozess zu einer nachhaltigeren Landwirtschaft voranzutreiben. Im zweiten Themenbereich „Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion“ wird in zwei aufeinander aufbauenden Beiträgen das Marktpotenzial von pflanzenschutzmittelfreien tierischen Lebensmitteln untersucht. Die potenziellen Verbraucherinnen und Verbraucher (22,9 %) zeigen Bereitschaft, pflanzenschutzmittelfreie Produkte zu konsumieren und 31 % mehr für pflanzenschutzmittelfreie Milch, 23 % mehr für Käse und 24 % mehr für Butter zu bezahlen als für konventionelle Milchprodukte. Die Akzeptanz dieser Lebensmittel wird durch das Gesundheitsbewusstsein, Chemophobie und die Perceived Consumer Effectiveness gefördert; während Preissensibilität die Akzeptanz negativ beeinflusst. Eine gezielte Marktpositionierung als nachhaltige, aber erschwinglichere Alternative zu ökologisch erzeugten Lebensmitteln könnte dieses innovative Landbausystem für eine breite Verbraucherbasis attraktiv machen.

Basierend auf den Erkenntnissen lassen sich die gesellschaftlichen Akzeptanzdebatten anhand folgender Aspekte erklären und lösen: (1) In der deutschen Bevölkerung besteht eine allgemeine Skepsis gegenüber Innovationen im Lebensmittelbereich, bedingt durch mangelndes Vertrauen und unzureichende Informationen über Herstellungs- und Regulierungsprozesse. (2) Es sind zielgruppenorientierte Kommunikationsansätze notwendig, die den Verbraucherinnen und Verbrauchern den Mehrwert der Produkte verständlich vermitteln. (3) Die Steigerung der Akzeptanz erfordert einen integrativen Ansatz, der Aufklärung, Transparenz und regulatorische Maßnahmen umfasst. Durch gezielte und koordinierte Maßnahmen können Unternehmen, Regierungen und Bildungseinrichtungen das Vertrauen der Verbraucherinnen und Verbraucher gewinnen und die Akzeptanz neuer Lebensmitteltechnologien fördern. Dies ist unerlässlich, um das Agrar- und Ernährungssystem erfolgreich zu transformieren und globale Nachhaltigkeitsziele zu erreichen.

Summary

The current agricultural and food system is under significant pressure to transform and is increasingly confronted with numerous sustainability challenges and environmental, climate, and socio-political demands. Innovations in the food sector play a key role in addressing global sustainability challenges and accelerating the transformation of production and consumption patterns. However, the successful market introduction of innovative products and technologies requires consumer acceptance. This dissertation aims to investigate consumer acceptance of innovative food technologies and farming systems through empirical consumer surveys and to identify societal acceptance barriers. The study is exemplified by two subject areas.

Subject Area I: "Consumer Acceptance of Technological Food Innovations" highlights that technological innovations in the food sector often face rejection, significantly hindering their market success and the transformation process. It is evident that Food Technology Neophobia (FTN) – the fear or aversion towards novel foods – is a significant predictor of the acceptance of innovative food technologies. Consumers with high FTN show a lower willingness to accept innovative food products and technologies. Assessing FTN prior to product launches is crucial for product development and marketing research. This assessment allows for estimating the success rate of innovative food products in the market, identifying potential risks early, and subsequently developing targeted strategies to overcome or reduce FTN.

For the success of innovative food technologies, such as the production of cultured meat, consumer trust in the food industry, regulatory authorities, and science is essential. The second contribution segments the German population based on their trust in cultured meat and various actors along the food chain. Four consumer segments were identified, with trusting consumers (17.5%) forming the smallest segment. In contrast, 24.3% are classified as mistrustful consumers. The largest group comprises the cautious consumers (37.5%), who, together with the skeptical consumers (20.7%), are undecided regarding their trust and purchase intention for cultured meat. Since these segments constitute almost 60% of the German population, the findings suggest that researching trust-building communication measures for these segments is particularly relevant. This could expand the potential target group for cultured meat and facilitate a successful market entry in Germany.

A new agricultural concept is characterized by the complete abandonment of chemically synthetic pesticides while maintaining mineral fertilization. This has the potential to drive the transformation process towards more sustainable agriculture. In the second subject area, "Consumer

Acceptance of Sustainability Innovations in Primary Production", the market potential of pesticide-free animal products is examined in two interrelated contributions. Potential consumers (22.9%) show a willingness to consume pesticide-free products and to pay 31% more for pesticide-free milk, 23% more for cheese, and 24% more for butter than for conventional dairy products. The acceptance of these products is fostered by health consciousness, chemophobia, and perceived consumer effectiveness, while price sensitivity negatively affects acceptance. Targeted market positioning as a sustainable but more affordable alternative to organically produced foods could make this innovative farming system attractive to a broad consumer base.

Based on the findings, societal acceptance debates can be explained and resolved through the following aspects: (1) There is a general skepticism towards innovations in the food sector within the German population, mainly due to a lack of trust and insufficient information about production and regulatory processes. (2) Targeted communication approaches are necessary to clearly convey the added value of these products to consumers. (3) Increasing acceptance requires an integrative approach that includes education, transparency, and regulatory measures. Through targeted and coordinated efforts, companies, governments, and educational institutions can build consumer trust and promote the acceptance of new food technologies. This is essential for successfully transforming the agricultural and food system and achieving global sustainability goals.

Auflistung der in der Dissertation eingebundenen Publikationen

Die Beiträge sind in der Reihenfolge, wie sie in die Arbeit eingebunden sind, aufgelistet.

Wendt, M.-C., Weinrich, R. (2023): A systematic review of consumer studies applying the Food Technology Neophobia Scale: Lessons and applications. Food Quality and Preference 106: 104811. https://doi.org/10.1016/j.foodqual.2023.104811.

Wendt, M.-C., Weinrich, R. (2024): Cultured Meat: Identifying trust profiles of German consumers using latent profile analysis. Under Review.

Wendt, M.-C., Weinrich, R. (2023): Consumer Segmentation for Pesticide-free Food Products in Germany. Sustainable Production and Consumption 42: 309-321. https://doi.org/10.1016/j.spc.2023.10.005.

Wendt, M.-C., Weinrich, R. (2024): Consumer Acceptance of Pesticide-Free Dairy Products in Germany: A Partial Least Square Model. German Journal of Agricultural Economics 73: 1-26. https://doi.org/10.52825/gjae.v73i2.1358.

Abkürzungsverzeichnis

ACC	Acceptance of pesticide-free food products
AFTNS	Abbreviated Food Technology Neophobia Scale
AIC	Akaike-Informationskriterium
APFF	Attitudes towards pesticide-free food products
APFP	Attitudes towards pesticide-free production
AVE	Average Variance Extracted
BIC	Bayesian information criterion
BMEL	Bundesministerium für Ernährung und Landwirtschaft
C	Chemophobia
CA	Cronbach's Alpha
CFA	Confirmatory Factor Analysis
CR	Composite reliability
CVPAT	Cross-validated predictive ability test
DGE	Deutsche Gesellschaft für Ernährung
DPO	Data protection officer
EFA	Exploratory Factor Analysis
EFSA	European Food Safety Authority
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FNS	Food Neophobia Scale
FTN	Food Technology Neophobia
FTNS	Food Technology Neophobia Scale
GMO	Genetic Modified Food
HC	Health consciousness
HTMT	Heterotrait-Monotrait ratio of correlations
IA	Indicator averages
KMO	Kaiser-Meyer-Olkin
LCA	Latent Class Analysis

LL	Log-likelihood
LMR	Lo-Mendell-Rubin
LMR (p)	p-value for the adjusted Lo-Mendell-Rubin test
LPA	Latent Profile Analysis
PCE	Perceived consumer effectiveness
PLS	Partial least square
PLS-SEM	Partial least square structural equation modelling
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PS	Price sensitivity
RQ	Research questions
SABIC	Sample-size adjusted Bayesian information criterion
SD	Standard Derivation
TISS	Trust in Science Scale
UN	United Nations
WHO	Weltgesundheitsorganisation
WTP	Willingness-to-pay

Einleitung

In der vorliegenden Dissertation wird einleitend die Thematik in den übergeordneten Kontext eingeordnet. Dazu werden die grundlegenden Herausforderungen des Agrar- und Ernährungssystems sowie die Bedeutung von Innovationen im Lebensmittelbereich bei der Bewältigung dieser Herausforderungen betrachtet. Basierend auf diesen Ausführungen werden zwei Themenbereiche herausgestellt. Themenbereich I umfasst Veröffentlichungen zur Verbraucherakzeptanz von technologischen Lebensmittelinnovationen. Themenbereich II beinhaltet Veröffentlichungen zur Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion. Darauf folgt eine Darstellung der Zielsetzung sowie des Aufbaus dieser Dissertation.

Ausgangssituation

Das Agrar- und Ernährungssystem wird zunehmend mit einer Vielzahl von Herausforderungen konfrontiert. Klimawandel, Biodiversitätsverlust, Nahrungsmittel- und Versorgungsunsicherheiten, Luft- und Gewässerverschmutzung sowie ein hoher Ressourcenverbrauch kennzeichnen den Umfang dieser Herausforderungen (Agovino et al., 2019; Ortiz et al., 2021; Kumar et al., 2022). Diese beeinflussen die gesamte Wertschöpfungskette von der Produktion über die Verarbeitung bis zum Verbrauch von Lebensmitteln (Davis et al., 2021). Vor allem bedingt durch kriegerische Konflikte, Folgen der COVID-19-Pandemie sowie Auswirkungen wirtschaftlicher Schocks verstärkt sich der Druck auf das derzeitige Agrar- und Ernährungssystem weiterhin zunehmend (Stephens et al., 2020; Bilali und Hassen, 2023). Zusätzlich zu diesen Herausforderungen weist das derzeitige Agrar- und Ernährungssystem trotz stetiger Produktivitätssteigerungen Dysfunktionalitäten auf. Crippa et al. (2021) belegt, dass das globale Agrar- und Ernährungssystem derzeit weltweit für etwa ein Drittel aller Treibhausgasemissionen verantwortlich ist. Weiterhin leiden etwa bis zu 828 Millionen Menschen weltweit an Hunger (FAO et al., 2022). Gleichzeitig sind 2,5 Milliarden Erwachsene übergewichtig (WHO, 2024). In diesem Zusammenhang wird die wechselseitige Beziehung zwischen ernährungs-, umwelt- und gesundheitlichen Aspekten deutlich. Diese beschriebenen komplexen Wechselwirkungen und ihre Auswirkungen werden von Tilman und Clark (2014) als das „Ernährung-Umwelt-Gesundheits-Trilemma“ bezeichnet. Eine isolierte Betrachtung des Agrar- und Ernährungssystems ist aufgrund dieser Vernetzung nicht zielführend. Vielmehr sollte auf einen tiefgreifenden ganzheitlichen Transformationsprozess des Agrar- und Ernährungssystems hingesteuert werden, um die UN-Ziele für eine nachhaltige Entwicklung (Sustainable Development Goals) zu erreichen

(McGreevy et al., 2022). Vor diesem Hintergrund werden Innovationen im Agrar- und Ernährungssektor als wesentliche Voraussetzung gesehen, um globale Klima- und Umweltherausforderungen zu adressieren und eine Transformation zu nachhaltigen Produktions- und Konsumgewohnheiten zu beschleunigen (FAO, 2017; Herrero et al., 2020).

Trotz sich fortwährend ändernden gesellschaftlichen Ansprüchen und Verbraucherwünschen belegen wissenschaftliche Untersuchungen jedoch, dass ein Großteil der Verbraucherinnen und Verbraucher neuartigen Produkten und Prozesstechnologien kritisch gegenüberstehen. Daher werden Innovationen insbesondere im Lebensmittelbereich häufig mit einem ablehnenden Verhalten begegnet (Cardello, 2003; Tuorila und Hartmann, 2020). Damit ist der Erfolg eines Transformationsprozesses des Agrar- und Ernährungssystems erheblich beeinträchtigt. Eine Umstellung auf nachhaltige und innovative Strategien ist daher nur möglich, sofern die Verbraucherinnen und Verbraucher nicht nur das Bewusstsein für die Notwendigkeit eines Transformationsprozesses des derzeitigen Agrar- und Ernährungssystems entwickeln, sondern auch aktiv einer nachhaltigen Ernährungsweise folgen. Anpassungen ihrer Konsummuster sind hierzu erforderlich (Lusk und McCluskey, 2018; Willett et al., 2019). Demnach sind Innovationen und Technologien nur dann zielführend, wenn die Verbraucherakzeptanz entsprechender Produkte und Praktiken sichergestellt ist. Innovationen im Lebensmittelbereich müssen daher eng mit den Bedürfnissen der Verbraucherinnen und Verbraucher verknüpft werden (Kühne et al., 2010). Vor diesem Hintergrund sind empirische Untersuchungen im Bereich des Verbraucherverhaltens von großem Interesse, um Verbrauchereinstellungen und deren Bewertungsmuster zu diesem Themenkomplex entsprechend klassifizieren zu können. Innovative Lebensmitteltechnologien wie kultiviertes Fleisch (Themenbereich I) sowie innovative landwirtschaftliche Landbausysteme (Themenbereich II) verfügen über ein hohes Potenzial, das derzeitige ressourcenintensive Agrar- und Ernährungssystem in ein effizienteres und nachhaltigeres System umzuwandeln (Zimmermann et al., 2021; Sinke et al., 2023). Im Folgenden werden die beiden Themenbereiche näher beleuchtet.

Themenbereich I: Verbraucherakzeptanz von technologischen Lebensmittelinnovationen

Prognosen zufolge wird die Weltbevölkerung bis zum Jahr 2050 auf 9,8 Milliarden Menschen ansteigen (FAO, 2018). Bedingt durch den steigenden Lebensstandard und den zunehmenden Wohlstand, insbesondere in Entwicklungsländern, steigt die Nachfrage bzw. der Konsum von tierischen Proteinen. In diesem Zusammenhang prognostiziert die FAO (2018) einen Anstieg der Fleischnachfrage um mehr als zwei Drittel bis zum Jahr 2050. Treten diese Erwartungen

ein, werden sich die Umwelt- und Klimaauswirkungen, die aus der Tierhaltung bzw. der Fleischerzeugung resultieren, drastisch verschärfen. Die intensive Nutztierhaltung ist für etwa 14,5 % der weltweiten Treibhausgasemissionen verantwortlich (Gerber et al., 2013). Weiterhin nimmt der Anbau von Futtermitteln weltweit etwa ein Drittel der weltweiten Anbaufläche in Anspruch (Steinfeld et al., 2006). Darüber hinaus hat die steigende Nachfrage nach tierischen Produkten bei gleichzeitigem Mangel an nutzbaren landwirtschaftlichen Flächen in der Vergangenheit vermehrt dazu geführt, dass die Nutztierhaltung eines der größten Ursachen für die Abholzung von Wäldern und deren Umwandlung in Ackerfläche geworden ist (Steinfeld et al., 2006). Die massive Abholzung von Wäldern führt neben der Bodendegradation unter anderem zum Aussterben von Tierarten und damit zu Biodiversitätsverlusten (Kok et al., 2020).

Die Ausführungen verdeutlichen, dass die Reduktion des Fleischkonsums zur Förderung einer nachhaltigen Ernährung und zur Eindämmung der Probleme, die mit einem übermäßigen Fleischkonsum einhergehen, notwendig ist (Tilman und Clark, 2014; Willett et al., 2019). Beispielsweise ist in Deutschland der menschliche Fleischverzehr zwar von etwa 60,9 kg pro Person und Jahr im Jahr 2018 auf 51,6 kg pro Person und Jahr im Jahr 2023 gesunken (BLE, 2024). Laut der Eat Lancet Kommission sollte sich allerdings der Pro-Kopf-Verbrauch auf 15 kg pro Jahr im Jahr 2050 reduziert haben, um den Treibhauseffekt und weitere Klimaauswirkungen, die mit der intensiven Nutztierhaltung einhergehen, effektiv einzuschränken (Willett et al., 2019).

Um die ökologischen Auswirkungen eines übermäßigen Fleischkonsums zu reduzieren, besteht ein wesentlicher Ansatz darin, nicht nur den Fleischkonsum insgesamt zu reduzieren, sondern den Fleischkonsum auch durch alternative Proteinquellen zu ersetzen. Somit sind Fleischalternativen zur Förderung einer nachhaltigen Ernährung, zur Sicherstellung des Proteinbedarfs und im Rahmen des Transformationsprozesses des Agrar- und Ernährungssystems von großer Bedeutung (Onwezen et al., 2021; Etter et al., 2024, Sendhil et al., 2024). So wurden in der Vergangenheit vermehrt neuartige Produkt- und Prozessinnovationen hervorgebracht, mit denen der Fleischkonsum drastisch reduziert oder substituiert werden könnte. Inzwischen bietet der Lebensmitteleinzelhandel ein breites Sortiment an Fleischalternativen auf Grundlage verschiedener Rohstoffe, wie beispielsweise Hülsenfrüchten, Gemüse, Getreide und anderen pflanzlichen Rohstoffen, an. Diese bilden ein etabliertes Produktsegment mit erheblichen Zuwachsraten (Sha und Xiong, 2020). Allein im Jahr 2023 wurden in Deutschland im Vergleich zum Vorjahr etwa 16,6 % mehr Fleischersatzprodukte produziert. Im Vergleich zum Jahr 2019 hat sich die Produktion von Fleischersatzprodukten mehr als verdoppelt (+ 113,8 %) (Statistisches

Bundesamt, 2024). Damit zeichnet sich insgesamt ein deutlicher Aufwärtstrend ab, der neben einem wachsenden Gesundheits- und Umweltbewusstsein der Verbraucherinnen und Verbraucher unter anderem auch durch Ernährungsmuster, wie dem Veganismus oder Vegetarismus, verstärkt wird (Ulhas et al., 2023).

Zunehmend finden neben pflanzlichen Fleischalternativen auch weitere tierische Proteinquellen wie Algen oder Insekten Beachtung. Darüber hinaus wird intensiv zu weiteren neuartigen Prozesstechnologien, wie beispielsweise kultiviertes Fleisch, geforscht (Onwezen et al., 2021). Kultiviertes Fleisch, auch bekannt als In-vitro Fleisch, ist eine innovative technologische Alternative zur konventionellen Fleischproduktion. Die Technologie zielt darauf ab, Fleisch direkt aus tierischen Stammzellen zu erzeugen, die sich im Labor zu Muskelfasern entwickeln. Anschließend können diese zu herkömmlichen Fleischprodukten für Burger oder Fleischwaren verarbeitet werden (Post, 2012; Stephens et al., 2018). Studien belegen, dass kultiviertes Fleisch gegenüber der konventionellen Fleischproduktion ein großes Potenzial, insbesondere im Hinblick auf einen geringeren Wasser- und Flächenbedarf und niedrigere Treibhausgasemissionen (Sinke et al., 2023), bietet. Obwohl kultiviertes Fleisch einen wesentlichen Beitrag zum Nachhaltigkeitswandel leistet und somit wesentliche umwelt- und klimarelevante Herausforderungen adressieren kann, ist eine erfolgreiche Markteinführung neben regulatorischen Hürden maßgeblich von der Akzeptanz der Verbraucherinnen und Verbraucher abhängig (Pakseresht et al., 2022).

Vorliegende Studien zeigen sowohl Treiber als auch Barrieren des Konsums von kultiviertem Fleisch aus Verbrauchersicht. Zu den wichtigsten Treibern gehören der Tierschutz (Weinrich et al., 2020; Bryant und Sanctorum, 2021; Quevedo-Silva und Pereira, 2022), die ökologische Nachhaltigkeit und die Ernährungssicherheit (Slade, 2018; Mancini und Antonioli, 2019; Weinrich et al., 2020). Zu den wichtigsten Barrieren zählen hingegen Neophobie (Dupont et al., 2022; Heidmeier und Teuber, 2022; Krings et al., 2022; Baum et al., 2023), Unnatürlichkeit (Siegrist et al., 2018; Dupont und Fiebelkorn, 2020), Sicherheitsbedenken (Bryant und Barnett, 2020; Krings et al., 2022), Bedenken hinsichtlich der Nährwertqualität (Gómez-Luciano et al., 2019), Ekel gegenüber kultiviertem Fleisch sowie Misstrauen gegenüber Unternehmen (Verbeke et al., 2015; Wilks et al., 2019; Siegrist und Hartmann, 2020).

Obwohl verschiedene Forschungsarbeiten die Rolle des Vertrauens in Bezug auf die Akzeptanz von kultiviertem Fleisch aufgegriffen haben, liegt der Fokus dieser Arbeiten meist auf einer eingeschränkten Perspektive des Verbrauchervertrauens in die Wissenschaft, in staatliche Regulierungsbehörden oder der Lebensmittelindustrie (Verbeke et al., 2015; Wilks et al., 2019;

Zhang et al., 2020; Lin-Hi et al. 2023; Kühn et al., 2023; Lewisch und Riefler, 2023). Die Betrachtung des Verbrauchervertrauens aus verschiedenen Perspektiven des Lebensmittelsystems sowie die Bestimmung spezifischer Verbrauchersegmente basierend auf dem Vertrauen in kultiviertes Fleisch wurde demnach noch nicht adressiert. Ebenso zeichnet sich aus der vorhandenen Literatur ab, dass die Food Technology Neophobia (FTN), d. h. die Angst oder Abneigung gegenüber neuen oder unbekannten Lebensmitteltechnologien (Cox und Evans, 2008), einen wesentlichen Prädiktor für die Verbraucherakzeptanz von technologischen Lebensmittelinnovationen darstellt. Ein systematischer Literaturüberblick über die Food Technology Neophobia Scale (FTNS) bleibt bisher jedoch aus. Diese Forschungslücken werden in den Beiträgen I.1 und I.2 der vorliegenden Dissertation adressiert.

Themenbereich II: Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion

Parallel zu den Herausforderungen, die vor dem Hintergrund der Deckung des menschlichen Proteinbedarfs diskutiert werden, wird die Landwirtschaft mit zunehmenden Forderungen an nachhaltige und umweltschonende Wirtschaftsweisen im Bereich des Ackerbaus konfrontiert. So ist der Einsatz von chemisch-synthetischen Pflanzenschutzmitteln in der Landwirtschaft zu wichtigen Themen in kontroversen öffentlichen Debatten geworden (Young et al., 2022). Die „Farm-To-Fork-Strategie“ der Europäischen Union zielt darauf ab, den Einsatz von chemisch-synthetischen Pflanzenschutzmitteln sowie die damit verbundenen Risiken bis 2030 zu halbieren (Europäische Kommission, 2020). Grundsätzlich schützt der Einsatz von chemisch-synthetischen Pflanzenschutzmitteln landwirtschaftliche Erzeugnisse vor Krankheiten und Schaderregern. Weiterhin konnte durch die Anwendung eine weltweite Steigerung der Nahrungsmittelproduktion ermöglicht werden (Cooper und Dobson, 2007; Hedlund et al., 2019). Gleichzeitig wird ein übermäßiger Einsatz von chemisch-synthetischen Pflanzenschutzmitteln mit negativen Umweltauswirkungen, wie dem Biodiversitätsverlust sowie negativen Auswirkungen auf die Bodenqualität, in Verbindung gebracht (Sánchez-Bayo und Wyckhuys, 2019; Pelosi et al., 2021). Darüber hinaus weisen Studien auf erhebliche Gesundheitsrisiken im Zusammenhang mit Pflanzenschutzmittelrückständen in Lebensmitteln hin, darunter unter anderem das Risiko von Geburtsfehlern sowie neurologischen Störungen (Clementi et al., 2008; Baldi et al., 2010; Wickerham et al., 2012). Weiterhin belegen Nitzko et al. (2022), dass deutsche Verbraucherinnen und Verbraucher grundsätzlich jegliche Mengen an Pflanzenschutzmittelrückständen in Lebensmitteln oder im Trinkwasser als kritisch betrachten.

In diesem Zusammenhang drängt der politische und gesellschaftliche Druck zunehmend auf innovative landwirtschaftliche Landbausysteme, die ohne den Einsatz von chemisch-synthetischen Pflanzenschutzmitteln auskommen. Nachhaltige, widerstandsfähige und gleichzeitig innovative Landbausysteme sind erforderlich, um sowohl die Ernährungssicherheit zu gewährleisten als auch die negativen Umweltauswirkungen der landwirtschaftlichen Praktiken zu minimieren (Jacquet et al., 2022). Ein wesentlicher Impuls, der die Notwendigkeit nachhaltigerer Lösungen und Innovationen in landwirtschaftliche Landbausysteme zu integrieren auslöste, ist unter anderem auf Studien zurückzuführen, die die weltweit ausreichende Nahrungsmittelversorgung in der Zukunft allein aus ökologischer Landwirtschaft in Frage stellen (Muller et al., 2017; Connor, 2018; Meemken und Qaim, 2018). Innovative Landbausysteme, die sich durch einen Verzicht auf chemisch-synthetische Pflanzenschutzmittel bei gleichzeitiger Beibehaltung der mineralischen Düngung auszeichnen, bieten vor dem Hintergrund dieser Erkenntnisse das Potenzial, gesellschaftspolitische Forderungen zu adressieren (Zimmermann et al., 2021).

Bisherige Studien heben verschiedene Vorteile dieses Systems hervor. Gegenüber dem konventionellen Anbau bietet die Produktionsweise im Hinblick auf gesteigerte Ökosystemleistungen, Erhaltung von Agrarlandschaften, Schutz der biologischen Vielfalt sowie der Vermeidung von Pflanzenschutzmittelrückständen in Nahrungsmitteln Vorteile. Im Vergleich zum ökologischen Anbau bietet diese Produktionsweise den Vorteil von Mehrerträgen und geringere Hürden für Landwirtinnen und Landwirte bei der Etablierung in den landwirtschaftlichen Betrieb (Zimmermann et al., 2021; Finger und Möhring, 2022; Möhring und Finger, 2022). Dieses Anbausystem stellt somit eine Neuorientierung im Ackerbau dar und kann zwischen dem konventionellen und dem ökologischen Landbau angesiedelt werden. Für Verbraucherinnen und Verbraucher besteht somit die Möglichkeit, ihre Kauf- und Konsumgewohnheiten im Interesse der Nachhaltigkeit anzupassen (Nitzko et al., 2024).

Obwohl dieses neue landwirtschaftliche Konzept das Potenzial hat, eine Nachhaltigkeitstransformation maßgeblich voranzutreiben, ist nicht sichergestellt, dass die Verbraucherinnen und Verbraucher entsprechende Lebensmittel schätzen und kaufen. Ob und inwieweit ungenutzte Marktpotenziale für diese Produkte erschlossen werden können, hängt maßgeblich von der Akzeptanz der Verbraucherinnen und Verbraucher ab. Eine weitgehende Ablehnung dieses Lanbausystems würde sowohl die Markteinführung behindern als auch die Nachhaltigkeitstransformation wesentlich beeinträchtigen (Nitzko et al., 2024). Bisher werden in der wissenschaftlichen Literatur jedoch die Verbraucherakzeptanz dieses Landbausystems sowie daraus resul-

tierende Produkte in der deutschen Bevölkerung nicht umfassend betrachtet. Vorhandene Publikationen fokussieren sich auf die Bewertung von Pflanzenschutzmittelrückständen im Trinkwasser sowie in Lebensmitteln (Nitzko et al., 2022), auf die Akzeptanz pflanzlicher Produkte, die aus diesem Landbausystem hervorgehen (Nitzko et al., 2024) sowie die Verbraucherpräferenz hinsichtlich der Kennzeichnung dieser Produkte (Nitzko und Spiller, 2023). Daher ist es von großem Interesse, die Akzeptanzfaktoren der Verbraucherinnen und Verbraucher zu tierischen Lebensmitteln, die aus diesem Landbausystem hervorgehen, zu identifizieren und spezifische Verbrauchersegmente herauszustellen. Diese Forschungslücken werden in den Beiträgen II.1 und II.2 der vorliegenden Dissertation behandelt.

Ziele und Aufbau der Dissertation

Die vorliegende Dissertation befasst sich mit ausgewählten Fragestellungen des Verbraucherverhaltens in der Bioökonomie. Die Verbraucherakzeptanz von technologischen Lebensmittelinnovationen sowie von Nachhaltigkeitsinnovationen in der Primärproduktion stehen entsprechend ihrer Relevanz bei der Transformation des Agrar- und Ernährungssystems im Fokus der Betrachtung. Empirische Untersuchungen werden am Beispiel von kultiviertem Fleisch sowie einem Landbausystem, das auf den Einsatz von chemisch-synthetischen Pflanzenschutzmitteln verzichtet, bei gleichzeitiger Beibehaltung der mineralischen Düngung[1], durchgeführt. Folgende Forschungsfragen werden im Rahmen der vorliegenden Dissertation beantwortet:

1) Welche Rolle spielt die Food Technology Neophobia bei der Akzeptanz innovativer Lebensmitteltechnologien und welche Verbrauchersegmente lassen sich hinsichtlich des Vertrauens in kultiviertes Fleisch identifizieren? (Themenbereich I)

2) Welche Faktoren beeinflussen die Verbraucherakzeptanz von tierischen Lebensmitteln, die aus einem innovativen Landbausystem, das auf den Einsatz von chemisch-synthetischen Pflanzenschutzmitteln verzichtet, hervorgehen und wie groß ist eine potenzielle Zielgruppe für diese Produkte? (Themenbereich II)

Die Erkenntnisse können praktische Empfehlungen für die Lebensmittelindustrie liefern, insbesondere für das Marketing, die Preisgestaltung und auch für politische Entscheidungsträgerinnen und Entscheidungsträger. Weiterhin können diese einen wertvollen Beitrag zur Förderung nachhaltiger Produktions- und Konsummuster leisten. Darüber hinaus tragen diese zur Erzielung der Sustainable Development Goals – insbesondere 2 „Kein Hunger“, 3 „Gesundheit

[1] In der vorliegenden Dissertation werden Produkte, die aus diesem Landbausystem hervorgehen, einheitlich als „pflanzenschutzmittelfreie Produkte“ bezeichnet, da bisher keine Definition dieses Systems existiert.

und Wohlergehen“, 12 „nachhaltiger Konsum und Produktion“ sowie 13 „Maßnahmen zum Klimaschutz“ – und gleichzeitig zur Reduktion der beschriebenen Umwelt- und Klimaauswirkungen bei (United Nations, 2015).

Die Dissertation gliedert sich in zwei Themenbereiche. Der Aufbau ist in Tabelle 1 dargestellt.

Tabelle 1: Aufbau der Dissertation.

Einleitung		
Themenbereich I: Verbraucherakzeptanz von technologischen Lebensmittelinnovationen		
Artikelnummer	**Name des Artikels**	**Autoren**
I.1	A systematic review of consumer studies applying the Food Technology Neophobia Scale: Lessons and applications	Wendt, M.-C., Weinrich, R. Food Quality and Preference, 2023: 106 (104811)
I.2	Cultured Meat: Identifying trust profiles of German consumers using latent profile analysis	Wendt, M.-C., Weinrich, R. Under Review beim Journal Appetite
Themenbereich II: Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion		
II.1	Consumer Segmentation for Pesticide-free Food Products in Germany	Wendt, M.-C., Weinrich, R. Sustainable Production and Consumption, 2023: 42, 309-321
II.2	Consumer Acceptance of Pesticide-free Dairy products in Germany: A Partial Least Square Model	Wendt, M.-C., Weinrich, R. German Journal of Agricultural Economics, 2024: 73, 1-26
Diskussion und Schlussbetrachtung		

Quelle: Eigene Darstellung.

Im Folgenden werden die einzelnen Beiträge der vorliegenden Dissertation vorgestellt. Anschließend werden die Beiträge in der Form, wie sie in den jeweiligen Fachjournalen veröffentlicht bzw. eingereicht wurden, dargestellt. Die Dissertation endet mit einer Diskussion und Schlussbetrachtung.

Themenbereich 1: Verbraucherakzeptanz von technologischen Lebensmittelinnovationen

Der erste Themenbereich der Dissertation widmet sich der Verbraucherakzeptanz von technologischen Lebensmittelinnovationen. Der Beitrag I.1 „A systematic review of consumer studies applying the Food Technology Neophobia Scale: Lessons and applications“ gibt zunächst einen systematischen Literaturüberblick über bereits veröffentlichte Studien, die die Food Technology Neophobia Scale (FTNS) verwendet haben. Mithilfe des Literaturüberblicks wird der Stand der Forschung zur Food Technology Neophobia Scale systematisch dargestellt sowie der Einfluss der Food Technology Neophobia auf die Akzeptanz von Lebensmittelinnovationen herausgearbeitet. Der zweite Artikel I.2 „Cultured Meat: Identifying trust profiles of German consumers using latent profile analysis“ basiert auf einer quantitativen online-basierten Verbraucherbefragung (n=1,099). Dieser Beitrag hat zum Ziel, verschiedene Verbrauchersegmente in der deutschen Bevölkerung hinsichtlich ihres Vertrauens in kultiviertes Fleisch sowie beteiligte Akteurinnen und Akteure herauszustellen und diese explizit zu beschreiben.

Themenbereich 2: Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion

Im zweiten Themenbereich der Dissertation werden Nachhaltigkeitsinnovationen in der Primärproduktion betrachtet. Bei dieser Betrachtung steht ein Landbausystem im Fokus, das sich durch einen Verzicht auf chemisch-synthetische Pflanzenschutzmittel bei gleichzeitiger Beibehaltung der Mineraldüngung auszeichnet. Artikel II.1 „Consumer Segmentation for Pesticide-free Food Products in Germany” untersucht mithilfe einer latenten Profilanalyse die vorherrschenden Akzeptanzmuster unter deutschen Verbraucherinnen und Verbrauchern (n=1,010) zu diesem Landbausystem. Dabei wird analysiert, wie sich die Einstellungsmuster hinsichtlich dieser Produkte sowie die Zahlungsbereitschaften der Verbraucherinnen und Verbraucher unterscheiden. Darauf aufbauend werden in Beitrag II.2 „Consumer Acceptance of Pesticide-Free Dairy Products in Germany: A Partial Least Square Model” Treiber und Barrieren herausgestellt, die die Einstellung und Akzeptanz gegenüber diesen Produkten beeinflussen.

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Teil I: Verbraucherakzeptanz von technologischen Lebensmittelinnovationen

I.1 A systematic review of consumer studies applying the Food Technology Neophobia Scale: Lessons and applications

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Abstract

Novel food technologies can be a part of the solution to address global challenges and shift to sustainable food production and consumption patterns. However, innovations in the food industry are characterized by high market failures, for a novel food technology will only succeed in the market if it meets with consumer acceptance. Insights into the acceptance or rejection of novel food technologies can be achieved using the food technology neophobia scale (FTNS), where food technology neophobia expresses consumer reluctance to try foods produced using novel technologies. To extend understanding of the FTNS to food professionals and food researchers, we conducted a systematic review of published studies that have used the scale since its development in 2008. This allows us to structure useful evidence from all published articles using the scale in their methodological approach. We share methodological findings and findings regarding socio-demographic variables and consumer behavior. We find the scale confirmed as a valid and reliable predictor of responses to novel food technologies. These findings should help professionals in the food industry and in food research identify population segments that have more or less willingness to try novel products and so design strategies to avoid failure of food technology innovations in the market.

Keywords: Food scales, consumer acceptance, novel technologies, novel foods, consumer behaviour

1. Introduction

Innovative and sustainable strategies in the food industry are critical to address global challenges such as greenhouse gas emissions, food waste, and food insecurity (UN, 2021). In this regard, novel processing technologies offer benefits in terms of resource efficiency, impact on climate change, food safety, shelf life, nutritional value, and sensory quality (Martins et al., 2019). While technical innovations are generally viewed positively, novel technologies in food production and processing have been a polarizing issue and often meet resistance from consumers (Cardello, 2003; Siegrist, 2007; Tuorila and Hartmann, 2020). Studies by Rozin et al. (2004) and Rozin et al. (2005) indicate that especially ideational factors (e.g., the natural is preferred because it is in principle the “right”, meaning, more moral or more aesthetic) and instrumental reasons (e.g., the natural is healthier, more effective, more environmentally friendly) play an important role in explaining the preferences for the natural. However, without consumer acceptance, food innovations and technologies cannot be effective (Kühne et al., 2010).

Although novel production technologies such as nanotechnology, genetic engineering, 3D food printing, and in vitro meat have the potential to promote a sustainability transition and thus tackle global challenges, they are not always perceived positively by consumers (Sodano et al., 2016; Caulier et al., 2020; Ali et al., 2021; Baum et al., 2021; Coderoni and Perito, 2021; Krings et al., 2021). Some consumers are concerned about the risks of novel process technologies and seem to prefer in principle "natural", meaning less processed, products (Martins et al., 2019). Rozin et al. (2004) show that the preference for natural is considerably stronger in the food, than in the medical sector. Such aversion to novel food technologies, known as food technology neophobia (FTN), impairs the success of a dietary transformation process (Chen, 2018). Public perception and consumer concerns about novel food technologies are also reflected in high failure rates of novel process technology adoption in the food market (Chen et al., 2013; Egolf et al., 2019; Nucci and Hallman, 2015; Cattaneo et al., 2019). These failure rates can be attributed, at least in part, to FTN, which leads to a rejection of novel food technologies (Chen, 2018). Consequently, sustainability change is also inhibited instead of driven forward.

Therefore, it is advisable to test consumer acceptance of novel food technologies before a costly development phase (Cox and Evans, 2008; Frewer et al., 2011). With this in mind, there is a growing body of literature in consumer and market research regarding FTN. The Food Technology Neophobia Scale (FTNS) developed by Cox and Evans (2008) would seem to offer the greatest potential as a measurement instrument (Table 1). Compared to the Food Neophobia Scale (FNS) (Pliner and Hobden, 1992), the FTNS has been far more successful in predicting willingness to try novel food technologies because it focuses on technology rather than just food (Cox and Evans, 2008; Evans et al., 2010; Matin et al., 2012; Coppola et al., 2014; Verneau et al., 2014). The scale is designed to help identify consumer segments that either accept or reject novel food technologies (Evans et al., 2010). In addition, the scale can be used to determine the level of anxiety toward new food technologies.

The original scale was designed as a 13-item scale grouped into 4 factors:

- necessity of new food technologies,
- perception of risks,
- healthy choices, and
- information / media.

Each factor was rated by a series of items on a 7-point Likert scale (Table 1) ranking responses from 1 ("strongly disagree") to 7 ("strongly agree") with a centre neutral point of "neither" (Cox

and Evans, 2008). The FTNS is expressed as a sum score across the 13 items, generated by summing the individual answers to the 13 items measured on the 7-point Likert scale. As a result, the FTNS yields a value between 13 and 91, with a higher score indicating greater aversity to novel food technologies (Cox and Evans, 2008).

Table 1

Items included in the Food Technology Neophobia Scale (FTNS).

Factor	Item
New food technologies are unnecessary (1)	1. There are plenty of tasty foods around so we don't need to use new food technologies to produce more. 2. The benefits of new food technologies are often grossly overstated. 3. New food technologies decrease the natural quality of food. 4. There is no sense trying out high-tech food products because the ones I eat are already good enough. 5. New foods are not healthier than traditional foods. 6. New food technologies are something I am uncertain about.
Perception of risks (2)	7. Society should not depend heavily on technologies to solve its food problems. 8. New food technologies may have long term negative environmental effects. 9. It can be risky to switch to new food technologies too quickly. 10. New food technologies are unlikely to have long term negative health effects. (R).
Healthy choice (3)	11. New products produced using new food technologies can help people have a balanced diet. (R). 12. New food technologies give people more control over their food choices. (R).
Information / media (4)	13. The media usually provides a balanced and unbiased view of new food technologies. (R).

Note: (R) indicates reversed scored items.

Since its development and increasing global popularity, the original scale has undergone several adjustments. These include changing the original 7-point Likert scale to a 5-point scale (Matin et al., 2012; Chen et al., 2013) or reducing the items from the original 13 to 4 (Verbeke, 2015). Similarly, Schnettler et al. (2017) designed the Abbreviated Food Technology Neophobia Scale (AFTNS), which includes only nine items and one factor; it has been used in three other studies (Baum et al., 2021; Rabadán, 2021; Rabadán and Bernabéu, 2021).

Nonetheless, questions of reliability and validity remain regarding the FTNS. The ideal approach to synthesizing current findings and identifying knowledge gaps related to FTN is a systematic literature review. Only one study to date has included the FTNS in its review

(Giordano et al., 2018); however, the researchers did not systematically review all papers applying the scale and limited their discussion to the descriptive level.

To better characterize the current research landscape and qualify the FTNS, we conducted a systematic review of all published studies that methodologically use the FTNS. The systematic review provides an overview of existing knowledge about the use of the FTNS, factors that may influence the level of FTN, as well as areas for future research. We thus draft our research questions as:

1) Is the FTNS a suitable tool to measure consumer acceptance of novel food technologies?
2) What is the impact of FTN on willingness to try products created using novel technologies?
3) What research areas should be addressed in future studies?

The paper is structured as follows: in the next section, we present the methods used to conduct the review, followed by an overview of the studies and our main findings. We then discuss the findings, point to knowledge gaps, and draw conclusions. Our findings will help professionals in the food industry and those engaged in food research better understand FTN; the findings are of particular value for product developers and market researchers. All researchers who would like to use the scale will gain an orientation to its different variants.

2. Methods

Our systematic literature review is based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. Following the PRISMA principle ensures a transparent, replicable and complete research approach (Moher et al., 2009). The results of the entire process of identification, screening, eligibility and inclusion of articles are illustrated in Fig. 1. Articles available since the scale was developed in 2008 through December 2021 were included in this review.

First, relevant publications were identified using the scientific database Elsevier Scopus. The Scopus database was chosen because it is considered the largest database in academia. Indeed, Scopus is estimated to be 60% larger than the Web of Science (Zhao and Strotmann, 2015) and thus covers a wide range of journals and offers about 20% more coverage in citations (Falagas et al., 2008). The search was performed on title, abstract, and keywords using the query "(food AND technology AND neophobia)" and was limited to studies in English. Overall, the literature research identified 79 articles on SCOPUS. Four additional articles were identified from forward and backward searches. The 83 articles were screened based on the titles and abstracts to

ensure they used the FTNS as an instrument to evaluate individual FTN. On this basis, 28 papers were excluded as inapplicable. One other paper was excluded because no full text could be obtained. The remaining 54 full text articles were then evaluated for eligibility. This led to eliminating four articles as they did not use the FTNS in their methodological approach. Another paper was removed because the full text was not published in English. Overall, 49 articles were included in the systematic literature review.

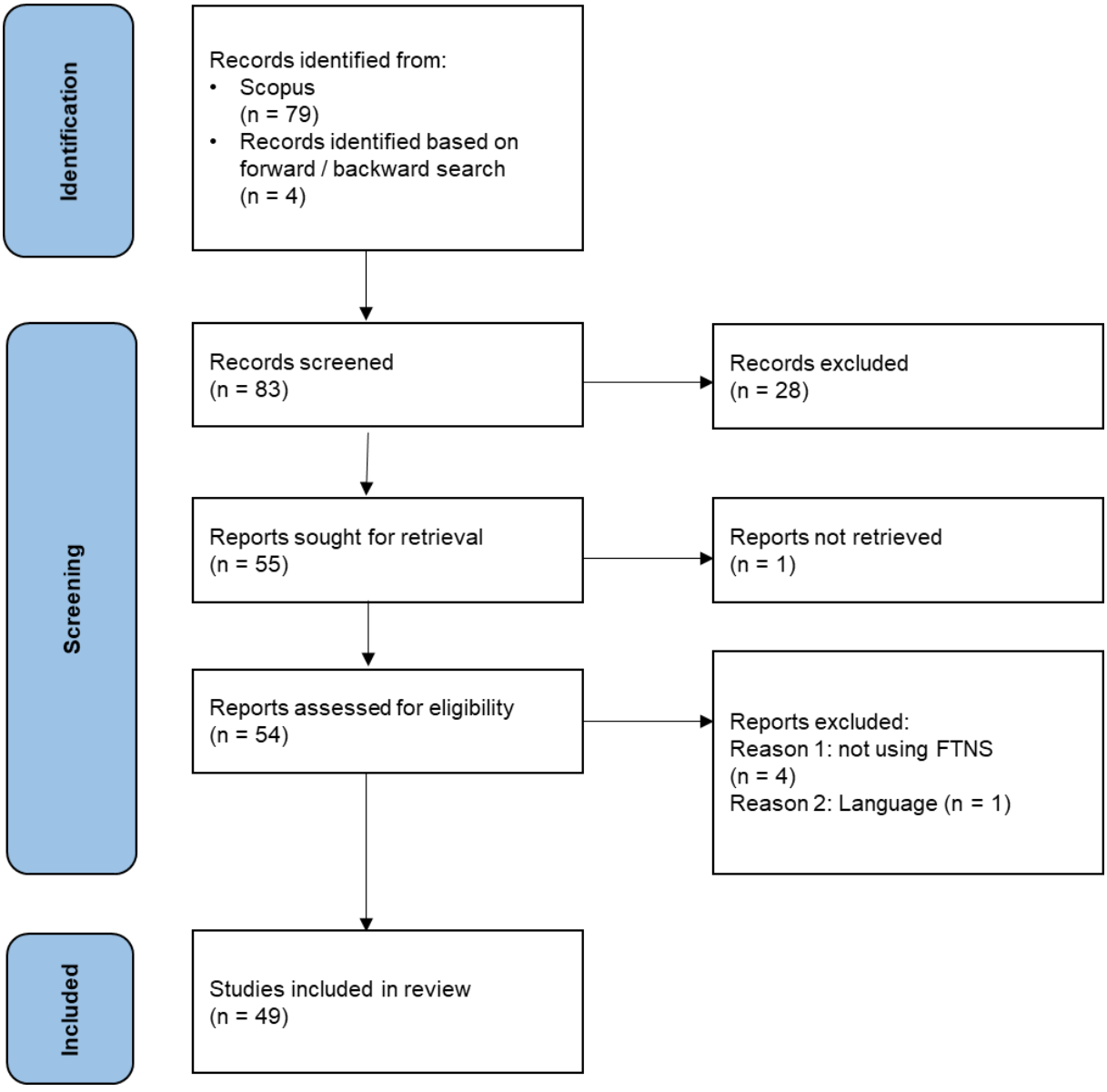

Fig. 1. PRISMA flow diagram for the selection of studies.

To conduct a systematic evaluation of these 49 articles, we divided our analysis into two parts:

1) We started with a quantitative analysis using a category system (Armat et al., 2018; Assarroudi et al., 2018). The articles were categorized and pertinent attributes tabulated using MS Excel. These included for each article the name of the authors, the year, and

the journal in which the study was published, the products and technologies which were the focus in the study, the country of the individuals participating, the sample size, the study design, the data acquisition method for FTNS and the FTNS measurement (number of items and points in the Likert scale). The category system is presented in Table 2 and the information extracted from the articles in Appendix A.

2) We then conducted a qualitative content analysis (Graneheim et al., 2017; Kuckartz, 2014) using the software MaxQDA (Kuckartz and Rädiker, 2019). We loaded the articles into MaxQDA and analyzed the study's objective, the reported outcomes regarding the FTNS as well as limitations and recommendations for future research. The coding of the articles was conducted by two coders: The first author read and coded all relevant articles, while the second author read and coded five (10%) randomly selected articles to check for consistency. The interrater reliability was generally high (Cohen's kappa (0.86)) and disagreement between the authors was resolved by a discussion resulting in full consensus.

Results thus include descriptive findings related to the categories listed below in Table 2. We present these and then describe results related to the FTNS.

Table 2

Overview of categories included in our results.

Dimension	**Categories**
Metadata	• Year of Publication • Publishing journal • Geographical scope • Study design and sample size • Representative studies • Technological and product focus • FTNS measurement
Findings on the food technology neophobia scale	• Findings on methodologies • Findings on socio-demographic variables • Findings on products and technologies • Findings on consumer behavior

3. Results

3.1 Metadata

Year of publication

Fig. 2 shows that the FTNS has been applied increasingly in recent years. After the development of the scale in 2008, eight papers were published in the first seven years (up to and including 2014) (16%). Most articles found for this review were published in the eight years from 2015 until January 2022 (84%, n=41). The number of studies published between 2008 and 2022 varied between zero and ten per year. Tracked as publications per year, applications of FTNS follow an increasing trendline as shown in Fig. 2.

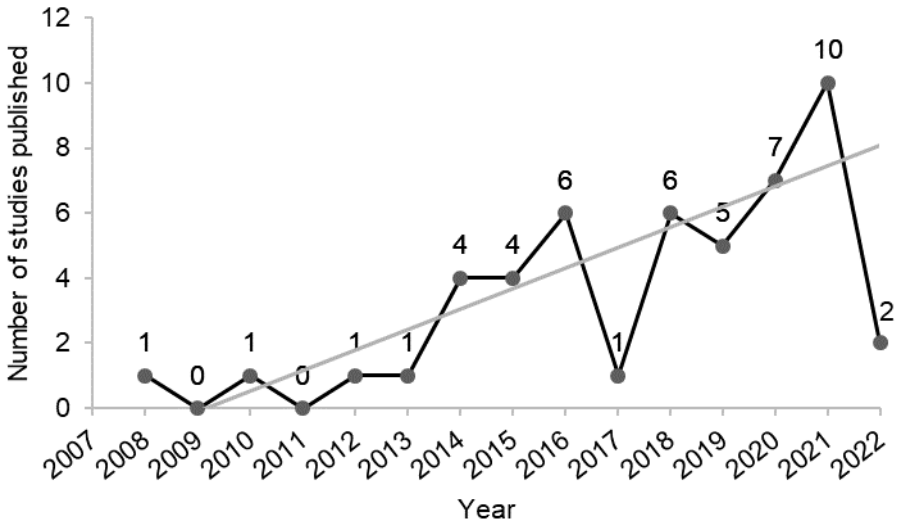

Fig. 2. Published article counts applying FTNS (2008-2022).

Note**:** Last search was conducted on 15th December 2021. Two studies were published in the 2022 journal but were available online in 2021.

Publishing journal

Further, the papers have appeared in 20 academic journals. To date, the Journal of Food Quality and Preferences has published by far the most papers (16 studies) followed by Appetite and the following journals: Journal of Food Science and Technology, Food Research International, British Food Journal, and Foods (three papers each). The remaining 18 papers are distributed among 14 different journals.

Geographical scope

Fig. 3 shows that the studies evaluating FTN with FTNS are geographically not evenly distributed. The majority of the studies have been conducted in high income and upper middle- income

countries, particularly in Europe. Italy is by far the most studied country (13 studies). There follow these countries, ordered by study frequency: Brazil (five), China (five), USA (four), Spain / Australia / Canada (three each), Switzerland / Germany / Poland / UK / South Korea / Chile (two each). Other countries, such as Belgium / Finland / Uganda / Mexico / Netherlands / Dominican Republic, are represented only once. Further, one study is from a low-income country (Uganda). Four studies employed a multi-country approach, collecting the data in two (Ali et al., 2021; Gómez-Luciano et al., 2021) or three countries (Ortega et al., 2020; Krings et al., 2021). The other 45 papers all adopted a single country approach.

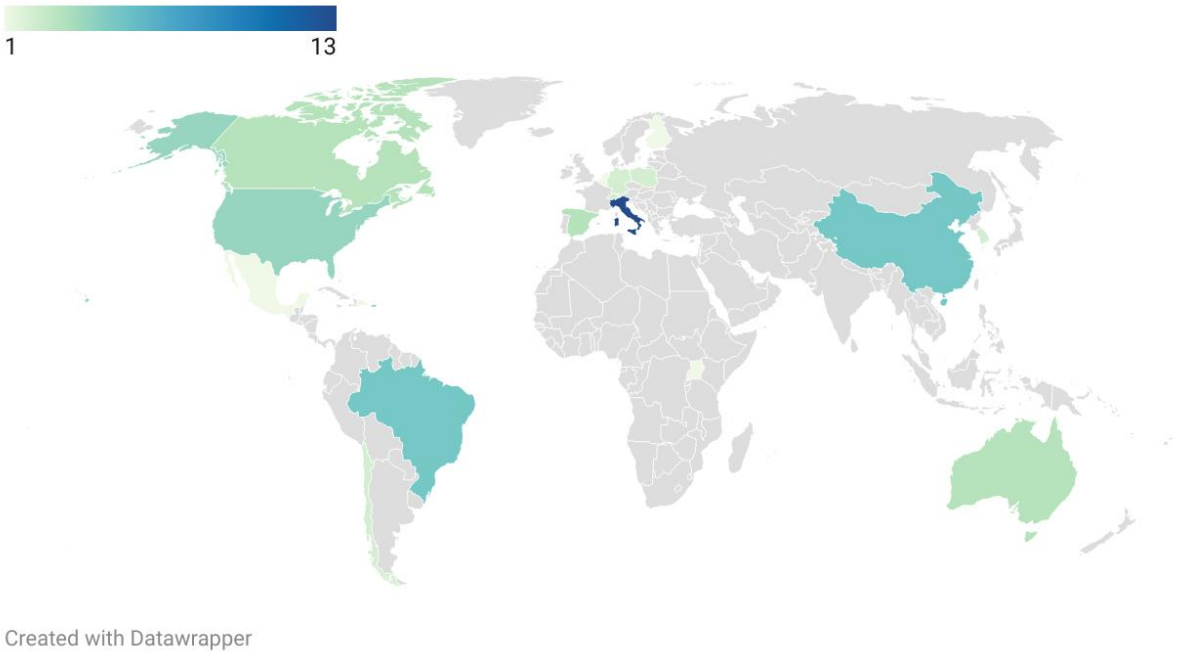

Fig. 3. Distribution of studies of food technology neophobia. Intensity of color indicates the number of studies in each country. The map was created by Datawrapper from www.datawrapper.de.

Study design and sample size

Overwhelmingly, all 49 studies relied on quantitative methods, meaning no qualitative methodologies were applied. The quantitative studies applied three different methods of data acquisition, the most common being online surveys (29), followed by interviewer-administered questionnaires (13). Another eight studies applied a paper-and-pencil questionnaire for data collection. It should be noted that the study by Lee et al. (2021) used both a paper-and-pencil questionnaire and an online survey.

Sample sizes vary widely, ranging from 12 participants in a paper-and-pencil-questionnaire (Caulier et al., 2020) to 2,844 participants in an online survey (Ortega et al., 2020). The average sample size of quantitative studies is 501. Of the 49 studies, 37 had a sample size below 500

and seven studies included between 500 and 999 participants, leaving five with a sample size of at least of 1,000 participants.

Representative studies

The majority of the studies (43 studies) did not seek, acquire or demonstrate representative samples, meaning only six are representative (Kim et al., 2014; Verbeke, 2015; Jeżewska-Zychowicz and Krolak, 2015; Vidigal et al., 2015; Allen et al., 2018; Gómez-Luciano et al., 2021). A representative sample allows statements to be made about the underlying population based on the results.

Technological and product focus

Moreover, we analyzed the technological and products focus in the studies under review. The technology focus of the FTN studies varies widely. Ten studies concentrated on fortification / functional food, another nine focused on genetic modification / genome editing, while five focused on nanotechnology, insect production and pasteurization. Another five studies concentrated on insect production. Further, another three studies focused on 3D food printing and two studies on cultivated meat. The remaining papers concentrated on different technologies for food preservation – nanotechnology, high-pressure processing, modified atmosphere packaging, vacuum packaging or cold plasma technology – or on upcycling and recycling technologies.

Moreover, the technologies have been applied to a number of different products. The products used most frequently are fruits as well as vegetables (eight studies), dairy, e.g., yogurt, cheese and milk (seven studies), followed by beverage / cereal products (six studies). In addition, meat, wine, and insects were tested to determine the FTN. Apart from that, in some studies, the technology and / or the products were not specified and food or food processing in general was mentioned.

FTNS measurement

The last part of the metadata is related to the FTNS measurement. The results reveal that eleven different FTN configurations of measurement items and Likert scale points have been used by researchers. The most common is the original FTNS with 13 items assessed on a 7-point Likert scale (28 studies). Call this a (13,7) configuration. Five studies used a (9,6) configuration. Then four studies each used (13,5) and (4,5) configurations. Two studies used a (4,6) and a (12,7) configuration. One study each used (13,6); (6,7); (6,5) and (10,7).

3.2 Findings on the food technology neophobia scale

3.2.1. Findings on methodologies

Development of the FTNS

The 2008 study by Cox and Evans focused on the development of a new scale to identify consumer segments that have greater or lesser FTN and to predict consumer willingness to try foods using novel technologies. The authors constructed a psychometric scale with good internal consistency (Cronbach's alpha = .83). Further, convergent validity of the FTNS was confirmed as the scale correlates with other scales designed to measure constructs that target similar aspects, such as the Trust in Science Scale (TISS) (Bak, 2001) and the Food Neophobia Scale (FNS) (Pliner and Hobden, 1992). Cox and Evans (2008) also reported a correlation between the FTNS and the "Willingness to Try" scales (Bäckström et al., 2004) which underlies the predictive validity of the FTNS. Subsequently, Evans et al. (2010) implemented test-retest measurements on a sample of 131 Australian consumers to assess scale reliability. They concluded that the FTNS is a stable, reliable, valid and predictive tool to measure the level of FTN within Australian consumer segments. However, the original scale (13 items, 7-point Likert scale) has undergone various changes and adjustments since 2008, which we consider below.

Translation and validation of FTNS into different languages

To replicate the FTNS for individuals with different cultural backgrounds and in different countries, several studies have translated and validated the scale using the back-translation approach (Brislin, 1970), while the remaining studies adopted the already translated and validated scales in the respective language[2]. Difficulties in translating individual items were not reported in the studies. The FTNS has been translated into Portuguese (Vidigal et al., 2014; Vidigal et al., 2015; Martins et al., 2019; Martins et al., 2020), Spanish (Schnettler et al., 2016; Schnettler et al., 2017; Rabadán, 2021; Rabadán and Bernabéu, 2021), Chinese (McKenzie et al., 2021; Ortega et al., 2020; Ali et al., 2021), Italian (Verneau et al., 2014; Sodano et al., 2016; Caracciolo et al., 2016; Cattaneo et al., 2019; Coderoni and Perito, 2020; Ortega et al., 2020; Coderoni and Perito, 2021), Korean (Kim et al., 2014; Lee et al., 2021), Finnish (Deegan et al., 2015), German (Lammers et al., 2019; Baum et al., 2021) and Polish (Modlinska et al., 2020).

[2] Vidigal et al. 2015, Martins et al. 2019 and Martins et al. 2020 used the Portuguese version by Vidigal et al. 2014. Schnettler et al. 2017, Rabadán 2021 and Rabadán and Bernabéu 2021 used the Spanish version by Schnettler et al. 2016. Sodano et al. 2016 used the Italian version by Verneau et al. 2014.

Modification of number of items

As shown by the varied scale configurations, researchers have often modified the number of items. The study by Verbeke (2015) selected four items from the first factor of the original scale, "Necessity of New Food Technologies" (Table 1). Their selection procedure was based on the factor loadings described initially by Cox and Evans (2008). They chose to assess: "There are plenty of tasty foods around so we don't need to use new food technologies to produce more", "The benefits of new food technologies are often grossly overstated", "New food technologies decrease the natural quality of food" and "There is no sense in trying out high-tech food products because that ones I eat are already good enough" on a 5-point Likert scale.

The studies by Schlup and Brunner (2018), Brunner et al. (2018), Lammers et al. (2019), Coderoni and Perito (2020) and Coderoni and Perito (2021) also followed the same rationale as Verbeke (2015) and chose the same four items. Other researchers did not provide their rationale for making the item reductions observed: from 13 to 12 (Furno et al., 2016; Verneau et al., 2019), to ten (Lee et al., 2021), to nine (Ali et al., 2021) and to six items (Caulier et al., 2020; Gómez-Luciano et al., 2021).

Abbreviated Food Technology Neophobia Scale

In line with the modification of number of items, Schnettler et al. (2016) determined the psychometric properties of the original FTNS in a Chilean sample of 332 consumers and reported no evidence for the validity of the original FTNS structure. Seeking a model with a good fit to the data, they derived an abbreviated version of the FTNS, the Abbreviated FTNS, or AFTNS. This new scale includes only one factor instead of four and only nine items, with item numbers 1, 7, 8 and 13 dropped because they did not fit the data. Moreover, the AFTNS adopted a 6-point Likert scale, opting to eliminate the midpoint, as Schnettler et al. (2013) had suggested respondents tend to choose the middle to simplify their decision. Later, Schnettler et al. (2017) tested the AFTNS and confirmed it as a suitable tool to measure the level of acceptance of foods produced with new food technologies. A few subsequent studies, such as Baum et al. (2021), Rabadán (2021) and Rabadán and Bernabéu (2021) have applied the AFTNS in their methodology.

3.2.2. Findings on socio-demographic variables

Several socio-demographic variables, such as age, gender, income, level of education and country, have been considered intensively in studies using the FTNS. Researchers have identified various associations between these socio-demographic variables and their impact on the degree

of food technology neophobia. However, these associations cannot serve as a basis for broad claims because the underlying studies were conducted in different years, in different consumer segments, and in different countries; they also varied in the products and technologies considered. Nonetheless, some tendencies can be derived from the results, and these are presented in Table 3.

Table 3

Overview findings on socio-demographic variables.

Socio-demographic variable	Results related to the food technology neophobia scale
Age	• No significant differences between age and FTN (Evans et al., 2010; Cattaneo et al., 2019; Proserpio et al., 2019) • FTN decrease with age (McKenzie et al., 2021; Chen et al., 2013) • FTN increase with age (Jeżewska-Zychowicz and Krolak, 2015 (rep.); De Steur et al., 2016; Martins et al., 2019; Proserpio et al., 2020; Vidigal et al., 2015 (rep.); Salgado-Beltrán et al., 2018; Rabadán, 2021; Rabadán and Bernabéu, 2021; Ortega et al., 2022)
Gender	• No significant differences in FTN scores between men and women (Evans et al., 2010; Chen et al., 2013; De Steur et al., 2016; Cattaneo et al., 2019; Proserpio et al., 2019; Proserpio et al., 2020) • Men less neophobic than women (Schnettler et al., 2017; Martins et al., 2019) • Men more neophobic than women (Jeżewska-Zychowicz and Krolak, 2015 (rep.); McKenzie et al., 2021; Ortega et al., 2022)
Income	• No significant relationships between income and FTN (Chen et al., 2013) • FTN is lower in higher income groups (McKenzie et al., 2021; Salgado-Beltrán et al., 2018; Martins et al., 2019; Coderoni and Perito, 2020; Ortega et al., 2022) • FTN is higher in higher income groups (De Steur et al., 2016)
Education	• No significant relationships between education and FTN (McKenzie et al., 2021; Chen et al., 2013) • FTN is higher in less educated groups (Evans et al., 2010; Verbeke, 2015 (rep.); Jeżewska-Zychowicz and Krolak, 2015 (rep.); Vidigal et al., 2015 (rep.); De Steur et al., 2016; Martins et al., 2019; Cattaneo et al., 2019; Rabadán, 2021; Rabadán and Bernabéu, 2021; Ortega et al., 2022)
Country and the result for the FTNS[3]	Brazil • Mean = 77.20 (range = 13-91) (Coutinho et al., 2021) • Mean = 47.0 (SD = 12.0; range = 13-91) (Vidigal et al., 2015) (rep.) Australia • Mean = 55.00 (range = 13-91) (Cox and Evans, 2008)

[3] The FTNS is expressed as a sum score across the items, generated by summing the individual answers to the items measured on the Likert scale. A higher score indicating greater aversity to novel food technologies (Cox and Evans, 2008). Values are expressed with mean and if specified SD (standard deviation).

	• Mean = 54.65 (SD = 10.82; range = 13-91) (Lease et al., 2014) • Mean = 53.62 (SD = 11.3; range = 13-91) (Evans et al., 2010)
Canada	• Mean = 58.45 (SD = 6.2; range = 13-91) (Matin et al., 2012) • Mean = 38.97 (SD = 7.8; range = 13-65) (Chen et al., 2013)
Italy	• Mean = 60.90 (SD = 11.3; range = 13-91) (Verneau et al., 2014) • Mean = 55.20 (SD = 13.7; range = 13-91) (Caracciolo et al., 2016) • Mean = 48.50 (SD = 10.1; range = 13-91) (Proserpio et al., 2019) • Mean = 44.20 (SD = 13.7; range = 13-91) (Cattaneo et al., 2019) • Mean = 40.30 (SD = 8.4; range = 13-91) (Proserpio et al., 2020)
Uganda	• Mean = 58.70 (range = 13-65) (De Steur et al., 2016)
China	• Mean = 52.50 (range = 13-91) (Ortega et al., 2022)
Chile	• Mean = 38.70 (SD = 7.7; range = 9-54) (Schnettler et al., 2017)

Note: The abbreviation "rep." indicates a representative sample.

3.2.3. Findings on products and technologies

Several studies examined the effect of the FTN on the acceptance of products created using novel food technologies. These various products and technologies can be assigned to six different categories: Genetic modified / edited food, food fortification, insects as a food option, shelf-life technologies, 3D food printing technology, and up- and recycling technologies. The findings for these categories follow.

Genetic modified / edited food

Several studies have used the FTNS to study consumer acceptance of genetically modified food and food fortification. Evans et al. (2010) reported that the FTNS is a significant predictor of whether consumers would taste food labelled as genetically modified. The study by Chen (2018) and Kim et al. (2014) confirmed that consumers with a higher degree of FTN are less willing to consume genetically modified foods. Ali et al. (2021) also found in a Chinese and American sample that consumer trust in genetically modified food is negatively influenced by FTN. Ortega et al. (2022) highlighted the key role of FTN in correctly predicting consumer acceptance of genetically edited rice and pork.

Food fortification

Other studies focused on food fortification. Vidigal et al. (2015) investigated the influence of different levels of neophobia (low, medium, high) on consumer willingness to try yogurt using conventional and non-conventional technologies. They suggest that consumers with medium or high FTN are less willing to try new or non-conventional technologies such as foods labelled as enriched with bioactive protein, organic, transgenic and with nanocomposites. Acceptance of conventional technologies such as pasteurization shows no relation to different levels of FTN, as these technologies are already well known to and trusted by consumers.

These results indicate that greater consumer neophobia leads to a higher likelihood of a consumer rejecting the option to taste food made through a novel technology. In this line, the results by Caracciolo et al. (2016) support the role of FTN as a significant determinant of the consumption frequency of dietary supplements, indicating that consumer characterized by higher FTN are associated with a lower consumption frequency of dietary supplements. Similar results were obtained by Jeżewska-Zychowicz and Krolak (2015) who used the scale to estimate the relationship between willingness to eat cereal products fortified with fibre and FTN. Further, Verneau et al. (2019) investigated the role of food technology neophobia toward the acceptance of canned crushed tomatoes enriched with lycopene. The results of this study follow a similar pattern as these previous studies (Jeżewska-Zychowicz and Krolak, 2015; Caracciolo et al., 2016).

Proserpio et al. (2019) ascertain that after consumer segmentation, adolescents with a low or medium degree of food technology neophobia are more willing to consume a novel flat bread enriched with beta-glucans compared to adolescents with a higher degree of food technology neophobia.

Insects

Another group of studies examined the role of FTN in predicting the acceptance of insects as a food option. According to Verbeke (2015) consumer readiness to adopt insects as a meat substitute can be explained by food technology neophobia. The author also notes that people perceive the production of food from insects not only as unfamiliar and unusual but also as unnecessary. The study by Schlup and Brunner (2018) has also shown a negative correlation between FTN and the willingness to adopt insects as a meat substitute or to consume edible insects in general. However, they also show that prior consumption of insects can reduce the negative effects of FTN on willingness to consume novel products. The negative correlation between

FTN and consumer inclination to consume edible insects has also been observed by Lammers et al. (2019) and Gómez-Luciano et al. (2021).

Shelf-life technologies

Moreover, a few studies have evaluated the suitability of FTN in predicting consumer acceptance of different shelf-life technologies. Matin et al. (2012) studied the correlation of FTN with consumer acceptance of nanotechnology, in general and in food packaging and foods. They found that higher levels of FTN strongly predict negative consumer attitudes toward nanotechnology and consumer perceptions of the risk-benefit tradeoff of the technology. This relation was also observed by Vidigal et al. (2015) and Sodano et al. (2016).

Another study evaluated the influence of FTN on Canadian consumer perceptions of a novel and largely unfamiliar fresh meat vacuum packaging technology and determine that consumers with a lower level of FTN are more willing to accept vacuum packaged meat (Chen et al., 2013). In this regard, the study by Demartini et al. (2018) pointed out that FTN is the most relevant predictor of consumers' acceptance of shelf-life extension on packaged fresh fish fillets. Another study by Martins et al. (2019) explored the influence of FTN on consumers' perception of different fruit juices processed using different technologies (fresh juice, cold pressed juice, pasteurized juice, pressurized juice and non-pressurized juice). They found that consumers tend to be more neophobic toward the use of technology in fruit juice, so the higher the level of FTN, the more likely consumers are to perceive juices processed by either conventional or innovative technologies negatively. Their results suggest that a higher level of FTN may not only influence consumer perception of products processed with novel technologies but also those processed by any technology at all. A later study by Martins et al. (2020) found that more neophobic consumers tend to show an aversion to novel foods and prefer fresh juices without the addition of other ingredients or processing technologies. On the other hand, consumers with lower FTN show a preference for novelty, e.g., cold-pressed and pressurized juices.

3D food printing technology

Further, a few studies have focused on the relation between FTN and acceptance of 3D food printing technology. The study by Brunner et al. (2018) shows that negative consumer attitudes toward food produced with 3D food printing technology can be predicted by their level of technology neophobia. The study by Caulier et al. (2020) confirm a negative correlation between 3D food printing and food technology neophobia.

Up- and recycling technologies

The remaining studies focused on up- and recycling technologies. Cattaneo et al. (2019) studied the acceptance of food by-products, while Coderoni and Perito (2020) investigated the attitudes toward waste-to-value food and Coderoni and Perito (2021) focused on the association between FTN and food produces with upcycled ingredients. All these studies came to the same conclusion, namely, FTN is a good predictor of consumer attitudes toward these products. Further, Lease et al. (2014) examined consumers acceptance of recycled water in meat products.

3.2.4. Findings on consumer behavior

21 studies investigated the relation between FTN levels and risk perception, consumer attitudes, norms, and behavioral intentions. These are important predictors of purchase intention. Studies have also examined how receiving information about various novel food technologies impacts the phobia around it.

Risk perception

Several studies indicate that FTN correlates with consumer perception of risk and the assessment of the benefits of a technology (Coppola et al., 2014; Chen, 2018; Ali et al., 2021). This finding is reinforced by the observation of Chen et al. (2013), indicating that FTN scores are positively correlated with the level of food safety concern, meaning more neophobic consumers tended to be more concerned about food safety. Similarly, Krings et al. (2021) found consumers with higher FTN perceived clean meat as less safe than regular meat. Verneau et al. (2014) and Verneau et al. (2019) explain this association through the fact that consumers perceive less risk in familiar food products. In turn, consumers who perceive high risks and see utter uselessness in technology will refrain from purchasing such products (Vidigal et al., 2014). Similar results were obtained by Verneau et al. (2019) who indicate that the perception of risks associated with novel products decrease the willingness to pay. Furthermore, Chen et al. (2013) reported a negative correlation between FTN and openness to innovation. This suggests that less neophobic consumers tend to be more open to innovations.

Consumer attitudes, norms, and behavioral intentions

Coppola et al. (2014) identify that consumers with a higher negative tendency toward novel food technologies and a higher tendency to worry about environmental risks are less likely to purchase the novel product. Similarly, De Steur et al. (2016) found that healthy choice motives negatively influence consumers attitudes toward technologies as well as purchase intention. Similar results were obtained by Proserpio et al. (2019) who reported that consumers with a

lower degree of FTN seem to have healthier behavior compared to consumers with higher FTN. Moreover, Rabadán and Bernabéu (2021) suggest that consumers with lower levels of FTN are more aware of protecting the environment and so more willing to try food produced using novel technologies. However, Coderoni and Perito (2020) found that consumers abstain from trying waste-to-value food, even though it could reduce environmental impacts.

Influence of information

Several studies have investigated the influence of information on novel technologies on consumer FTN. Brunner et al. (2018) reported that providing consumers with high FTN factual information about 3D food printing technology did little to calm fears and reservations, and thus neophobia toward the technology persisted. For consumers already informed, further information even led to an increase in neophobia. These findings are consistent with Evans et al. (2010) who found additional information about novel technologies had no influence on FTNS scores or the willingness to try new products. These results are consistent with the observations by Demartini et al. (2018) who reported that the level of FTN does not respond to information treatments.

In contrast, other studies (Vidigal et al., 2015; Deegan et al., 2015; Cattaneo et al., 2019) have reported positive effects on the degree of FTN from providing information. Vidigal et al. (2015) state that the provision of information is a key factor in the acceptance of new types of technology. This suggests that providing a description of the advantages and disadvantages of technologies (organic, genetically modified, enriched with bioactive proteins, nanotechnology) could increase the acceptance of these technologies and coincidently reduce the level of FTN (Vidigal et al., 2015). Deegan et al. (2015) found consumers with lower levels of FTN responded positively to the communication of technical information about novel technologies and also convinced them to consider purchasing a novel Emmental-type cheese made from low-pressure homogenized milk. Cattaneo et al. (2019) confirmed that consumers appreciated receiving information and found that it can facilitate the purchase decisions of consumers with high FTN, just as a lack of information seems to reduce the confidence in foods. Rabadán (2021) adds that a greater product involvement resulted in lower FTN.

4. Discussion

Our survey results show growing interest in food technology neophobia, especially in recent years. The year 2021 saw the greatest number of articles using an FTN scale in their methodology (ten studies). This was the peak of a trend started with the introduction of the FTN scale in 2008, so we assume that the numbers of studies will increase in 2022 and beyond.

All papers found for this review used a quantitative study design and that most used online surveys. As the original scale was developed in 2008, a qualitative approach such as interviews or focus group discussions would allow us to dive deeper into consumers current understanding of the items and to integrate current concerns into the scale which we might not have been aware of so far. Such understanding is needed to unveil new perspectives on promoting consumer acceptance. This is an important starting point for future research.

Despite the growing number of studies on FTN, we find most of the research has followed a single country approach, focusing on consumers in high income countries, mainly European countries and especially Italy (Verneau et al., 2014; Coppola et al., 2014; Caracciolo et al., 2016; Sodano et al., 2016; La Barbera et al., 2016; Demartini et al., 2018; Cattaneo et al., 2019; Proserpio et al., 2019; Coderoni and Perito, 2020; Proserpio et al., 2020; Ortega et al., 2020; Coderoni and Perito, 2021). Information about food technology neophobias among consumers in low-income countries is lacking, as we have only one study conducted in Uganda (De Steur et al., 2016).

Even under single-country conditions, a comparison of the level of FTN in the same country shows highly heterogeneous results (Table 3), let alone comparisons across countries. In this regard, for example, Coutinho et al. (2021) and Vidigal et al. (2015) both explored food neophobia in Brazil and found very different levels of FTN. Similarly, studies conducted in Italy have shown broad differences in FTN levels, as evidenced by the range between 44.20 (SD = 13.7; range = 13-91) (Cattaneo et al., 2019) and 60.90 (SD = 11.3; range = 13-91) (Verneau et al., 2014). In this line, it should be noted that it is difficult to draw any conclusions from the variation in mean scores by country, given the sampling was mostly unrepresentative. Thus, biased samples or differences in recruitment criteria lead to pronounced within-country variations. Results corroborate the difficulty in drawing consistent conclusions about a country's readiness for novel foods from FTN scores. This suggests that the determinants that influence

consumer preferences in a country are not wholly captured by an FTN scale and that the question bears further investigation. On this basis, future research should also ascertain whether, in principle, a uniform level of FTN can be identified for a country.

In this regard, a notable finding is that only six of the reviewed studies used a socio-demographically representative sample (Kim et al., 2014; Verbeke, 2015; Jeżewska-Zychowicz and Krolak, 2015; Vidigal et al., 2015; Allen et al., 2018; Gómez-Luciano et al., 2021). This highlights another limitation of the extant literature and identifies another relevant knowledge gap. Conclusions from non-representative samples cannot be applied to the whole population of a country. Research is needed using samples that mirror to the greatest extent possible the socio-demographic structure of the relevant consumer population.

Another point is related to Ritchey et al. (2003) observations, namely, difficulties could arise when a scale developed and validated in a specific South Australian sample (Cox and Evans, 2008) and its use become widespread. It is not hard to imagine the influence of cultural differences affecting the perceptions and interpretations of items, resulting in discrepancies between study results. Indeed, Schnettler et al. (2016) emphasize the influence of country-specific culture on the scale's validity. Of course, to use the scale concept under different linguistic and cultural circumstances, it has been translated and validated into different languages. However, the use of an FTN scale in different countries on different continents involves further validation, especially as samples used have often been relatively small and not representative of the country's population structure. From our perspective, the statistical weakness of the studies available for review is one of the review's major findings. On this basis rest recommendations for future research with larger and more representative samples, if a true measure of consumer readiness for novel food technologies is to be found.

Beyond language issues, several studies implemented modifications in the original FTNS regarding the use of a different number of items. Those changes produced eleven different configurations of the original FTNS in the 49 studies surveyed, each varying in the number of items or number of points on the associated Likert scale. Considering all these changes, we observe that several studies did not make use of the entire structure derived by the scale's initial developers. Moreover, the prerequisite for implementing changes to the original FTNS would be to conduct exploratory factor analysis (EFA) and / or confirmatory factor analysis (CFA). This methodical approach would ensure convergent validity and determine the degree of stability of the new scale. But without a transparent rationale and procedure for modifying the scale, the quality of the result cannot be assured.

For example, to assess the quality of the FTNS used in their study, McKenzie et al. (2021) conducted exploratory and confirmatory factor analysis on a Chinese sample. Results showed that a modified 11 item version fit the data better than the original structure of the FTNS. Furthermore, Schnettler et al. (2016) conducted a confirmatory factor analysis in a Chilean sample and concluded no evidence of scale validity for the original FTNS. Thus, Schnettler et al. (2016) and Schnettler et al. (2017) proposed the AFTNS (nine items, 6-point Likert scale) as a simplified international measure of the acceptance of food using novel technologies. However, Schnettler et al. (2016) and Schnettler et al. (2017) conducted their studies on a specific Chilean sample. Thus, further research is needed to verify the use of the AFTNS and other variations of the FTNS in different samples and in other countries. We acknowledge that replication of a study is of course always of less interest to publishers, but for future research, a study with a smaller sample could be conducted first and then through a larger consortium on all Western, Southern, Northern and Eastern European countries to check the replicability of the scale.

Few studies evaluate specifically the relations between socio-demographic variables and food technology neophobia scores. Results present very different conclusions across variables. Hence, no consistent conclusions regarding the effect of age, gender, income and country on the level of FTN can be identified. However, ten out of twelve studies show education effects, suggesting a strong influence on the level of FTN. Thus, from our perspective, it makes sense to include the factor education in future research, as this factor shows the same direction in several studies, where it indicates that the FTN is higher in less educated groups. Overall, it is clear that it does not seem possible to explicitly describe the socio-demographic profile of a consumer with a high level of FTN with the evidence available so far, pointing to further avenues for future research.

However, some general conclusions can be drawn regarding the relationship between FTN and consumer behavior. All studies coincide in finding a negative correlation between FTN scores and consumer willingness to taste or to consume novel food products (Coppola et al., 2014). Several authors find that FTN is a factor that could impede the acceptance of novel food products, including for example the readiness to adopt insects as a substitute to meat protein (Verbeke, 2015; Schlup and Brunner, 2018; Lammers et al., 2019; Gómez-Luciano et al., 2021). Other studies find that higher levels of FTN predict aversion to innovations, a finding that could be very important for future food production. Such aversion can impede the acceptance of nanotechnology for food production (Vidigal et al., 2015; Matin et al., 2012; Sodano et al., 2016), of genetically modified / edited foods (Evans et al., 2010; Chen, 2018; Kim et al., 2014; Ali et

al., 2021; Ortega et al., 2022), of 3D food printing (Brunner et al., 2018; Caulier et al., 2020) or of the production of food from up- and recycling processes (Cattaneo et al., 2019; Coderoni and Perito, 2020; Coderoni and Perito, 2021).

Some studies have already undertaken research to assess consumer risk perceptions and food safety concerns about novel food technologies and to draw conclusions about their level of FTN. Results suggest that consumer risk perceptions and food safety concerns reinforce their reluctance to accept new food technologies (Chen et al., 2013). Further, innovations in food production seem to be perceived by consumers with a higher FTN as tending to be unhealthy, uncertain, unnatural, untrustworthy and are associated with risks in general (Chen, 2018; Coutinho et al., 2021). However, deeper insights into consumer behavioral intentions are still lacking, which is not surprising, since no qualitative studies on FTNS have been done that could offer the opportunity for a comprehensive understanding of respondent motivations, mindsets, and attitudes, studies that could also bring forth new insights into allaying consumer FTN and the corresponding scales.

Further, several studies have examined the effect on FTN of providing information about various novel food technologies. However, the effects have not yet been clarified (Brunner et al., 2018; Evans et al., 2010; Demartini et al., 2018; Vidigal et al., 2015; Deegan et al., 2015; Cattaneo et al., 2019; Rabadán, 2021; Martins et al., 2020). Several factors such as pre-existing knowledge about novel technologies and the individual level of FTN, play an important role. In this regard, not all authors concur that the level of FTN will decrease, if trustworthy and understandable information about novel food products and food technologies is provided. Frewer et al. (2003) added that trust in information sources, regulators and especially institutions responsible for promotion, management and regulation have a decisive impact on how consumers react to novel products and technologies. Thus, it cannot be said that providing information will necessarily lower the level of FTN, nor will it necessarily increase consumer confidence in novel food technologies. Further, Kahan et al. (2011) reported that consumers tend to form risk perceptions that are consistent with their personal and cultural values. Thus, consumers are inclined, in terms of risk perception of novel technologies, to hold opinions that mirror their cultural disposition toward technological risks. Cohen et al. (2000), Cohen et al. (2007) and Kahan (2010) added that personal and cultural values should underpin communication strategies, because individuals tend to react more open-mindedly when they are shown risk information that individuals associate with a conclusion supporting their cultural values instead of threatening it. Overall, Frewer et al. (2003) calls for trustworthy information, whilst Kahan

et al. (2001) suggests information that aligns with values of the individual. It is possible that the two approaches are necessary to elicit positive consumer responses to novel food technologies and lower the level of FTN, which should be explored in future research. However, it has been well established that consumer fears and reluctance toward novel food technologies are difficult to remove (Brunner et al., 2018).

Further research is needed to create different strategies by which information treatments may serve to influence entrenched food technology neophobias. To this end, framing studies that study different formulations of a message with the same content to see how these influence the behavior of the recipient could test the effect of different communication strategies on consumer attitudes and beliefs about novel food technologies. This could lead to deeper insights into individual suggestibility.

The overarching finding of this survey is that a scale to measure FTN is highly relevant to forecasting the acceptance or rejection of novel food technologies and the willingness of consumers to try or consume such products. Results related to FTN can be especially helpful for food product developers and for marketing research in general to increase the success rate of novel food products in the market and to define target groups in more detail (Cox and Evans, 2008). From our perspective, it would be beneficial to conduct broader research into the following areas:

1) First, a main issue for scientists is the small amount of representative studies existing related to FTN. Thus, further validation (test-retest) of previous findings is required, which should include a larger sample size and representative samples of the respective population - in high and upper middle-income countries as well as in lower middle- and low-income countries.
2) Second, additional research into the effects of different opportunities to influence the level of neophobia, especially the provision of information about novel food technologies, is also necessary as the success of any innovation depends on positive consumer responses to the technology (Cox and Evans, 2008). For this reason, more in-depth analyses by scientists is necessary to identify factors which may alter consumer attitudes toward novel food technologies. In addition, further research is needed to estimate the effect size of FTN relative to other drivers of food acceptance.
3) Finally, as a support for marketing decision makers and marketing purposes in general, it is important to focus on the characteristics of food technology neophobic consumers in contrast to those of early adopters of novel food products and food technologies. For

novel food technologies to help relieve unsustainable environmental pressures, food producers must better understand the attitudes, norms and behavioral patterns of the consumers they aim to serve.

5. Conclusion

There is clear evidence that current consumption and production patterns need to shift radically toward more sustainable technologies to curb global challenges such as the climate crisis. Novel food technologies could make a significant contribution to promoting the sustainability transition. However, the market entry opportunities for innovations in the food industry are blocked by the phenomenon known as food technology neophobia (FTN), the fear or, or aversion to, novel foods produced by technology.

Thus, understanding consumer FTN is crucial for the success or failure of novel technologies in the marketplace, and it is also beneficial for developers in the food industry and those involved in food research aiming to match products to consumer preferences. Since its introduction in 2008, the FTN scale concept has been applied in many different studies and its use has become widespread, especially in recent years when food security in combination with sustainable production has become a focus of research. With its broadened use in various contexts, scale changes and adaptations have evolved. However, modifications from the original 13-item, 7-point Likert scale are not necessarily qualified to ensure convergent validity in using the scale as a measure of FTN. Still, we can answer our first research question in the affirmative:

1) Is the FTNS a suitable tool to measure consumer acceptance of novel food technologies?

The FTN scale can prove a reliable and valid measure of FTN. The scale can identify segments of the population with greater or lesser willingness to try new food technologies, and it can serve as a good predictor of consumer acceptance. Our second question:

2) What is the impact of FTN on willingness to try products created using novel technologies?

is answered by the findings of this review. Food technology neophobia has been well documented for a wide range of food innovations and novel food technologies in different countries and among consumers who perceive no benefit to the products. FTN tracks with consumer confidence and risk perception. Findings agree that individuals with a higher degree of food technology neophobia are less willing to try foods produced using novel technologies and associate those products with negative characteristics.

3) What are research areas that should be addressed in future studies?

From our perspective, test-retest studies of previous findings should be implemented with larger sample sizes as well as representative samples - in high and upper middle-income countries as well as in lower middle- and low-income countries. Further, investigations into characteristics of food technology neophobic consumers in terms of socio-demographic variables, attitudes, intentions and behavioral patterns would be valuable in understanding those consumers in more detail. Also, qualitative research into factors that may influence consumer FTN is needed to find strategies to reduce aversion to new foods among neophobic consumers.

We would like to stress the importance of putting these findings into proper perspective. Novel food technologies are urgently needed in the sustainability transition; they are needed to ensure sustainable dietary habits as well as sustainable food production processes. Further, new food technologies not yet tested, such as cultivated milk with large potential to unburden the environment from conventional livestock production, are promising to drive more sustainable diets in the future. Yet the example of GMO foods shows how the lack of consumer acceptance can limit the impact of novel technologies on the market. To assess the likelihood of such acceptance, the FTNS proves to be a suitable tool, though it is important to use a validated and trustworthy configuration of the scale.

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Appendix A

Table A.1

Summary of reviewed publications.

Author (s), year	Journal	Products	Technology	Country	Representative (yes / no)	Sample size	Type of study	FTN Scale configuration
Cox and Evans, 2008	Food Quality and Preference	Fruit juice, prawns, oilseeds, yoghurt, salads	Pasteurization, High pressure processing, modified atmosphere, triploidy, Genetic modification, Fortification	Australia	No	294	Online survey	13 items, 7-point Likert Scale
Evans et al., 2010	Appetite	Orange juice, bread, yoghurt, cheese, smoked salmon and prawns	Pasteurization, Fortification, Selective breeding, Triploidy, Genetic modification, Nanotechnology	Australia	No	131	Online survey	13 items, 7-point Likert Scale
Matin et al., 2012	International Journal of Consumer Studies	Food and food packaging	Nanotechnology	Canada	No	777	Online survey	13 items, 5-point Likert Scale
Chen et al., 2013	Food Quality and Preference	Beef	Vacuum packaging	Canada	No	99	Paper and pencil questionnaire	13 items, 5-point Likert Scale
Verneau et al., 2014	Appetite	Fat reduced food, functional food, Ready-to-eat frozen food	Food processing	Italy	No	555	Interviewer-administered questionnaire	13 items, 7-point

Author (s), year	Journal	Products	Technology	Country	Repre-senta-tive (yes / no)	Sam-ple size	Type of study	FTN Scale configu-ration
								Likert Scale
Lease et al., 2014	Food Quality and Preference	Meat products obtained using recycled water	Types of water undergoing recy-cling treatment include: sewage effluent, stormwater runoff, do-mestic greywater and industrial wastewater	Australia	No	101	Interviewer-administered questionnaire	13 items, 7-point Likert Scale
Coppola et al., 2014	Italian Journal of Food Science	Organic foods, functional foods, low-fat products, ready to eat products, short chain products	Food processing	Italy	No	355	Interviewer-administered questionnaire	13 items, 7-point Likert Scale
Kim et al., 2014	Food Research International	GM foods	Genetic modification	South Ko-rea	Yes	387	Interviewer-administered questionnaire	13 items, 7-point Likert Scale
Verbeke, 2015	Food Quality and Preference	Insects	Insect production	Belgium	Yes	368	Online sur-vey	4 items, 5-point Likert scale

Author (s), year	Journal	Products	Technology	Country	Representative (yes / no)	Sample size	Type of study	FTN Scale configuration
Jeżewska-Zychowicz and Krolak 2015	Polish Journal of Food and Nutrition Science	Cereal products fortified with fibre	Fortification	Poland	Yes	1000	Online survey	13 items, 7-point Likert Scale
Vidigal et al., 2015	LWT - Food Science and Technology	Yoghurt	Pasteurization, genetic modification, Fortification, Nanotechnology	Brazil	Yes	389	Interviewer-administered questionnaire	13 items, 7-point Likert Scale
Deegan et al., 2015	Food Quality and Preference	Novel Emmental-type cheese	Low pressure homogenisation	Finland	No	229	Online survey	13 items, 7-point Likert Scale
Schnettler et al., 2016	Food Quality and Preference	Food	Not specified	Chile	No	332	Interviewer-administered questionnaire	13 items, 6-point Likert Scale
De Steur et al., 2016	Appetite	Matooke (Cooking banana)	Production of matooke	Uganda	No	209	Interviewer-administered questionnaire	13 items, 5-point Likert Scale

Author (s), year	Journal	Products	Technology	Country	Repre-senta-tive (yes / no)	Sam-ple size	Type of study	FTN Scale configu-ration
Furno et al., 2016	Food Quality and Preference	Crushed tomatoes en-riched with lycopene	Functional food	Italy	No	190	Paper and pencil ques-tionnaire	12 items, 7-point Liker Scale
Caracciolo et al., 2016	Italian Journal of Food Science	Dietary supplements	Food supplement production	Italy	No	368	Interviewer-administered questionnaire	13 items, 7-point Likert Scale
Sodano et al., 2016	British Food Journal	Nanofoods	Nanotechnology	Italy	No	275	Online sur-vey	13 items, 7-point Likert Scale
La Barbera et al., 2016	British Food Journal	Crushed tomatoes en-riched with lycopene	Functional food	Italy	No	100	Online sur-vey	13 items, 7-point Likert Scale
Schnettler et al., 2017	Food Research International	Food	Nanotechnology, genetic modifi-cation, cloning	Chile	No	372	Interviewer-administered questionnaire	9 items, 6-point Likert Scale
Schlup and Brunner, 2018	Food Quality and Preference	Insects	Insect production	Switzer-land	No	379	Paper and pencil ques-tionnaire	4 items, 6-point

Author (s), year	Journal	Products	Technology	Country	Repre-senta-tive (yes / no)	Sam-ple size	Type of study	FTN Scale configu-ration
								Likert Scale
Brunner et al., 2018	Food Quality and Preference	3D-printed food	3D-food printing	Switzer-land	No	260	Paper and pencil ques-tionnaire	4 items, 6-point Likert Scale
Salgado-Beltrán et al., 2018	Sustainability	Rice-based dessert	Rice production	Mexico	No	266	Interviewer-administered questionnaire	13 items, 7-point Likert Scale
Allen et al., 2018	British Food Journal	Dairy products	Dairy production	Canada	Yes	1705	Online sur-vey	13 items, 7-point Likert Scale
Chen, 2018	Journal of the Science of Food and Agriculture	GM foods	Genetic engineering	China	No	487	Online sur-vey	13 items, 7-point Likert Scale

Author (s), year	Journal	Products	Technology	Country	Representative (yes / no)	Sample size	Type of study	FTN Scale configuration
Demartini et al., 2018	Sustainable Production and Consumption	Fish fillets	Shelf-life extension	Italy	No	418	Online survey	13 items, 7-point Likert Scale
Martins et al., 2019	Food Research International	Fruit juice	Pasteurization, Pressurization, non-pressurization, cold pressurization	Brazil	No	423	Online survey	13 items, 7-point Likert Scale
Cattaneo et al., 2019	Journal of Food Science and Technology	Food by-products	Food by-products processing	Italy	No	273	Interviewer-administered questionnaire	13 items, 7-point Likert Scale
Lammers et al., 2019	Food Quality and Preference	Insect burger	Insect production	Germany	No	516	Online survey	4 items, 5-point Likert scale
Verneau et al., 2019	Nutrients	Crushed tomatoes enriched with lycopene	Fortification	USA	No	100	Online survey	12 items, 7-point Likert Scale

Author (s), year	Journal	Products	Technology	Country	Representative (yes / no)	Sample size	Type of study	FTN Scale configuration
Proserpio et al., 2019	Foods	Flat bread	Fortification	Italy	No	285	Online survey	13 item, 7-point Likert Scale
Martins et al., 2020	Journal of Food Science and Technology	Fruit juice	Pasteurization, Pressurization, non- pressurization	Brazil	No	369	Online survey	13 items, 7-point Likert Scale
Coderoni and Perito, 2020	Journal of Cleaner Production	Waste-to-value (WTV) food	Producing waste to value food	Italy	No	477	Online survey	4 items, 5-point Likert scale
Caulier et al., 2020	Food Quality and Preference	3D-printed food snacks: cookies	3D-food printing	Netherlands	No	12	Paper and pencil questionnaire	6 items, 7-point Likert Scale
Coimbra et al., 2020	Journal of Food Science and Technology	Whey dairy beverages	Ohmic heating	Brazil	No	100	Paper and pencil questionnaire	13 items, 5-point Likert Scale

Author (s), year	Journal	Products	Technology	Country	Representative (yes / no)	Sample size	Type of study	FTN Scale configuration
Modlinska et al., 2020	Nutrients	Insects	Insect production	Poland	No	99	Paper and pencil questionnaire	13 items, 7-point Likert Scale
Proserpio et al., 2020	Foods	Extruded snacks	Extrusion	Italy	No	42	Online survey	13 items, 7-point Likert Scale
Ortega et al., 2020	European Review of Agricultural Economics	Pork	Genetic modification	USA, China, Italy	No	2844	Online survey	13 items, 7-point Likert Scale
Ali et al., 2021	GM Crops & Food	GM foods	Genetic modification	China, USA	No	650	Online survey	9 items, 7-point Likert Scale
McKenzie et al., 2021	Food Quality and Preference	Domestic food and beverage products	Not specified	China	No	1917	Online survey	13 items, 7-point Likert Scale

Author (s), year	Journal	Products	Technology	Country	Representative (yes / no)	Sample size	Type of study	FTN Scale configuration
Coutinho et al., 2021	LWT - Food Science and Technology	Chocolate milk drink	Cold plasma technology	Brazil	No	1085	Online survey	13 items, 7-point Likert Scale
Coderoni and Perito, 2021	Waste Management	Products enriched with upcycled ingredients	Upcycling	Italy	No	317	Online survey	4 items, 5-point Likert Scale
Gómez-Luciano et al., 2021	Journal of International Food & Agribusiness Marketing	Insects	Insect production	Spain, Dominican Republic	Yes	401	Online survey	6 items, 5-point Likert Scale
Baum et al., 2021	Food Quality and Preference	Cultivated meat	Cultivated meat production	Germany	No	617	Online survey	9 items, 6-point Likert Scale
Lee et al., 2021	Journal of Hospitality and Tourism Management	3D-printed food	3D-food printing	South Korea	No	343	Online survey, paper and pencil questionnaire	10 items, 7-point Likert Scale
Rabadán, 2021	Foods	Wine	Wine processing	Spain	No	400	Interviewer-administered questionnaire	9 items, 6-point

Author (s), year	Journal	Products	Technology	Country	Repre-senta-tive (yes / no)	Sam-ple size	Type of study	FTN Scale configu-ration
								Likert Scale
Rabadán and Bernabéu et al., 2021	Journal of Cleaner Produc-tion	Wine	Wine processing	Spain	No	400	Interviewer-administered questionnaire	9 items, 6-point Likert Scale
Krings et al., 2021	Food Quality and Preference	Cultivated meat	Cultivated meat production	EU, UK, USA	No	1169	Online sur-vey	13 items, 7-point Likert Scale
Jaeger et al., 2022	Food Quality and Preference	Fruits, vegetables	Indoor vertical farming	UK	No	837	Online sur-vey	13 items, 7-point Likert Scale
Ortega et al., 2022	Food Quality and Preference	Gene-edited food: rice and pork products	Genome Editing	China	No	835	Online sur-vey	13 items, 7-point Likert Scale

Teil I: Verbraucherakzeptanz von technologischen Lebensmittelinnovationen

I.2 Cultured Meat: Identifying trust profiles of German consumers using latent profile analysis

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Der Originalbeitrag ist unter Begutachtung im Journal Appetite.

Abstract

The global challenge of sustainable food production and consumption can be addressed with sustainable food technologies. One such, cultured meat, can contribute to improving food security and to do so more humanely and with fewer environmental impacts than conventional meat production. However, its acceptance is hampered by government safety regulations such as those of the European Food Safety Authority (EFSA), food industry resistance, and consumer distrust. Considering trust as essential for buying and eating new food products on a regular basis, we investigated consumer trust profiles in the German population. We used latent profile analysis of online survey data from 1099 consumers to identify four profiles, distinct in their trust level toward cultured meat and corresponding actors. The smallest profile, the Trusting Consumers (17.5%), express the highest trust level and purchase intention for cultured meat. They are more likely to be younger, more educated, have higher incomes, the highest level of involvement, and the lowest food technology neophobia. However, 24.3% are Distrustful Consumers, who are not willing to purchase cultured meat because they distrust the EFSA, cultured meat, fellow humans, and food manufacturers. They are 56 and older, less educated, have lower incomes, and report the highest level of food technology neophobia. The largest group are the Cautious Consumers (37.5%), who with the Sceptical Consumers (20.7%) are undecided in their trust level and their purchase intention for cultured meat. As they make up almost 60% of the German population, our results suggest that further research into suitable communication measures is especially relevant for these profiles to ensure credibility, increase trust, and thus, extend the potential consumer base for a sustainable meat product.

Keywords: cultured meat, latent profile analysis, trust, consumer, sustainable food production

1. Introduction

Industrial animal husbandry accounts for 14.5% of greenhouse gas emissions worldwide, covers about 80% of the world's arable land, and contributes to deforestation (Steinfeld et al., 2006; FAO, 2009; Gerber, 2013). In addition to its environmental impacts, meat production and increased meat consumption negatively exacerbate world hunger and negatively impact human health, e.g., by increasing the risk of cardiovascular diseases (Tilmann and Clark, 2014). The interactions of various negative external effects have led to calls from scientists for a reduction in global meat consumption as well as a change in the current food systems toward more sustainability (Tilmann and Clark, 2014). To contribute to this, alternative sources of animal protein, such as insects, and plant-based meat substitutes, such as tofu, have been explored in a variety of ways (Onwezen et al., 2021).

However, novel food technologies can also contribute to the sustainability transition (UN, 2021). Cultured meat, also known as clean, synthetic, or in vitro meat, is a possible, technological alternative for meat production. The technology aims to produce meat directly from animal stem cells, which requires significantly less animal involvement. These stem cells develop in the lab into muscle fibres that can be processed into common meat products (Post, 2012; Stephens et al., 2018). Though the technology is still under development, it offers the potential to produce meat with significant advantages over industrial animal husbandry. These include reduced demand for water and land, lower greenhouse gas emissions, lower eutrophication potential (Tuomisto, 2019; Sinke et al., 2023), more humane animal welfare (Stephens et al., 2018), and better human health resulting from nutrient profiles enriched with omega-3 fatty acids (Post, 2012).

Although it offers a sustainable alternative to conventional meat, the technology is novel, and its commercial success hinges on consumer acceptance. Previous studies have found both drivers of and barriers to cultured meat consumption. Key drivers include animal welfare (Weinrich et al., 2020; Bryant and Sanctorum, 2021; Quevedo-Silva and Pereira, 2022), ecological sustainability, and food security (Slade, 2018; Mancini and Antonioli, 2019; Weinrich et al., 2020). Key barriers include neophobia (Gómez-Luciano et al., 2019; Krings et al., 2022), unnaturalness (Dupont and Fiebelkorn, 2020), safety concerns (Bryant and Barnett, 2020; Krings et al., 2022), nutritional quality (Gómez-Luciano et al., 2019; Shaw and Mac Con Iomaire, 2019; Zhang et al., 2020), disgust, and distrust in companies (Verbeke et al., 2015; Wilks et al., 2019; Siegrist and Hartmann, 2020).

Of these, trust is at the heart of a novel food's acceptance. Consumers currently have little trust in food chains and production systems, with distrust caused by food scandals, safety incidents, changes in food production practices, and the increasing globalisation of the food market (Coveney et al., 2015; Giampietri et al., 2018). These realities have distanced consumers from food development and production, increasing the importance of consumer trust in the food supply chain and its related actors. This is especially true for the success of novel food technologies.

Previous studies have investigated consumer trust in science (Verbeke et al., 2015; Wilks et al., 2019; Lewisch and Riefler, 2023), trust in government safety regulations (Zhang et al., 2020), and trust in the food industry (Shaw and Mac Con Iomaire, 2019; Siegrist and Hartmann, 2020). Two studies have examined the role of trust in acceptance of cultured meat in Germany. Lin-Hi et al. (2023) investigated the role of organizational trustworthiness, and Kühn et al. (2023) examined the impact of meat attachment on trust.

What we do not find in the literature is a consumer segmentation based on their trust level in cultured meat and its corresponding actors. It is reasonable to expect varying levels of trust depending on consumer demographics. To investigate this, we used the consumer trust toolkit (Benson et al., 2020), a valid and reliable measure of trust in different perspectives of the food system. Using latent profile analysis (LPA) of online survey responses, we profiled German consumer segments by their trust level in cultured meat, pursuing two research questions:

1. RQ1. What consumer trust profiles related to cultured meat can be found in Germany?
2. RQ2. What attributes characterize the different profiles?

This paper is organized as follows. After reviewing the literature on consumer trust, we present the survey design, data collection method, and statistical analysis used in this study. This is followed by our main findings, and our discussion. Finally, we draw a conclusion. Our results can support decision makers in the food sector develop marketing strategies and products targeting consumers with the greatest readiness to accept cultured meat.

2. Literature Review

Trust is a complex concept that various disciplines such as economics, sociology, and psychology have explored, with multiple definitions of the concept emerging. However, the most well-known is "*the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party*" (Mayer et al., 1995).

Unfortunately, consumer trust in food has been eroded by well-documented food scandals, for instance the horse meat scandal in Germany in 2013, from which a particular distrust in the meat industry has developed. Further, increasing globalisation and complexity of the food market have increasingly distanced consumers from the sources of their food. As a result, consumers wish to know the source of the food they buy, under what conditions it was grown, and how it was treated, produced, and packaged (Lu et al., 2016). To assess their concerns about food quality and safety, consumers generally have to count on the details provided by and from various actors involved in different stages in the food chain (Giampietri et al., 2018).

This is especially the case regarding novel food technologies such as cultured meat. Having limited knowledge of the technology, consumers are not in a position to decide whether cultured meat carries possible risks. Consumers do not see the many stages undertaken between production and consumption, and this alone can widen any trust gap that might exist. Consumers have little choice but to rely on actors in the food supply chain, trusting (or not) in government safety

regulations which establish the processes to ensure food safety and monitor the industry (Vega-Zamora et al., 2019). In this regard, traceability and transparency along the food chain have become contentious issues (Lu et al., 2016).

A comprehensive measurement of trust across the food value chain requires measuring the different trust types arising at each stage (Coveney et al., 2015). The consumer trust toolkit (Benson et al., 2020) provides a valid and reliable instrument for evaluating types of consumer trust in foods and its associated actors. The scale encompasses 41 items distributed across six different types of trust:

- Organisation trust,
- Interpersonal trust,
- Chain trust,
- Product trust,
- Organisation distrust, and
- Interpersonal distrust.

Benson et al. (2020) demonstrate that the consumer trust toolkit can be utilized to any organisation, product, or actor in the food system. We chose to apply it to the European Food Safety Authority (EFSA), which state independent scientific consultation on food safety issues, serves as the basis for regulatory measures by the European Commission, and thus contributes to consumer protection. In the toolkit, *organisation trust* measures consumer trust in an organisation associated to food but not integrated in the food chain. Applied to the EFSA in its role in monitoring a part of the food chain, the scale used 17 items, such as: "*I trust EFSA.*" (Benson et al., 2020).

The item *product trust* measures trust in a food product, in this study, EU cultured meat. The scale used 10 different items to measure product trust, for example: "*EU cultured meat is trustworthy.*". The item *interpersonal trust* assesses how trusting a person is in general; the scale contained five items, for example: "*Most people are basically honest.*". Under *chain trust* is understood consumer trust in food chain actors, for example food manufacturers; our latent profile analysis used seven items to assess this, such as: "*Food manufacturers take good care of the safety of our food.*" (Benson et al., 2020).

Additionally, two trust types capture consumer distrust. The first, *organisation distrust* as it relates to EFSA was measured with three items, for example: "*Information from EFSA has been proven wrong in the past.*". The second, *interpersonal distrust* was measured with four items, for example: "*I never rely on other people.*" (Benson et al., 2020).

3. Material and Methods

3.1 Survey design and data collection

We conducted an online-based survey of German consumers. The survey is subdivided into four main parts. First of all, participants were asked for age, gender, German Federal State residency, monthly net income, education level, number of household members, and number of children (Federal Statistic Office, 2023). Further, participants used a five point-Likert scale (1= "never" to 5= "five times or more") to indicated how frequently they purchased meat. They further indicated which one of five diets they follow: omnivorous (no restrictions), flexitarian (reduced and conscious meat consumption), pescetarian (no meat, but fish), vegetarian (no meat and no fish), or vegan (no animal-based foods).

In the second part of the survey, participants used five point-Likert scales to indicate their knowledge about cultured meat (1="very bad" to 5="very good"), the frequency of their encountering information about cultured meat in the past 12 months (1 = "never" to 5 = "Often"), and their interest in cultured meat (1 = "none at all" to 5 = "very strong"). Participants then read the following general description of cultured meat:

> *Cultured meat (also called in-vitro meat) is animal meat that is made in a lab with the use of muscle stem cells. These cells extracted from living animals, transferred to a suitable medium, and cultivated in a bioreactor. The bioreactor creates the necessary conditions for the cells to grow, resulting in thin layers of meat. The objective is to establish a food product that matches conventional meat in terms of appearance, smell, consistency, and flavour. Cultured meat is already available in Singapore and the USA, but not yet in Europe (BMEL, 2023).*

To ensure the quality of subsequent answers, two questions were then posed. The questions (e.g., "*Cultured meat is produced in a laboratory using muscle stem cells*." and "*In Germany, cultured meat can already be bought in supermarkets.*") were designed to guarantee that participants had a correct understanding of cultured meat, that previous misinformation had been clarified, and that answers were not influenced by their subjective attitudes. Participants could only continue the survey if they answered both questions satisfactorily.

Participants were then asked to indicate their willingness to buy, try, and regularly eat cultured meat; their willingness to eat cultured meat as a replacement for conventionally produced meat; and their willingness to eat cultured meat compared to plant-based meat substitutes (five-point Likert scale from "Definitely yes" to "Definitely no") (adapted from Wilks and Phillips, 2017).

In the third part of the survey, participants read the following description about EFSA:

> *EFSA is the European Food Safety Authority. It offers independent scientific consultation on risks in the food sector. Its consultation is incorporated into European legislation and influences policymaking (BMEL, 2021). One of EFSA's tasks is to assess the safety of novel foods for consumers in the EU. Cultured meat is considered as a novel food and therefore falls under the EU's Novel Food Regulation. In order to protect consumers from any potential risks of new foods not previously consumed in the EU, novel foods are subjected to a comprehensive health assessment by the EFSA as part of the approval process. Cultured meat may only be sold in the EU if it has been approved (BMEL, 2020).*

This text was again followed by two quiz questions to assess understanding (*EFSA assesses the potential health effects of cultured meat on humans as part of the authorization procedure.*" and "*Cultured meat can be placed on the market without approval.*"). Participants had to answer correctly to continue with the survey. They were then asked to value the EFSA and their own attitudes on the consumer trust scale of Benson et al. (2020) described in section two. All 41 items were presented on seven-point Likert scales, ranging from "I do not agree at all" (1) to "I completely agree" (7) and were translated into German using the back translation technique (Brislin, 1970). That meant two bilingual translators worked independently to translate English to German, while a third person back translated into English. Subsequently, the translated version was compared with the original version of the consumer trust scale, and modifications were made to maintain content-related and linguistic accordance.

The fourth part of the survey assessed neophobia using the German version of the *Abbreviated Food Technology Neophobia Scale* (AFTNS) from Baum et al. (2021) and adapted from Schnettler et al. (2017). Here, six-point Likert scales were used. The AFTNS measures the fear of novel food technologies and serves as a key predictor of consumer rejection of food products produced by novel technologies (Wendt and Weinrich, 2023). An example item is: "*The benefits of new food technologies are often grossly overstated.*" (Baum et al., 2021).

Data collection occur via a fee-based online-panel provider who incentivised the German participants in January 2024. We established quotas for age, gender, household net income, education, and German Federal State residency to obtain a maximum representative sample for the German population (Federal Statistical Office, 2023). The survey has been approved by the University of Hohenheim Ethics Committee, and the data protection officer (DPO) from the University of Hohenheim agreed to release the survey.

To prevent response distortions due to sequence effects, items in the survey were presented randomly. Before the survey was finalized, a pretest was run with eight people to identify comprehension problems, technical difficulties, or inconsistencies. The pretest used the think aloud method whereby individuals speak their thoughts out loud while completing the survey (Ericsson and Simon, 1980). Findings of the pretest were collected and implemented before the final data collection to refine the survey before final launch.

Before starting the survey, each participant was asked for consent. Participants who did not consent to the study were excluded automatically. Further, two quality trap questions were included in the survey to safeguard the quality of the data (Please click here to check "*Agree*"). The panellists who clicked an incorrect answer were screened out. Another 17 participants were excluded as they had the same response pattern in a row. The final data sample consisted of 1099 participants.

3.2 Data analysis

All descriptive analyses were undertaken with IBM SPSS Statistics 27 (SPSS, 2021). Further, an exploratory factor analysis (Promax rotation) was used for data reduction using SPSS. As recommended by Worthington and Whittaker (2006), items with factor loadings under 0.3 were excluded. The Kaiser-Meyer-Olkin (KMO) value and the Barlett's Test of Sphericity were applied to guarantee that the sample was adequate for factor analysis. To measure the strength of the reliability of the factors, Cronbach's alpha was assessed. The last step of the statistical analysis was a latent profile analysis (LPA), accomplished using LatentGOLD Version 6.0 (Vermunt and Magidson, 2021).

An LPA is a latent class analysis (LCA) with continuous data. The main aim of an LPA is the division of individuals in a heterogeneous population into homogeneous profiles (Vermunt and Magidson, 2002). Compared to traditional methods, such as hierarchical cluster analysis, an LPA is a categorical latent variable modeling approach that uses individual probabilities to classify profiles. We used the bias-adjusted 3-step approach, which ensures that external variables (covariates) do not influence the structure of the latent profiles (Vermunt, 2010).

We began by estimating a standard latent class model to profile participants with six different indicators adopted from the consumer trust scale (Benson et al., 2020). In this step, covariates were excluded. This step involved identification of the best fitting model, so determining the optimum number of latent profiles. As recommended by Spurk et al. (2020), we ran models using from two to ten latent profiles and compared estimates to select the best fit. Additionally,

we applied the Lo-Mendell-Rubin (LMR) test to compare each model to a neighbouring model with one fewer class to determine if the model fit was significantly improved.

The final model selection was further guided by several quality criteria, including the Akaike information criterion (AIC) (Akaike, 1974), the Bayesian information criterion (BIC) (Schwarz, 1978) and the sample-size-adjusted BIC (SABIC) (Sclove, 1987). We used entropy values to assess the accuracy with which cases are grouped into the correct profile. The higher the entropy value, the better the classification provided by the model (Berlin et al., 2014).

Beyond these goodness-of-fit-criteria, parsimony, theoretical assumptions, interpretability, and the uniqueness of the classes were also factored into the decision on the final model (Vermunt and Magidson, 2002; Berlin et al., 2014).

With the model selected, we characterized each profile based on the means of the indicators (Dahling et al., 2017; Moeller et al., 2018) and calculated the proportional profile sizes. As a final step, we included covariates in the model using the maximum likelihood estimation and ran Wald tests to compare the mean scores of the different profiles.

4. Results

The results of our online survey of consumer trust related to cultivated meat are grouped into descriptive statistics from the survey (4.1), results of factor analysis (4.2) and of the LPA (4.3).

4.1. Descriptive statistics

Our sample consists of 1,099 German consumers. Of the 1,099 respondents, the majority were male (51.0%) and had a mean age of 49. Table 1 compares our sample statistics against national averages, showing the survey is an approximately nationally representative sample of the German population with regard to age, gender, and region. The sample had a higher representation of respondents with post-secondary education and a lower representation of those with the highest net income.

Table 1

Sociodemographic variables.

Variable	Description	Percentage Sample (%)	Percentage Germany (%)
Age (years)	16-35	25.2	27.0
	36-55	32.8	30.8
	56 and older	42.0	42.2
Gender	Male	51.0	49.2
	Female	49,0	50.8

Variable	Description	Percentage Sample (%)	Percentage Germany (%)
Region	North	17.6	16.2
	South	29.4	29.2
	East	19.2	19.4
	West	33.8	35.2
Education level	No qualification	2.8	7.5
	Primary school	28.7	28.6
	Secondary school	30.6	30.0
	A-levels	37.9	33.5
Net household income (€)	Less than 1250	10.3	9.1
	1250-1750	11.5	9.2
	1751-2500	18.4	15.7
	2501-3500	20.4	18.5
	3501-5000	22.3	20.1
	More than 5000	17.2	27.4

Note: For the education level, the "No answer" statement was not queried in this study, thus the education level in the German population reach a total of 99.6% (Federal Statistic Office, 2023). Source: Federal Statistic Office, 2023.

As shown in Fig. 1, respondents also declared their weekly frequency of meat purchases on a five point-Likert scale.

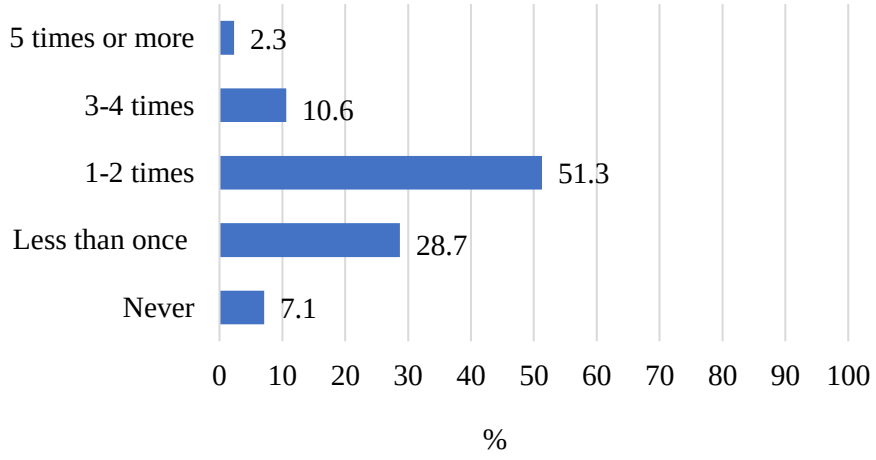

Fig. 1. Weekly purchase frequency of meat (N = 1099).

Further, participants indicated the diet they follow; results are shown in Fig. 2.

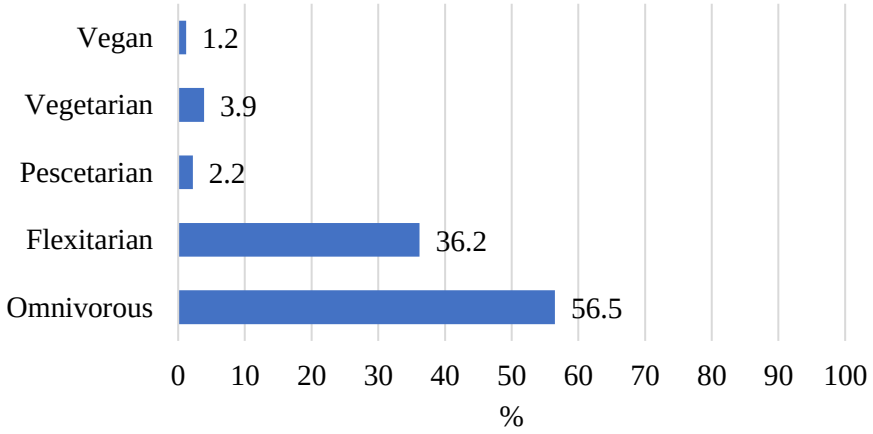

Fig. 2. Consumer Diets (N = 1099).

Respondents also indicated on a five-point Likert scale their subjective perception of their knowledge related to cultured meat and their interest in it. Results are shown in Fig. 3.

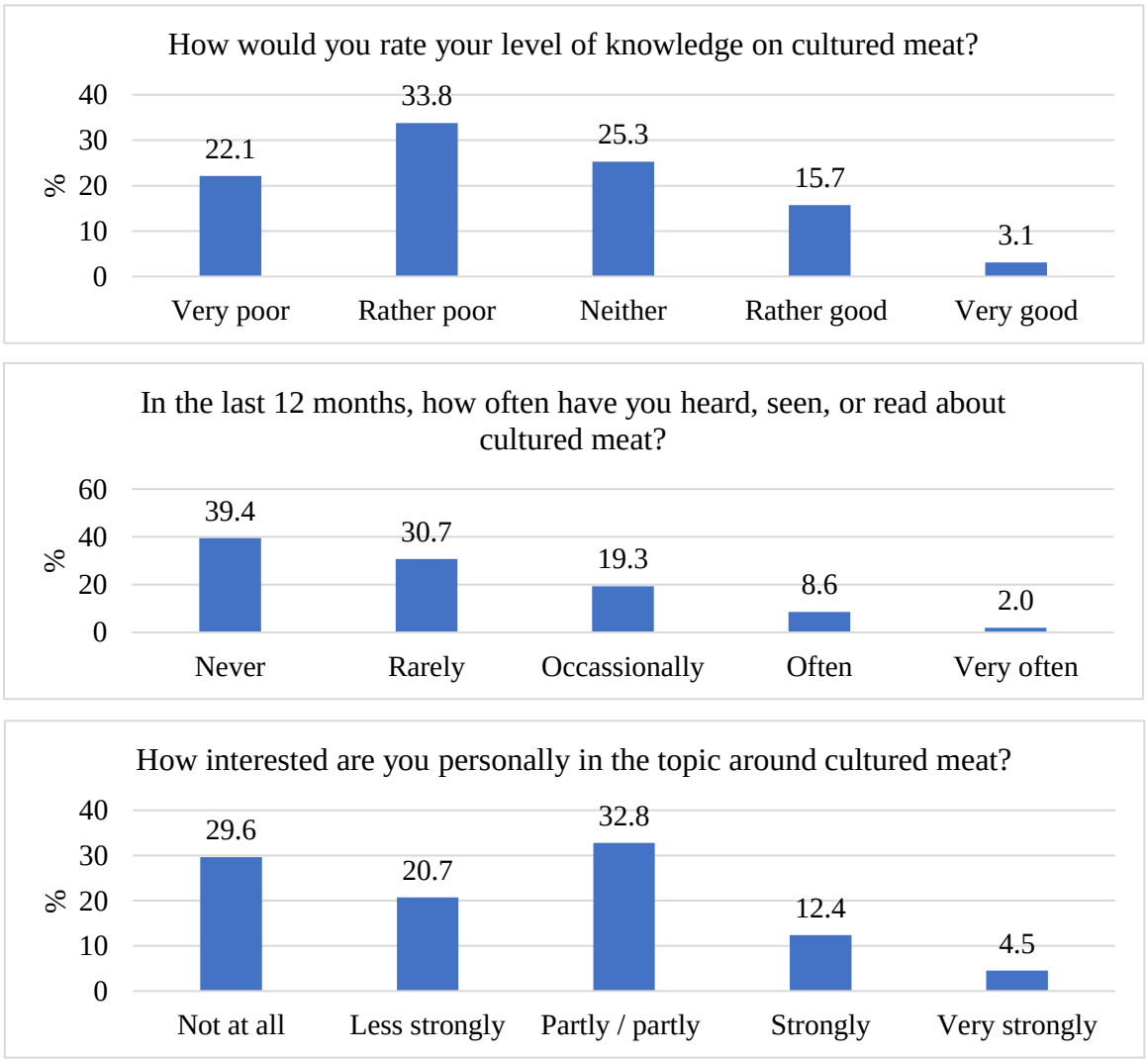

Fig. 3. Consumer familiarity with cultured meat (N = 1099).

Fig. 4 shows how our sample regards the selection and consumption of cultured meat, with percentages arranged left-to-right from strongest No to strongest Yes. 46% of the German population shows no purchase intention. In "buy" and "try", "unsure" is the leading category. However, more Germans would try cultivated meat than would not. Only in "eat regularly" is a majority of the German population leaning "no". "As a replacement", almost as many are "unsure" as those who are definite "No".

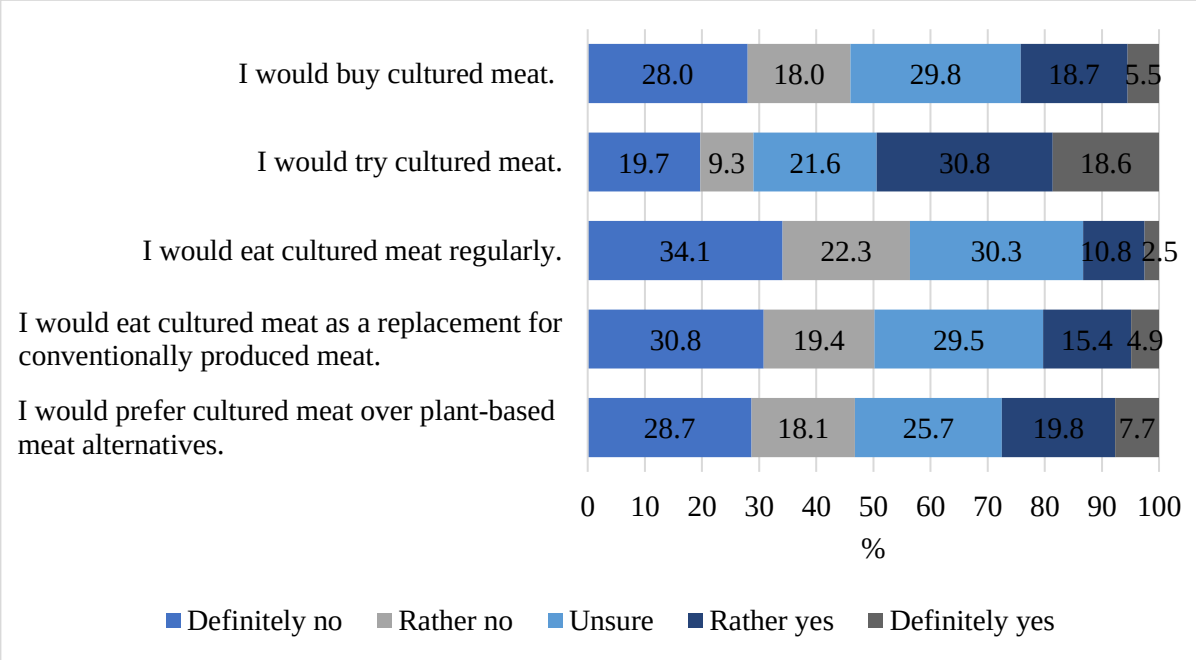

Fig. 4. Consumers purchase intention (N = 1099).

4.2 Factor Analysis

The results of the exploratory factor analysis showed excellent results on the Kaiser-Meyer-Olkin test (KMO = 0.976) as well as on Bartlett's test (chi- square (1891) = 64170.54, $p < 0.001$). Values shows that the variables fit for factor analysis (Kaiser, 1974; Field, 2009). Based on Kaiser's Criterion (eigenvalue >1) (Kaiser, 1960) and the Scree test (Cattell, 1966), the factor analysis yielded nine factors. These nine factors explain 71.09% of total variance; Table 2 shows the internal consistency of the factors using Cronbach's alpha. Cronbach's alpha ranges from 0.717 to 0.984, all of which are higher than the critical value of 0.7 (Hair et al., 2010). Variables were excluded from further data analysis if Cronbach's alpha could be improved as a result. The content of each factor and the corresponding statistics can be found in the Supplementary Material.

Table 2

Results of the Factor Analysis.

Factor	Description	Cronbach's alpha
1	Organization trust	0.984
2	Product trust	0.973
3	Acceptance of Cultured Meat	0.937
4	Interpersonal trust	0.910
5	Chain trust	0.910
6	Abbreviated Food Technology Neophobia	0.878
7	Interpersonal distrust	0.822
8	Organisation distrust	0.755
9	Involvement	0.717

Source: Authors' calculation.

4.3. Latent Profile Analysis

Step 1: Estimating a latent class model and identification of the final best fitting model

The following items from the consumer trust scale (Benson et al., 2020) were used as indicators: *Organisation trust, product trust, interpersonal trust, chain trust, organisation distrust,* and *interpersonal distrust.* To decide the final profile solution, we compared multiple model fit statistics as well as content-decision criteria for two to ten-profile solutions. A summary of goodness-of-fit-criteria is shown in Table 3.

Table 3

Overview of Latent Profile Models.

No. of profiles	LL	BIC (LL)	AIC (LL)	SABIC (LL)	LMR (*p*)	Entropy R^2
2-profiles	-8782.2	17739.5	17614.4	17660.1	0.0000	0.681
3-profiles	-8224.5	16715.1	16525.0	16594.4	0.0000	0.819
4-profiles	**-7789.8**	**15936.7**	**15681.6**	**15774.7**	**0.0000**	**0.847**
5-profiles	-7648.2	15744.5	15424.4	15541.3	0.0000	0.827
6-profiles	-7545.9	15630.9	15245.7	15386.3	0.0000	0.829
7-profiles	-7444,0	15518.3	15068.1	15232.4	0.0000	0.828
8-profiles	-7340.1	15401.5	14886.3	15074.3	0.0000	0.829
9-profiles	-7328.4	15469.1	14888.9	15100.7	0.3405	0.812
10-profiles	-7221.8	15346.9	14701.7	14937.2	0.0012	0.831

Note: LL = Log-likelihood; BIC = Bayesian information criterion; AIC = Akaike information criterion; SABIC = sample-size adjusted BIC; LMR (p) = p-Value for the adjusted Lo-Mendell-Rubin-test; bold values: selected number of profiles. Source: Authors' calculation.

In comparing profile solutions, we first considered profile size. Ideally in LPA, a profile size should not be smaller than 5% of the total sample, so we rejected the 7- to 10-profile solutions, leaving the 2-, 3-, 4-, 5- and 6-profile models to be assessed. The 6-profile solution had the smallest BIC, AIC, and SABIC values, but it did not provide meaningful insights. Further cause to reject it was parsimony (Vermunt and Magidson, 2002; Berlin et al., 2014). Then, we looked

at the remaining profile solutions. We determine the 4-profile solution is the best fitting solution, as it had adequate profile proportions, the highest entropy value, offered the most parsimonious solution, and permitted the greatest simplicity.

Step 2: Presentation of profile characteristics

The means of each profile for the six different consumer trust scale items are presented in Fig. 5. Trust in this figure is greater the more positive a trust item and the more negative a distrust item; distrust is greater the more negative a trust item and the more positive a distrust item.

We determined the names of the profiles based on members' response to all six scales. The first profile is the largest profile and represents the *Cautious Consumers,* making up 37.5% of the sample. The *Cautious Consumers* take a mostly neutral position that reflects neither strong trust nor strong distrust. This group does, however, show a slight tendency towards trust in cultured meat, the EFSA, food manufacturers, and interpersonal relations.

The second largest profile consists of 24.3% of the sample and describes the *Distrustful Consumers*. This profile has the lowest trust level in EFSA (-1.07), cultured meat (-1.09), fellow humans (-0.48), and food manufacturers (-0.66).

The third profile characterizes the *Sceptical Consumers* and consists of 20.7% of the sample. The *Sceptical consumers* mirror the *Cautious Consumers* in taking a mostly neutral position; however, theirs is a slight tendency towards distrust, while the first profile tends to trust.

Finally, the smallest profile at 17.5% represents *Trusting Consumers*. These consumers demonstrate trust in the EFSA (1.22), cultured meat (1.21), interpersonal relations (0.56), and food manufacturers (0.94).

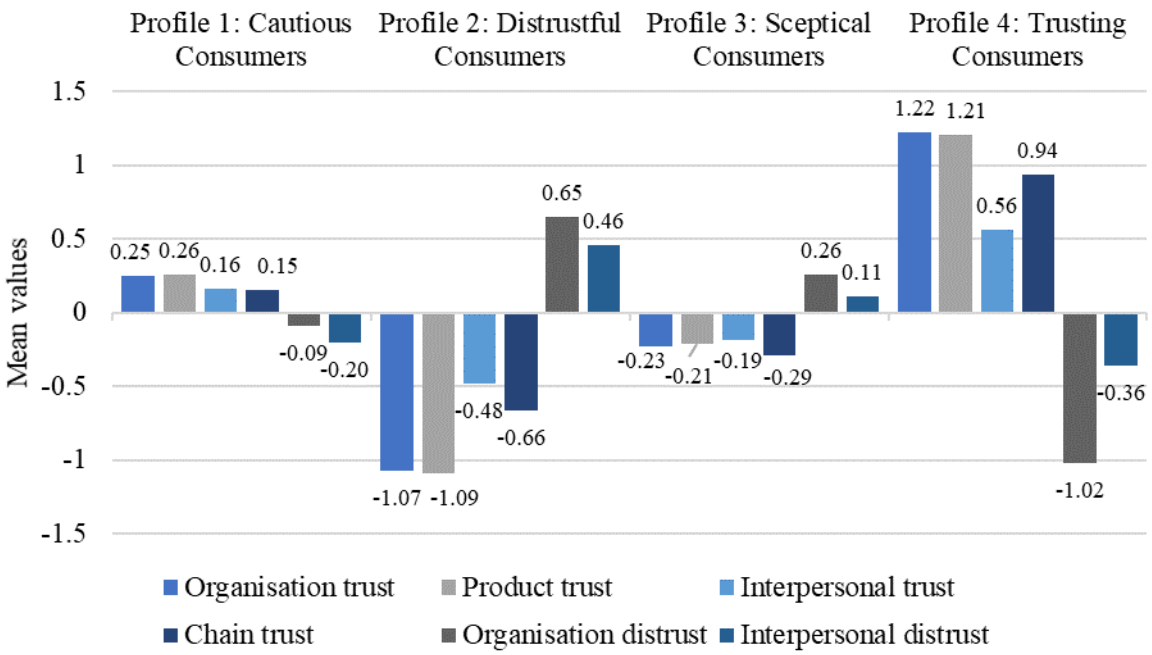

Fig. 5. Means of the indicators for the 4-profile solution.
Note: Scale from -3 (Strongly disagree) to +3 (Strongly agree).

Step 3: Inclusion of covariates

To further describe the characteristics of the four consumer profiles, we included the following covariates in the 4-profile model: acceptance of cultured meat, food technology neophobia, involvement with cultured meat, age, gender, household net income, education level, and diet. Wald tests were implemented to assess whether the profiles differed significantly in terms of Acceptance of Cultured Meat, AFTNS, and Involvement. Results are shown in Table 4 and Table 5.

Table 4

Characterization of each profile based on acceptance of cultured meat, food technology neophobia level and involvement in cultured meat.

Mean values	Profile 1: Cautious Consumers[a]	Profile 2: Distrustful Consumers[b]	Profile 3: Sceptical Consumers[c]	Profile 4: Trusting Consumers[d]
Acceptance of Cultured Meat	0.14[b,d]	-0.70[a,c,d]	-0.15[b,d]	0.83[a,b,c]
Food Technology Neophobia (AFTNS)	-0.21[b]	0.70[a,c,d]	0.05[b,d]	-0.57[b,c]
Involvement	0.01[c,d]	-0.19[c]	-0.32[a,b,d]	0.62[a,c]

Note: Exponents demonstrate significant differences in the pairwise mean levels. Scales - Acceptance, from -2 (Definitely yes) to +2 (Definitely no); AFTNS, from -3 (Strongly disagree) to +3 (Strongly agree) (without midpoint); Involvement, from -2 (Strongly disagree) to +2 (Strongly agree). Source: Authors' calculation.

As shown in Table 4, the Wald statistics indicate that the profiles differ significantly their acceptance of cultured meat (W = 60.451, $p < 0.001$), level of food technology neophobia

($W = 42.888$, $p < 0.001$), and involvement ($W = 15.736$, $p < 0.001$). The highest acceptance level for cultured meat occurs, as expected, under the *Trusting Consumers* (0.83), with the lowest under the *Distrustful Consumers* (-0.70). Food technology neophobia is the lowest among the *Trusting Consumers* (-0.57) and the highest among the *Distrustful Consumers*. Further, the familiarity and involvement with cultured meat is the highest among the *Trusting Consumers,* but the lowest among the *Sceptical Consumers*.

Table 5 represents the distribution of socio-demographic characteristics.

Table 5

Socio-demographic characteristics and diet of each profile.

Distribution of covariates given profile (%)	Profile 1: Cautious Consumers (37.5%)	Profile 2: Distrustful Consumers (24.3%)	Profile 3: Sceptical Consumers (20.7%)	Profile 4: Trusting Consumers (17.5%)	Overall
Age groups					
16-35	30.1	18.0	20.2	30.6	25.2
36-55	31.5	31.7	34.2	35.4	32.8
56 and older	38.4	50.3	45.6	34.0	42.0
Gender					
Male	47.4	55.4	50.2	53.9	51.0
Female	52.6	44.6	49.8	46.1	49.0
Net monthly household income (€)					
Less than 1250	9.7	13.7	10.4	6.7	10.3
1250-1750	11.0	12.4	13.7	8.6	11.5
1751-2500	16.0	20.7	21.5	16.5	18.4
2501-3500	21.2	18.1	22.8	19.1	20.4
3501-5000	24.0	20.8	18.4	25.5	22.3
More than 5000	18.2	14.5	13.1	23.7	17.2
Education level					
No qualification	2.7	1.6	3.3	4.3	2.9
Primary school	24.1	35.7	39.3	16.0	28.7
Secondary school	31.8	33.4	31.4	22.9	30.6
A-levels	41.4	29.4	25.9	56.8	37.9
Diet					
Omnivorous	52.7	62.1	63.1	48.9	56.5
Flexitarian	38.5	32.5	29.9	44.1	36.2
Pescetarian	3.1	0.0	4.0	1.0	2.2
Vegetarian	4.8	2.6	3.0	5.1	3.9
Vegan	0.9	2.8	0.0	1.0	1.2

Note: Significance level of 0.05. Age groups: No significant differences were found. Gender: The pairwise comparison revealed significant differences between profile 1 and 2, profile 2 and 3, profile 2 and 4. Income: The pairwise comparison revealed no significant differences. Education: The pairwise comparison revealed significant differences between profile 1 and 4, profile 2 and 4, profile 3 and 4. Diet: The pairwise comparison revealed significant differences between profile 1 and 2, profile 1 and 3, profile 2 and 3, and profile 3 and 4. Source: Authors' calculation.

Findings indicate that profiles do not differ significantly by age group ($W = 3.569$, $p = 0.72$), and net household income ($W = 6.550$, $p = 0.97$). Further, the Wald statistics shows that the covariates differentiate between the profiles statistically significant in terms of gender ($W = 9.388$, $p < 0.025$), education ($W = 53.643$, $p < 0.001$), and diet ($W = 115.854$, $p < 0.001$).

The *Distrustful Consumers* are described by the highest percentage (50.3%) of consumers older than 56 and the lowest between 16 and 35 (18%). Younger consumers (16-35 years) are included by a higher percentage among the *Cautious Consumers* (30.1%) and *Trusting Consumers* (30.6%). The *Trusting Consumers* the fewest consumers aged 56 or older (34.0%) compared to profiles 1, 2 and 3.

Gender differences can be seen in that the *Distrustful Consumers*, the second largest, consists of the lowest percentage of females (44.6%) compared to profiles 1, 3, and 4 ($p < 0.05$), whereas the largest profile, *Cautious Consumers*, is represented by the lowest percentage of males (47.4%).

Regarding the net household income, the *Distrustful Consumers* have the highest proportion of most consumers at the lowest income level, while the *Trusting Consumers* (the smallest profile) have the highest proportion of consumers at the highest income level.

By education, the highest level consists with a significantly higher proportion in the *Trusting Consumers* ($p < 0.05$), compared to the other three profiles. The lowest level was found in the *Sceptical Consumer*s. By diet, the highest proportion of omnivorous people are among the *Sceptical Consumer*s (63.1%) ($p < 0.05$). The highest proportion of vegetarians are among the *Trusting Consumers* (5.1%).

5. Discussion

Previous studies have indicated the lack of trust as a fundamental barrier to consumer acceptance of cultured meat (Verbeke et al., 2015; Shaw and Mac Con Iomaire, 2019; Wilks et al., 2019; Siegrist and Hartmann, 2020; Zhang et al., 2020; Lewisch and Riefler, 2023; Kühn et al., 2023; Lin-Hi et al., 2023). Using a latent profile analysis (LPA) of online survey data from 1,099 German consumers, the current study offers important new insights into levels of consumer trust related to cultured meat by (1) highlighting four homogenous subgroups of consumers defined by their similarities on the consumer trust scale (Benson et al., 2020), and (2) characterizing each profile based on socio-demographics, cultured meat acceptance, food technology neophobia, and involvement.

Results from our LPA suggest that trust in cultured meat and the corresponding actors in the food chain varies within the German population. The smallest profile (17.5%), the *Trusting Consumers*, expresses the highest trust in EFSA, cultured meat, fellow humans, and food manufacturers. This profile trusts that EFSA is honest with consumers, and rates the trustworthiness of cultured meat as high, and would agree that cultured meat is safe. Additionally, they believe

that most people are basically trustworthy, and food manufacturers maintain good standards for the safety of our food. Consumers grouped into this profile have the greatest acceptance for cultured meat, and they are willing to try and to purchase cultured meat. These results are consistent with our finding that the *Trusting Consumers* indicated the lowest food technology neophobia.

These findings highlight the broad relevance of trust as a key component in consumer willingness to purchase and consume cultured meat and are in line with those of Zhang et al. (2020), who found that consumers with a higher level of trust in government food safety agencies have a higher acceptance level of cultured meat. Siegrist and Hartmann (2020) similarly found participants who had higher levels of social trust – trust in the stakeholders in the food industry – evaluate cultured meat as more natural than individuals who had lower levels of trust. Further, the *Trusting Consumers* consist of individuals with the highest involvement, which is in line with previous findings, showing that an increased familiarity might improve cultured meat acceptance (Klöckner et al., 2022).

Socio-demographic parallels to other studies were found, showing that consumers who accept cultured meat are more likely to be younger, highly educated, and have a higher income (Slade, 2018). Further, the results from our study showed the *Trustful Consumers* with the highest share of flexitarians and vegetarians, in contrast to previous findings, which indicate cultured meat is more attractive to omnivores than to vegetarians (Mancini and Antonioli, 2019; Arora et al., 2020).

Communication strategies using our findings to target the *Trusting Consumers* should emphasize the positive characteristics and benefits of cultured meat to strengthen positive beliefs about it. Overall, the *Trusting Consumers* demonstrate opposite trust patterns to those of the *Distrustful Consumers*; however, the group of *Trusting Consumer* is around 7% smaller.

Among the four profiles, the *Distrustful Consumers* show the lowest trust (and the highest distrust) levels and the lowest acceptance of cultured meat. They are more inclined to say that they have no confidence in EFSA, and they do not believe that cultured meat is safe and trustworthy. They would rather disagree than agree that manufacturers have adequate knowledge to guarantee the safety of their food products; they also tend to be trustful of others. In line with previous studies, our findings show that lower acceptance of cultured meat is more important among consumers 56 and older, with lower education and income levels (Gómez-Luciano et al., 2019; Mancini and Antonioli, 2019; Weinrich et al., 2020; Zhang et al., 2020).

Consumer distrust in Germany has been underlined by Poppe and Kjærnes (2003), Fritz and Fischer (2007), and Peters et al. (2007), who have shown that Germany is generally seen as a lower trust economy where trust in food manufacturers is also low (Dolgopolova et al., 2015). Multiple food incidents in Germany may be associated to the lower trust levels compared to other countries (Murphy et al., 2021). Further, our findings link consumer distrust to higher levels of food technology neophobia. This finding is supported by Krings et al. (2022) who found consumers with higher food technology neophobia perceived cultured meat as less safe than conventional meat and associate cultured meat products with negative characteristics.

As *Distrustful Consumers* also show less involvement with the issue of cultured meat and the environmental benefits it seeks to deliver, we suspect that the lack of familiarity contributes to consumers' general reluctance to accept cultured meat. Overcoming this reticence will require providing believable and relevant information, which may not turn all grouped into this profile, but will be a key factor in the acceptance of cultured meat. Our findings suggest future research investigate making information accessible to consumers with a low level of trust.

Still, such effective communication is likely to most affect the *Cautious Consumers.* These comprise our biggest profile (37.5%) and are still undecided about the trustworthiness of cultured meat and the corresponding actors in the food chain. Our results show that this profile has the second highest trust in the EFSA, in cultured meat, and in their fellow humans and food manufacturers. However, they are uncertain about whom they can really trust. But their tendency, slight, is towards trust.

Similar to the *Cautious Consumers*, the *Sceptical Consumers* do not show particularly strong trust or distrust; however, theirs is a slight tendency towards distrust. Our results show that consumers in this profile have the second lowest trust in the EFSA, in cultured meat, in fellow humans, and food manufacturers. They tend to be sceptical that EFSA will keep its promises. Additionally, they tend not to trust cultured meat to be of high quality and would not agree that most people are basically good and kind.

Nonetheless, together *Sceptical* and *Cautious Consumers* make up almost 60% of the German population, and they take a mostly neutral position when it comes to trust in cultured meat and its corresponding actors.

Both the *Cautious* and *Sceptical Consumers,* remaining undecided in their trust level and cultured meat acceptance, may be amenable to increasing their trust in and thus, acceptance of cultured meat through targeted communication measures. Our results suggest that scepticism among these consumers about a new technology is explained by their lack of knowledge of the

technology and its advantages. Albertsen et al. (2020) mentioned that to raise consumer acceptance of novel foods, it is vital to lower the mistrust level. As trust is of high relevance, especially in the food market (Benson et al., 2020), we recommend decision-makers in the food industry investigate trust building measures that speak to these profiles, as that offers the chance to increase potential buyer ship and thus facilitate a successful market entry for cultured meat in Germany.

Transparency has been shown to be a key factor in both building and recover trust in the food industry (Wilson et al., 2017). We can infer that a lack of transparency would deter trust. We can conclude that transparent communication about the details of production processes may move the majority in the middle off feeling insecure and turning away from novel food. In this line, Zhang et al. (2020) argue that providing information about the advantages of cultured meat through trusted sources could raise acceptance. Chong et al. (2023) examined the effects of framing on consumer acceptance of cultured meat and found that "improves animal welfare" and "reduces carbon emissions and global warming" were two benefits that increased acceptance. Additionally, Verbeke et al. (2015) point to providing information about production and the certification process, as well as stringent regulation and trustworthy labelling, as ways to increase trust. Kouarfaté and Durif (2023) recommend messaging that combines ethical, intrinsic, and informational elements.

Additionally, the prevalence of distrust highlighted by this study strongly suggests the need for regulatory action plan controlling the manufacturing process, commercialization, and consumption of cultured meat. Transparency in this regard is equally important to increase consumer confidence in the novel food industry. Toward this end, future research could benefit from our findings about the different levels of consumer trust in cultured meat and the corresponding actors by focusing on designing tailor-made strategies for each profile. Overall, we recommend future research consider how to position cultured meat in the market to strengthen consumer trust in the product and the food chain that delivers it. In this regard, productive research into the design of packaging and communication strategies is needed.

A limitation of our study is that cultured meat is not yet commercialized in the German market; consumer acceptance was captured hypothetically. Thus, it is likely that consumer profiles can be better described once cultured meat is available on the German market. Further, our results refer to the German population. Findings can differ among countries, as the acceptance of novel food technologies as well as the general level of trust in organizations may differ.

6. Conclusion

Consumer trust is a prerequisite for food selection and consumption; it is even more important with novel food technologies. Without trust in the product and its associated food chain, cultured meat will not survive in the market. Previous studies have already highlighted consumer distrust in science, in government safety regulations, and in the food industry as key barriers to cultured meat acceptance. We sought to better understand these barriers through an online survey of 1,099 German consumers. Using latent profile analysis (LPA), we found the potential market for cultured meat can be divided into four consumer profiles. These are differentiated by items of trustworthiness taken from the already validated consumer trust toolkit of Benson et al. (2020). The results of our LPA suggest that approximately 17.5% of German consumers, the *Trusting Consumers,* show the highest trust levels towards EFSA, cultured meat, fellow humans, and food manufacturers; they are willing to try cultured meat. Compared to this profile, the *Distrustful Consumers* (24.3%) show the opposite trust pattern. Overall, marketing strategies are needed to address the *Cautious* and *Sceptical Consumers* as they make up almost 60% of the German population and are mostly neutral in their current evaluations. The increasingly dire climate change predictions make this an ideal time to build up a positive image of cultured meat in the German market.

The profiles we have identified can be considered as four stages of consumer trust and cultured meat acceptance. Thinking thus, marketing departments in the agri-food industry can design suitable transparent communication strategies for each profile. Cultured meat is a space-age technology, not directly tangible for consumers, meaning they must place their trust in various food chain actors. Building trust through open and honest communication strategies and credibility through independent certification are essential aspects of gaining the support of opinion leaders and the broad acceptance of cultured meat in society.

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Supplementary Material

Table S1. Factors and items

Factors and items
Factor 1: Involvement [1] (Cronbach's alpha: 0.717)
How would you rate your level of knowledge on pesticide residues in food?
In the last 12 months, how often have you heard, seen, or read about cultured meat?
How interested are you personally in cultured meat?
Factor 2: Acceptance of Cultured Meat)[2] (Cronbach's alpha: 0.937)
I would buy cultured meat.
I would try cultured meat.
I would regularly eat cultured meat.
I would eat cultured meat as a replacement for conventional meat.
Factor 3: Organisation trust[3] (Cronbach's alpha: 0.984)
You can count on EFSA.
I trust EFSA.
Consumers can always rely on EFSA.
EFSA keep their promises.
I believe in EFSA.
I have confidence in EFSA.
EFSA make me feel safe.
EFSA is sincere with consumers.
EFSA is honest with consumers.
EFSA is dependable.
I trust EFSA to provide accurate information.
EFSA has a good understanding of all the issues relevant.
EFSA take their responsibility to society seriously.
EFSA are good at looking at the evidence and judging what to do.
EFSA has practices that favour the consumer's best interests.
EFSA considers the consumer's welfare when making important decisions.
EFSA considers how future decisions and actions will affect the consumer.
Factor 4: Product trust[3] (Cronbach's alpha: 0.973)
I trust that EU cultured meat is high quality.
EU cultured meat is reliable.
I trust that EU cultured meat is safe.
I trust that EU cultured meat is fully traceable back to their origin.
I trust that EU cultured meat is authentic.
I trust that EU cultured meat is accurately labelled.
EU cultured meat is trustworthy.
EU cultured meat is honest.
EU cultured meat is truthful.
EU cultured meat have integrity.
Factor 5: Interpersonal trust[3] (Cronbach's alpha: 0.910)
Most people are basically honest.
Most people are trustworthy.
Most people are basically good and kind.
Most people are trustful of others.
Factor 6: Chain trust[3] (Cronbach's alpha: 0.910)
Food manufacturers give special attention to the safety of food.
Food manufacturers have the competence to control the safety of food.
Food manufacturers have sufficient knowledge to guarantee the safety of food products.
Food manufacturers are honest about the safety of food.
Food manufacturers are sufficiently open regarding the safety of food.
Food manufacturers can be trusted to protect the consumer from unsafe food.
Factor 7: Organisation distrust[3] (Cronbach's alpha: 0.755)

Information from EFSA is distorted.
Information from EFSA has been proven wrong in the past.
EFSA provides accurate information only to protect themselves and their own interests.

Factor 8: Interpersonal distrust[3] (Cronbach's alpha: 0.822)

If given a chance, most people would try to take advantage of you.
Most people are too busy looking out for themselves to be helpful.
You can't trust strangers anymore.
I never rely on other people.

Factor 9: Abbreviated Food Technology Neophobia Scale[4] (Cronbach's alpha: 0.878)

New foods are not healthier than traditional foods.
The benefits of new food technologies are often grossly overstated.
There are plenty of tasty foods around, so we do not need to use new food technologies to produce more.
New food technologies decrease the natural quality of food.
New food technologies are unlikely to have long term negative health effects.
New food technologies may have long term negative environmental effects.
It can be risky to switch to new food technologies too quickly.
Society should not depend heavily on technologies to solve its food problems.
There is no sense trying out high-tech food products because the ones I eat are already good enough.

[1] Scale from -2 = "Not at all" to +2 = "Very strong"
[2] Scale from -2 = "Definitely yes" to +2 = "Definitely no"
[3] Scale from -3 = "Strongly disagree" to +3 = "Strongly agree"
[4] Scale from 1 = "Strongly disagree" to 6 = "Strongly agree"
Note: Sources of items are listed in the main text.

Teil II: Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion

II.1 Consumer Segmentation for Pesticide-free Food Products in Germany

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Abstract

Global sustainability challenges need to be addressed with innovative measures to comprehensively drive sustainable production and consumption patterns, and, thus sustainability change. A new farming concept, non-organic but characterized by complete renunciation of pesticides, has the potential to facilitate the transformation toward more sustainable agriculture. To examine this market potential of pesticide-free animal food products, we conducted an analysis of consumer attitudes using online survey data from 1010 German consumers. Through latent profile analysis (LPA), four profiles were identified, distinct in their acceptance of pesticide-free products and their attitudes toward pesticide use. One profile, the *Prospective Consumers* (22.9%), indicated a willingness to consume pesticide-free products. They are willing to pay 31% more for pesticide-free milk, 23% more for pesticide-free cheese, and 24% more for pesticide-free butter, compared to conventional dairy. However, the largest representation is the *Unwilling Consumers* (39.3%), who will probably not be among the potential buyers of pesticide-free food products. Beyond, the *Indecisive Consumers* (30.9%), and the smallest profile (6.9%), the *Ambivalent Consumers*, are undecided in their purchase intention. Overall, the optimal target group represents the *Prospective Consumers*, whereas it cannot be ruled out that the *Indecisive Consumers* and the *Ambivalent Consumers* will develop into potential buyers, although this will require further research into suitable communication measures. Decision makers in the agri-food industry can make use of our findings and develop a marketing strategy that allows an understandable labelling of products while ensuring credibility in society.

Keywords: pesticide-free farming, pesticide residues, sustainable food production, latent profile analysis, consumer acceptance, willingness to pay

1. Introduction

Modern agriculture must simultaneously meet the challenges of climate change, biodiversity loss, world food supply, and provision for future generations. To meet the continuously increasing global demand for agricultural products and to do so with fewer adverse environmental effects presents a serious challenge for sustainable agriculture (Ortiz et al., 2021). New cropping systems are required to both provide food security and improve the environmental performance of agricultural systems (Carlisle et al., 2019). Which cropping systems might be able to safeguard the growing world's food supply while mitigating impacts on human health and the environment becomes a central question.

In any system, crop-protection is critical to safeguard yields, reduce crop losses, and produce high-quality food (FAO, 2019). Modern agriculture has adopted chemical crop-protection as an integral part of its practices. The use of pesticides to preserve agricultural products from infestations and diseases has indeed made it possible to increase global food production (Cooper and Dobson, 2007; Hedlund et al., 2019). At the same time, excessive use of pesticides can have adverse effects on the environment, such as biodiversity loss and soil and water contamination (Sánchez-Bayo and Wyckhuys, 2019; Pelosi et al., 2021). Human health can be threatened by pesticide poisoning (Boedeker et al., 2020).

As a consequence, the use of pesticides and the negative environmental effects of intensive crop production have become prominent topics in contentious public debates (Young et al., 2022). Further, there has been increasing consumer awareness and concern about pesticide residues in food products (Koch et al., 2017). Studies show that consumers in general consider any amount of pesticide residues in food products to be dangerous, even if it is does not exceed the maximum residue limit (Entine, 2011; Lamichhane et al., 2016). In particular, the fact that pesticide residues are detected in food and drinking water has caused uncertainty among consumers (Peterson, 2000; Williams and Hammitt, 2001) and led to greater consumer awareness of health risks from food. The growing concern about food quality, food safety, and sustainability has increased the pressure on agricultural producers to find methods free from the use of pesticides.

Similarly, reducing the application of pesticides is an essential objective addressed by several countries and a fundamental component for their agricultural policies (Barzman and Dachbrodt-Saaydeh, 2011; Lee et al., 2019). For example, the ‘Farm-To-Fork Strategy’ of the European Union aims to halve pesticide use and risks by 2030 (European Commission, 2020). In this regard, a new farming concept has been developed in an ongoing research project looking for a pesticide-free, but non-organic production system. The most significant property of this new farming concept is the entire renunciation of the use of pesticides. Further, in addition to the absence of pesticides, the new farming concept is characterized in particular by adept management of mineral fertilizers (Mack et al., 2023).

Although this new farming concept has the potential to foster a sustainability transformation, this does not ensure that consumers will value and purchase related food products (Mack et al., 2023). Without consumer acceptance of food grown without pesticides, the agri-food industry cannot successfully implement pesticide-free food production. Corresponding products will not be able to establish themselves in the market, and a sustainability transformation will be hindered. This makes it essential to assess consumer acceptance of food coming from such a new

farming system, lest efforts be wasted on cultivation of products for an ill-advised market launch (Zimmermann et al., 2021).

Previous consumer studies have examined consumer knowledge and attitudes regarding pesticide residues in food products (Nitzko et al., 2022; Simoglou and Roditakis, 2022; Wang et al., 2022). Collectively, these researchers demonstrated that the issue of pesticide residue carries considerable weight for consumers, who claim they want agricultural practices that involve reducing or avoiding the use of pesticides. Research has also been undertaken to determine the pesticide residue intolerance limits for unprocessed and processed food products (Nitzko et al., 2022), to predict consumer perception of benefit and risk (Koch et al., 2017; Simoglou and Roditakis, 2022), to examine consumer purchasing motives and willingness-to-pay (WTP) for pesticide-free food products (Wang et al., 2022), and to explore the influence of pesticide-free product labels on consumer perception and purchase intention (Farías, 2020). Most studies focus especially on food for direct human consumption, e.g. fruits and vegetables. However, pesticide-free milk production has not yet been covered in research. Yet, is it essential: When establishing a new pesticide-free, but non-organic farming concept, a holistic approach must be taken that not only considers individual agricultural products from arable farming but also includes products from animal husbandry. Animal feed, such as pastures, pellet products, and grain can be significant sources, which are equally affected by pesticides and thus enter the food value chain. Studies show that pesticide residues working through the food chain, when dairy cows consume feed contaminated with pesticides. As a consequence, pesticides are accumulated in body tissues of the cows and excreted with the fat in the dairy milk, resulting in contaminated dairy products with pesticide residues consumed by humans (Jeong et al., 2012; Bedi et al., 2018; Penagos-Tabares et al., 2023). Thus, this study refers on attitudes toward products made from animals whose feed has been grown without pesticides. In pesticide-free, but non-organic dairy production, cows are only fed with pesticide-free feed, regardless of the feeding system (e.g. grassland-based or feeding systems with purchased concentrates). Milk and dairy products, such as cheese and butter, are particularly suitable for this purpose of this study.

To the best of our knowledge, this is the first study to profile consumer segments by acceptance level using latent profile analysis. This study contributes to the existing literature on consumer research related to pesticide-free food products by examining a potential target group for these products in Germany and determining their corresponding WTP. Moreover, the current study also fills the gap in the literature by expanding the knowledge of the characteristics of the potential target group of pesticide-free animal food products. To this end, we surveyed a sample

of German consumers on their attitudes toward three food products from the new system: milk, butter and cheese in pursuit of two research questions (RQ):

RQ1. How large is the potential target group of potential buyers of these pesticide-free, but non-organic food products?

RQ2. How is this potential target group characterized?

The remainder of this paper is structured as follows: Section 2 provides an overview of the literature on consumer acceptance of pesticide-free food products. We then describe the material and methods used to conduct the consumer segmentation study. In section 4 main findings are presented. We then discuss the findings and provide ideas for further research. An overall conclusion is presented in Section 6. Our findings enable an assessment of consumer acceptance and market introduction opportunities for products obtained from the new farming concept and are of particular value for decision makers in the food industry, policy makers, retailers, and producers.

2. Literature Review

We first provide a literature review to identify studies examining findings on consumer preferences and food labelling (2.1) as well as willingness to pay for pesticide-free food products (2.2). Next, there is detailed information about the pesticide-free farming system to understand the main characteristics as well as economic factors (2.3).

2.1 Consumer Preferences and Food Labelling

Consumers have become more aware of environmental and health risks associated with the use of pesticides in food production. Both Koch et al. (2017) and Simoglou and Roditakis (2022) showed that consumers view pesticide residues in food products as one of the greatest threats to food safety and their own health. Thus, the pressure from the public against the use of pesticides in food production has risen in recent years, and an increasing number of consumers demand pesticide-free food products (Koch et al., 2017; Diaz-Siefer et al., 2022; Sapbamrer and Chittrakul, 2022). Magnusson and Cranfield (2005) highlighted that consumers interest for pesticide-free food products is strong for food products containing grains and oilseeds.

Associated with this is public perception of risk. Yeung and Morris (2001) revealed that the perception of risk has a strong impact on consumer purchasing behaviour. Their results indicate that consumers who perceive a high risk in the use of pesticides are willing to pay higher prices for food produced not using pesticides and thus lower risks in food products (Yeung and Morris, 2001). On the other hand, consumers who consider pesticides essential associate fewer risks

with food so produced, and they show higher acceptance of the use of pesticides (Dunlap and Beus, 1992).

In addition, several studies have investigated consumer preferences for product characteristics and food labelling. Results show that pesticide-free product attributes support consumers in assessing the quality of food, and labels have a positive effect on perceived value and buying intention, especially if specific information about the negative effect of pesticide use, e.g. harm to humans, animals and the environment is visualized (Farías, 2020; Diaz-Siefer et al., 2022; Gatti et al., 2022). Pesticide-free labels influence consumer perception in that consumers consider those products as healthier, of better quality, and more beneficial for the environment (Yiridoe et al., 2005; Farías, 2020). Bazoche et al. (2014) added that consumers preferred pesticide-free labels over labels indicating reduced pesticide use. In contrast, Edenbrandt et al. (2017) emphasized that Danish consumers perceive the organic label to be more important than the pesticide-free information in their decision making. However, the study by Bazoche et al. (2014) showed that consumer demand for foods produced with reduced pesticide use is limited and that labels indicating pesticide-free are generally rated higher. Further, according to Zheng et al. (2022) pesticide-free certification, e.g. in the form of a uniform label, is less costly and less complex compared to organic certification, as the latter is associated with higher requirements and regulations.

2.2 Willingness to Pay

A number of studies from different countries have analysed consumer WTP for pesticide-free food products. Results indicate that demographic factors, as well as health and environmental concerns, strongly influence WTP. A higher WTP for pesticide-free products has been associated with female gender, younger age, concerns about pesticides, consciousness of health and sustainability, and shopping at health food stores (Cranfield and Magnusson, 2003; Nandi et al., 2017). In contrast, other studies conducted by Haghiri and McNamara (2007), Hayati et al. (2017) and Khan et al. (2018) reported that the WTP increases with age due to growing health concerns. Further, Haghiri and McNamara (2007) found a higher WTP for men than for women.

Cai et al. (2019) showed that US consumers will pay a premium for pesticide-free pawpaws. However, results indicated that consumers were willing to pay a higher price premium for locally and organically produced pawpaws compared to pesticide-free ones. Beyond, Khan et al. (2018) further analysed that 93.5% of respondents in Pakistan were willing to pay higher prices for pesticide-free fruits. These results are in line with previous studies (Hayati et al., 2017; Nandi et al., 2017). Compared to the conventional price, 35% of the respondents were willing

to pay 16 to 20% more, and 24% were willing to pay 6 to 10% higher prices for pesticide-free fruits (Khan et al., 2018). Additionally, Hayati et al. (2017) highlighted that in Iran, 64% of the consumers would be willing to pay 5 to 20% more. Another 33% would be willing to pay a premium > 20% for pesticide-free fruits and vegetables (Hayati et al., 2017). In contrast, the study by Cranfield and Magnusson (2003) indicated that only about 5% of Canadian consumers would be willing to pay more than a 20% premium for pesticide-free foods compared to conventional products. Most Canadian consumers (over 65%) would only pay a surcharge between 1 and 10% compared to the reference product price. Another study by Wang et al. (2022) investigated Chinese consumers' WTP for pesticide-free celery, showing that rural consumers would pay a premium of 327%, whereas urban consumers would pay a premium of 390% a higher WTP for pesticide-free celery in China.

Overall, the evidence so far does not yet indicate a clear trend toward WTP for pesticide-free foods or the characteristics of a potential target group.

2.3 Pesticide-free Production as a Farming Concept

In this novel pesticide-free farming system, pesticides are replaced by, e.g. crop rotation adjustments, the use of naturally bred resistant varieties, and mechanical weed control (Wang et al., 2023). At the same time, allowing synthetic fertilizers in this pesticide-free farming system could limit the productivity loss, compared to organic farming. Finger and Möhring (2022) highlighted that pesticide-free farming has a greater adoption potential than organic farming, in particular due to significantly fewer adoption barriers for farmers. The less stringent requirements in the pesticide-free farming system mean that the average crop yields to be expected in pesticide-free cultivation (5.2t/ha) are higher than in organic cultivation (4.4t/ha), but about 25% lower than in conventional cultivation (7t/ha) (Böcker et al., 2019). Compared to conventional farming, pesticide-free farming is associated, at least in the short-run, with lower production levels, higher production costs, e.g., for mechanical weed control equipment, and larger yield variability, indicating higher production risks (Finger and Möhring, 2022; Heitkämper et al., 2023). These changed production conditions can lead to uncertainties among farmers who only have limited information and experience with such a novel production system. High uncertainty regarding expected production outcomes, as data on yields and costs is still rare, as well as the duration of policy programs and price markups can be essential adoption barriers for farmers for establishing pesticide-free farming systems (Finger and Möhring, 2022; Möhring and Finger, 2022). Thus, in particular during the period of transition redesigning of cropping systems make it necessary to support farmers to compensate for productivity losses (Jacquet et al., 2022; Mack et al., 2023). In Switzerland, researchers examined compensation

payments for farmers (Böcker et al., 2019; Möhring and Finger, 2022; Mack et al., 2023). Findings reflects that pesticide-free farming compensatory payments, combining direct governmental payments with market-based price premiums, seem to be sufficient to balance out negative effects on farmers' income (Böcker et al., 2019; Mack et al., 2023).

3. Material and Methods

To investigate consumer attitudes toward pesticide-free animal food products, we conducted an online survey of a sample of German consumers, as described below.

3.1 Data Collection and Sample

Data collection was completed in June 2022 in Germany. The sample was recruited via two professional online-panel providers. Incentives for participants were guaranteed through the panel providers. Quotas for the sample were set for age, gender, household net income, education and German Federal State residency, according to the distribution of the German population (Federal Statistical Office, 2023).

All survey items were presented randomly to counteract response bias due to sequence effects. Further, to ensure the quality of data, we inserted a quality check question in the survey (*To ensure data quality, here you have to choose the answer 'rather correct'*). Participants who chose a different answer were excluded from the questionnaire. Another ten participants were eliminated due to monotonous response behaviour ("speedliners", participants who always give the same answers in a row), and one participant was eliminated due to incomprehensible responses to the open questions. The final data sample included 1010 participants; it serves as a maximal representative sample of the German population in terms of age, gender and German Federal State residency, allowing conclusions to be drawn about the German population.

3.2 Survey Design

Prior to deployment of the online survey conducted to obtain information on demographics and attitudes toward pesticide-free food products, the questions were pretested. The pretest was conducted with 10 individuals (attention was paid to the distribution of gender, age, and education) to ensure the comprehensibility of the formulations and uncover possible logic and technical problems. The thinking aloud method was used. With this method, the individuals verbalized their thoughts while completing the questionnaire (Ericsson and Simon, 1980). The results were documented, and adjustments were made prior to the final survey distribution. The survey received ethical approval from the University of Hohenheim Ethics Committee and a release

from the data protection officer. Prior to completing the survey, each participant approved their declaration of consent.

The survey contains of five main parts structured as follows. The entire survey and the individual parts can be found in the supplementary information (S1. Consumer survey).

- Part 1: Sociodemographic variables (age, gender, German Federal State residency, monthly net income, education level, number of household members, number of children) were assessed at the beginning of the survey (Federal Statistic Office, 2023). Participants also completed a five point-Likert scale ranging from "not at all" to "five times per week or more" to indicate the weekly frequency of their purchases of milk; they did the same for purchases of cheese and butter. Participants who indicated "not at all" for any one of these products were screened out.

- Part 2: Consumer familiarity with pesticide residues in food products, for example "*How interested are you personally in the possible risks of pesticide residues in food?*" and their attitudes toward pesticide use in agriculture, for example "*Pesticides are harmless to humans when used properly*" were here captured on a five-point Likert scale. To validate results, a short general text on the advantages and disadvantages of the pesticide use in food production was presented, followed by two quiz questions. This ensured that the participants understood the topic correctly, that misinformation was excluded and that the results were not biased from previous incorrect subjective knowledge of the participants. Only if both questions were answered correctly could participants continue with the survey.

- Part 3: Willingness-to-pay for pesticide-free milk, butter and cheese was measured through an open request. An anchor price for conventional products (milk: 0.88 €, cheese: 2.69 €, butter: 2.09 €) based on current store checks in five German supermarkets was presented. To avoid unrealistic prices or typing errors, price limits were imposed; prices > 30% below conventional or 50% above organic prices were rejected, and the WTP had to be re-entered. In summer and autumn 2023, prices for dairy products are back at the same level as in June 2022. Further, sustainability aspects are still strong drivers for the German food market after a temporary period of high inflation.

- Part 4: Consumer perceptions of animal food products (milk, butter, cheese) produced without the use of pesticides, for example *"Milk, cheese, and butter produced without the use of pesticides can help preserve the ecosystem"* (adapted from Bruner, 2017 and Voss, 2008) as well as behavioural intention, for example *"I would buy milk produced*

without pesticides" (adapted from Hocquette et al., 2016; Wilks and Phillips, 2017) were collected using five-point Likert scales.

- Part 5: Items for target group analysis: Price consciousness (e.g. *"I try to buy food that is on sale"* (Gil and Soler, 2006), environment consciousness (e.g. *"I feel able to contribute to solving environmental problems by buying environmentally friendly products"* (Kim and Choi, 2005; Wesley et al., 2012), health consciousness (e.g. *"I take care of my health"*) (Michaelidou and Hassan, 2008), relevance of product information (e.g. *"I pay attention to the ingredient list when shopping"*) (Grunert et al., 1993), chemophobia (e.g. *"The chemical industry is responsible for more and more people getting cancer")* (Saleh et al., 2021), changes in consumption and purchasing behaviour due to inflation and increased food prices (e.g. *"I buy fewer organic products because of the price increases"*) (own items) were assessed using five-point Likert scales.

3.3. Data Analysis

First descriptive analyses of attitudes toward pesticide-free food products (milk, butter, cheese) were carried out using SPSS Version 27 (SPSS, 2021).

Second, using SPSS, an exploratory factor analysis (principal component analysis with Promax rotation) was conducted to reduce data complexity and explore the appropriateness of the factorial construct. As recommended by Tabachnick and Fidell (2001), variables with loadings <0.3 were suppressed from the final variable list. To evaluate the data quality, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test for sphericity were implemented. Further, the reliability of the factors was examined with Cronbach's alpha.

Third, latent class cluster analysis was conducted using LatentGOLD Version 6.0 (Vermunt and Magidson, 2021). The analysis was performed to detect homogeneous classes within our heterogeneous population based on the observed variables. It used one latent categorical variable and a set of continuous indicators in a method called latent profile analysis (LPA) (Vermunt and Magidson, 2002). The main difference between LPA and traditional, non-latent clustering approaches (e.g., k-means, hierarchical cluster analysis) is that LPA is a model-based approach that provides a goodness-of-fit estimation (Vermunt and Magidson, 2002). Our LPA analysis is based on the bias-adjusted 3-step approach developed by Vermunt (2010) to prevent external variables (covariates) from affecting the structure of latent profiles.

3.3.1 Step One

In the first step, we built and estimated a latent clustering model based on a set of indicators derived from the factor analysis, with covariates excluded. Latent profile models were then built based on five indicators retrieved from the exploratory factor analysis.

The *Acceptance level* provides valuable information on consumers' behavioural intentions and willingness to purchase pesticide-free products. Thus, this indicator forms an essential aspect for the determination of a potential target group.

Further, C*hemophobia* was used as an indicator as recent studies highlighted the increasing consumer concern about the use of chemical substances in food production (Jansen et al., 2020). Chemophobia is understood as consumers fear of chemicals. Chemophobic peoples are characterized by perceiving any amount of chemicals as a great risk for health issues and environmental disasters (Dickson-Spillmann et al., 2011; Bearth et al., 2019; Saleh et al., 2019). Consequently, chemophobics try to avoid contact with chemicals, seek out pesticide-free foods, and demand a ban on their use in agriculture. According to Saleh et al. (2021), chemophobia affects the level of consumer acceptance of pesticide use in food production and is a good predictor of pesticide-free food purchase. Therefore, the absence of pesticides is a primary reason for the choice of pesticide-free food products and a significant motivator for consumers purchases intentions. Prior studies suggest that consumers may perceive pesticide-free food products to be generally healthier, safer, of higher quality, and better for the environment than conventional foods (Teng and Lu, 2016). This perception shows that consumers concerns about pesticides are influenced by chemophobia (Saleh et al., 2021).

Moreover, *Environmental relief* was used as an indicator as consumers' opinions on the extent to which the pesticide-free farm system can reduce environmental impact and the resulting products gain in value determine food choices. Previous consumer research investigated consumers attitudes toward pesticide-free food production. Results indicate that consumers consider corresponding products to be less harmful, and less problematic for the environment (Yiridoe et al., 2005; Farías, 2020). According to Cranfield and Magnusson (2003), environmental benefits are one of the main drivers for switching to pesticide-free food products. Consequently, these consumer attitudes lead to strong positive preferences and purchase behaviour toward pesticide-free food products (Magnusson and Cranfield, 2005; Sapbamrer and Chittrakul, 2022; Wang et al., 2022). According to Ajzen (1991), attitudes are predictors of purchase intentions, resulting in the fact that the more favourable consumer attitudes toward pesticide-free production are, the stronger is the purchase intention of those products. Thus, consumers who are highly concerned about pesticides are more likely to have positive attitudes toward pesticide-free products and associate various benefits with pesticide-free food production. This relates to

a higher level of purchase intention. In addition, a*ttitude toward pesticides* were included as an indicator in the LPA. Studies show that there is a fundamental scepticism about the use of pesticides and their impact on the environment and the population. In this context, the use of pesticides in the production of food rated by more than half of the German consumers risks of pesticides greater than their benefits - even when used properly (Koch et al., 2017). Thus, consumers who believe there is a major risk to environment and human health even when pesticides are used properly and maximum residue levels are below limits will thus be more likely to support pesticide-free food production.

Closely related to this is consumer *Involvement* which is another indicator in the LPA. Pesticide residues in foods have been an essential subject of controversial public discussions and media coverage in Germany. Knowledge and acquiring information on pesticide residues is critical to attitude and behaviour related to pesticide-free farming systems (Koch et al., 2017). Results indicated that being unaware of maximum residue levels is associated with significantly higher levels of concern about pesticide residues. Further, a lack of awareness of these regulations may enhance the opinion that any residue level is associated with high risks to human health and the environment (Koch et al., 2017).

To determine the model with the best fit, we followed the suggestion of Spurk et al. (2020), and checked performance of the models for two to ten latent profiles. Several criterions were applied to determine goodness-of-fit and to select the optimal number of profiles. The Akaike information criterion (AIC), the Bayesian information criterion (BIC) and the sample-size adjusted BIC (SABIC) from Vermunt (2010) were criterions used to determine the quality of different models.

In addition, to assess each model's classification accuracy, the entropy value was calculated, with a higher entropy value indicating better classification quality (Berlin et al., 2014). We used the Lo-Mendell-Rubin (LMR) test to quantify comparisons between the model of interest and a model with one more profile (k vs. k+1 profiles), following the guideline of Spurk et al. (2020) that a non-significant *p*-value indicates a solution with one fewer profile (k-profile solution) is preferable.

Beyond, content decisions were also included in the assessment of the final model to ensure the best possible profile discrimination and substantive interpretability of the profiles (Vermunt and Magidson, 2002; Berlin et al., 2014). Further, in terms of meaningfulness and parsimony, the profile size was also considered since profiles with a small size may inconclusive and may have lower power as well as lower precision compared to larger profiles (Lubke and Neale,

2006). Thus, profiles representing < 5% of the total sample were refused (Lubke and Neale, 2006; Liljenstolpe, 2011).

3.3.2. Step Two

After deciding on the final latent profile solution and the assessment of the number of latent profiles, we assigned respondents to predicted latent profiles and described the substantive content of the single profiles based on the means of the indicators (Dahling et al., 2017; Moeller et al., 2018).

3.3.3. Step Three

In the last step, using the maximum likelihood adjustment method, covariates were involved in the model to assess the relationship between profiles membership and covariates and to illustrate the characteristics of these latent profiles. Wald tests were conducted to investigate the significance of the relationships between profile membership and covariates.

4. Results

In section 4, we present the descriptive findings of our consumer survey related to pesticide-free animal food products (4.1), as well as our results of the factor analysis (4.2), the latent profile analysis and the respective WTP (4.3).

4.1 Descriptive Statistics

A total of 1010 German consumers were included in the final survey statistics. Overall, our sample was 49.7% male, with an average age of 49 years. As Table 1 shows, in terms of age, gender and region, the demographic characteristics serve as a maximal representative sample of the German population. In terms of education and income, participants had a higher level of education compared to the respective German averages. The education level in the German population adds up to 99.6%, as the "No answer" statement (Federal Statistic Office, 2023) was not included in this study.

Table 1

Sociodemographic variables.

Variable	Description	Percentage Sample (%)	Percentage Germany (%)
Age (years)	16-35	26.3	27.1
	36-55	31.6	31.3
	56 and older	42.1	41.6
Gender	Male	49.7	49.3
	Female	50.3	50.7
Region	North	16.5	16.2

	South	28.0	29.2
	East	21.9	19.4
	West	33.7	35.2
Education level	No qualification	3.1	7.5
	Primary school	23.8	28.6
	Secondary school	34.4	30.0
	A-levels	38.8	33.5
Net household income (€)	Less than 1300	15.5	13.5
	1301-1700	11.2	9.2
	1701-2600	22.5	20.3
	2601-3600	20.7	17.6
	3601-5000	18.7	16.7
	More than 5000	11.4	22.7

Source: Federal Statistic Office, 2023.

Participants also completed a five point-Likert scale ranging from “not at all” to “five times per week or more” to indicate the weekly frequency of their purchases of butter, cheese and milk as shown in Fig.1.

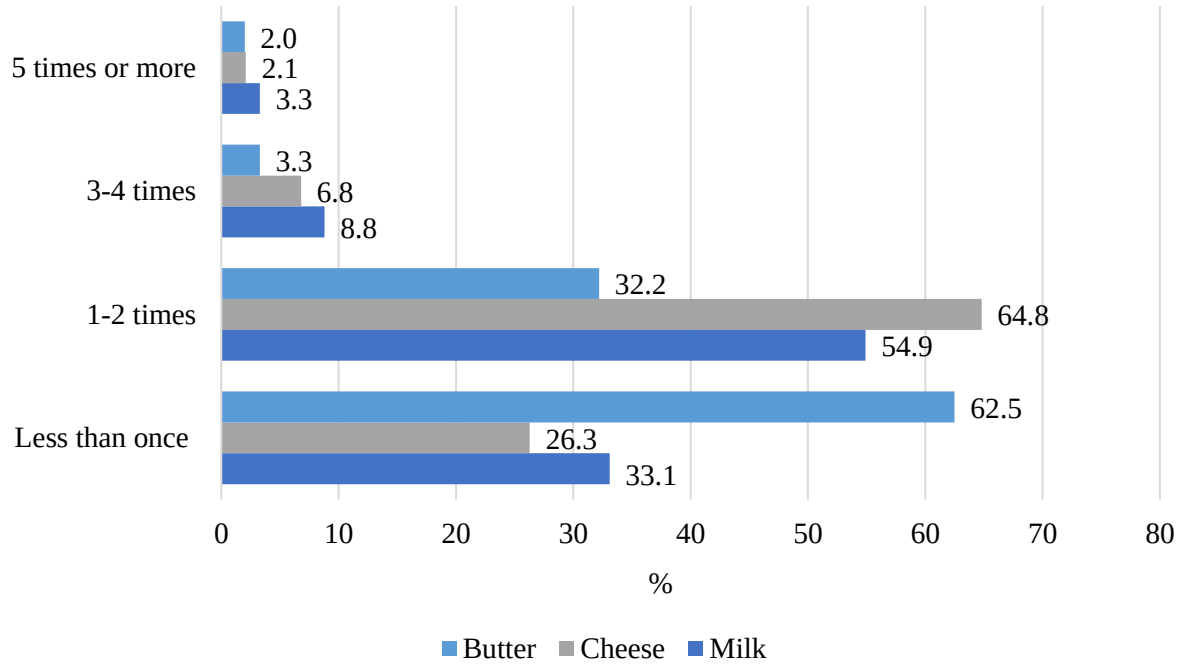
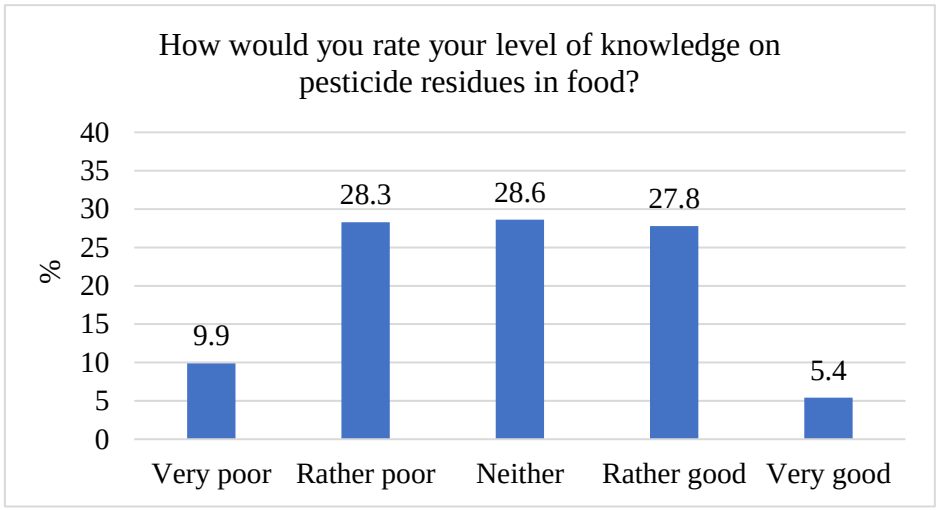
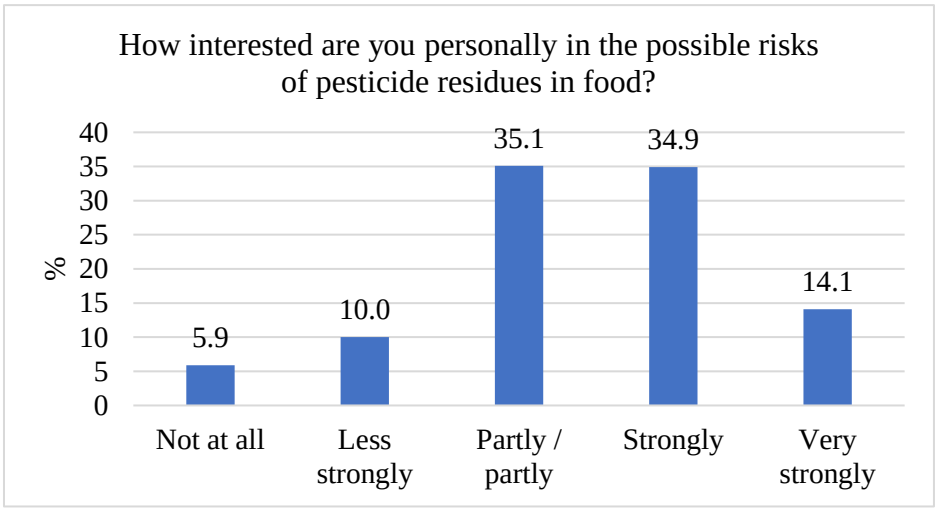


Fig. 1. Purchase weekly frequency of butter, cheese and milk (N = 1010).

Further, subjective perception of the knowledge, consumer interest in possible risks of pesticide residues in food and consumer familiarity with pesticide residues in food products were here captured on a five-point Likert scale. Results are presented in Fig. 2.





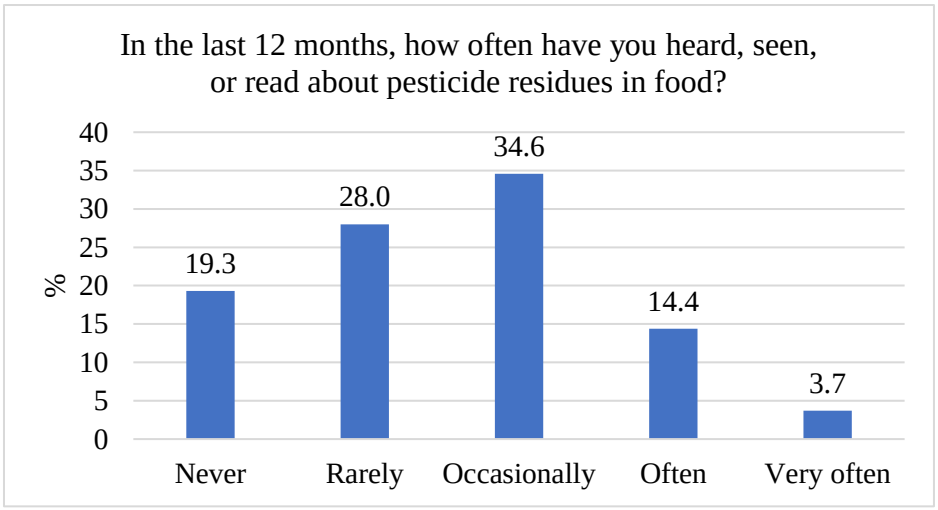


Fig. 2. Consumer familiarity with pesticide residues in food (N = 1010).

In addition, respondents were moderately concerned about pesticide residues in food, indicating a fundamental scepticism about the use of pesticides and their impacts on the environment and the population. However, about 10% could not make a statement about each of the statements. Results are shown in Fig. 3.

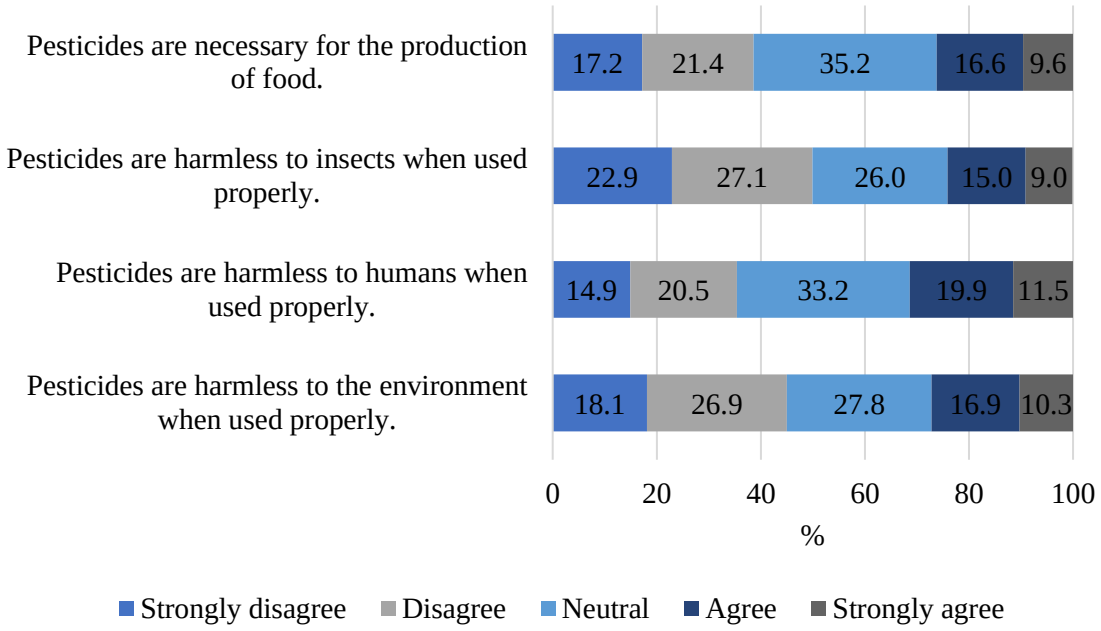


Fig. 3. Consumer opinion about pesticide use in food production (N = 1010).

Overall, German consumers appear enthusiastic concerning food produced without the use of pesticides and are in favor of pesticide-free production of the three dairy products (milk, butter, cheese) we solicited attitudes about. Results are illustrated in Table 2.

Table 2

Consumer opinions about pesticide-free dairy products in percent (%) (N = 1010).

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Milk, cheese, and butter produced without the use of pesticides are good for the environment.	1.1	2.7	12.3	33.6	50.3
Milk, cheese, and butter produced without the use of pesticides can effectively reduce environmental impact.	1.5	2.3	17.4	33.8	45.0
Milk, cheese, and butter produced without the use of pesticides can help preserve the ecosystem.	1.2	2.6	15.9	35.9	44.4
Milk, cheese, and butter produced without the use of pesticides would have many benefits.	1.0	2.3	15.1	35.2	46.4
Milk, cheese, and butter produced without the use of pesticides would make the product more valuable.	1.8	3.8	15.2	32.1	47.1
I would find milk, cheese, and butter produced without the use of pesticides good.	1.0	2.4	13.7	30.9	52.0

Source: Authors' calculation.

4.2 Results of the Factor Analysis

Exploratory factor analysis was implemented to ensure the quality of the variables used in determining potential target groups. Results of both Bartlett's sphericity test (chi- square (2556) = 44020.41, $p < 0.001$) and the Kaiser-Meyer-Olkin test (KMO = 0.944) indicate that the variables are suitable for factor analysis (Kaiser, 1970). Thus, a principal component analysis with Promax rotation was conducted. To decide the number of factors to be extracted, Kaiser's Criterion (eigenvalue >1) (Kaiser, 1960) and Scree test (Cattell, 1966) were examined, yielding in 11 factors which explain 65.84% of the total variation in the data. As presented in Table 3, the internal consistency of all 11 factors was supported by Cronbach's alphas ranging from 0.758 to 0.945, greater than the recommended cutoff of 0.7 (Hair et al., 2010). The table with all items and factor loadings is presented in the supplementary information (S2. Factor analysis; Table S1).

Table 3

Results of the factor analysis.

Factor	Description	Cronbach's alpha
1	Acceptance level	0.945
2	Purchase power (negative)	0.906
3	Chemophobia	0.863
4	Effectiveness of action	0.933
5	Environmental relief	0.917
6	Importance of product information	0.864
7	Health consciousness	0.852
8	Attitude toward pesticides	0.871
9	Price consciousness	0.821
10	Purchase power (indifferent)	0.764
11	Involvement	0.758

Source: Authors' calculation.

4.3. Results of the Latent Profile Analysis

4.3.1. Step 1: Building a Clustering Model and Model Selection

Five factors (*Acceptance level*, *Chemophobia*, *Environmental relief*, *Attitude toward pesticides*, *Involvement*) were chosen as indicators of different consumer profiles. Table 4 summarizes the results for two to ten-profile solutions.

Table 4

Summary of latent profile models.

No. of profiles	LL	BIC (LL)	AIC (LL)	SABIC (LL)	LMR (*p*)	Entropy R^2
2-profiles	5206.0	10554.0	10453.9	10487.3	0.0000	0.959
3-profiles	-4975.7	10168.0	10015.5	10066.4	0.0000	0.817
4-profiles	**-4870.7**	**10032.4**	**9827.4**	**9895.9**	**0.0000**	**0.835**
5-profiles	-4784.9	9935.2	9677.8	9763.7	0.0000	0.827
6-profiles	-4717.2	9874.2	9564.3	9667.8	0.0000	0.818
7-profiles	-4672.2	9858.6	9496.3	9617.3	0.0204	0.812
8-profiles	-4614.7	9818.2	9403.4	9541.9	0.0000	0.811
9-profiles	-4570.8	9804.7	9337.5	9493.4	0.0000	0.826
10-profiles	-4541.8	9821.3	9301.7	9475.2	0.0089	0.816

Note: LL = Log-likelihood; BIC = Bayesian information criterion; AIC = Akaike information criterion; SABIC = sample-size adjusted BIC; LMR (p) = p-Value for the adjusted Lo-Mendell-Rubin-test. Source: Authors' calculation.

The models with six to ten profiles were rejected since they contained profiles with very small sizes (< 5% of the sample). Thus, only the 2-, 3-, 4- and 5-profile models were evaluated, using multiple goodness-of-fit and content-decision criteria. We first considered the 5-profile solution, as this shows the lowest BIC-, AIC- and SABIC-values. However, the 5-profile solution did not offer essential explanation of much interest and added no meaningful new insights over the other models, leading us to exclude the 5-profile solution to maximize parsimony (Vermunt and Magidson, 2002; Berlin et al., 2014). In comparing the remaining three models, we decided the 4-profile solution was the best fit, since it had the highest entropy value, reasonable profile sizes (> 5%), and permitted meaningful interpretation of the profiles.

4.3.2. Step 2: Describing Profile Characteristics

Fig. 4 summarizes the results of the 4-profile solution and lists the mean scores of each profile. Profiles were named according to consumer acceptance level, buying intention, and attitudes toward pesticide use in food production. The largest and first profile with 39.3% of the sample depicts the *Unwilling Consumers*. The second profile with 30.9% of the sample represents the *Indecisive Consumers*. The third profile with 22.9% of the sample describes *Prospective Consumers*. The remaining 6.9% of the sample make up the *Ambivalent Consumers*.

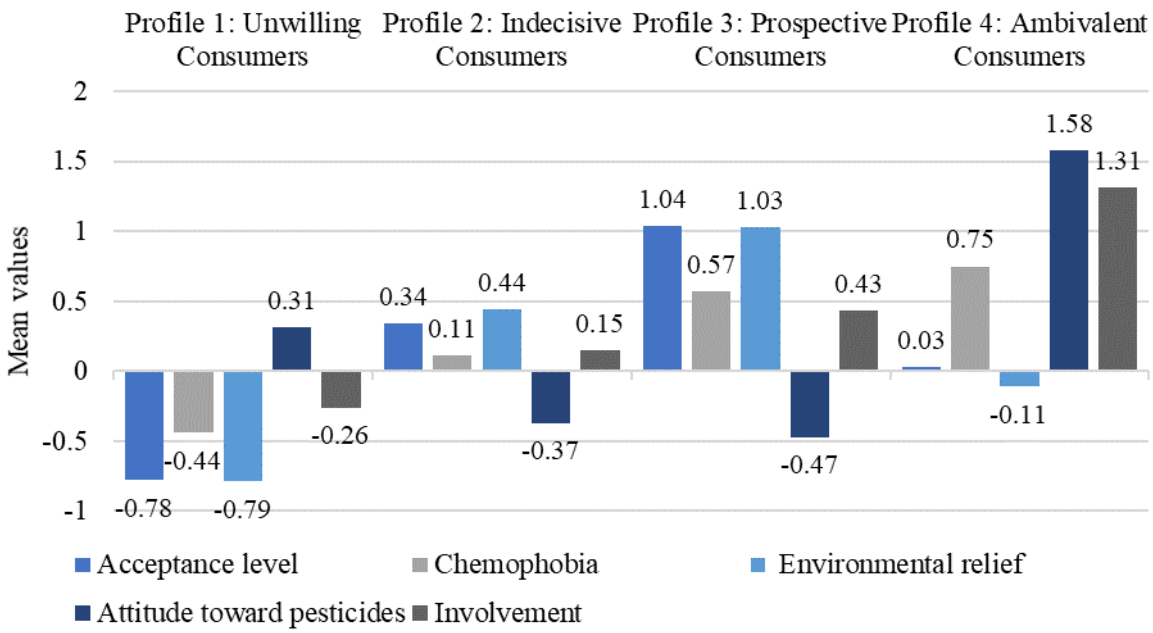


Fig. 4. Results of the Latent Profile Analysis of consumer attitudes toward pesticide-free food.
Note: Scale from -2 (Strongly disagree) to +2 (Strongly agree).

4.3.2.1. Profile 1 – the Unwilling Consumers

Profile 1 has the lowest acceptance level of pesticide-free products (-0.78). They would likely reject those products. This is underlined by the fact that they would rather not buy, try, regularly consume, or recommend these products to friends and family. Further, participants of profile 1 show the lowest level of chemophobia (-0.44), meaning they show the least aversion to and fear of chemical substances, including pesticides and their possible impact on the environment and human health. Consequently, they do not believe that producing products without the use of pesticides effectively reduces the environmental impact or makes the product more valuable (- 0.79). Further, these consumers are also more inclined to say that pesticide application is harmless to the environment, insects, and humans when used properly (0.31). However, this profile has the lowest involvement with the topic (-0.26) and seem to be less interested in the issue of pesticide residues in food. In addition, they also hear something about the topic only occasionally and also assess their own level of knowledge as rather worse than better.

4.3.2.2. Profile 2 – the Indecisive Consumers

Profile 2 is more inclined to try, buy, regularly consume, and recommend products from the new farming concept to family and friends. This profile has the second-highest acceptance rate (0.34). However, only a slight tendency can be seen in this respect. With regard to chemophobia, they feel rather neutral (0.11). In this context, it should be noted that they do not tend to assume that pesticide use, even when properly applied, is harmless to the environment, insects and humans (-0.37) which is a contrast to their acceptance rate. Further, they likely agree that products made without the use of pesticides can relieve pressure on the environment, which

makes pesticide-free products more valuable (0.44). These members rate their knowledge about pesticide residues in food second lowest, and are less interested in the topic than profile 3 and 4 (0.15).

4.3.2.3. Profile 3 – the Prospective Consumers

Consumers in profile 3 express a preference for pesticide-free products; they score the highest acceptance level of all profiles (1.04). Members of profile 3 would rather buy, try, regularly consume, and recommend pesticide-free food to friends and family. The greatest chemophobia among the three double-digit profiles. They tend to be more concerned about pesticides and potential impacts on the environment and human health. This is underlined by their conviction that food production without the use of pesticides has many advantages and can effectively relieve pollution pressure on the environment; this makes pesticide-free products more valuable (1.03). Furthermore, this profile has the most negative attitude toward pesticides. Its members tend to disagree with the claim that the use of pesticides is harmless to the environment, insects and humans when used properly (-0.47). They indicate the second-highest involvement in the question of pesticide residues in food products. Compared to consumers in profiles 1 and 2, those in this profile rate their level of knowledge higher and are more interested in the topic (0.43).

4.3.2.4. Profile 4 – the Ambivalent Consumers

Profile 4 has the second-lowest acceptance level regarding pesticide-free products; consumers in this group are undecided in their intention to buy, try, regularly consume, or recommend pesticide-free products to friends and family (0.03). Profile 4 also has the highest level of chemophobia (0.75). However, its members harbour the least critical attitude toward pesticides and are likely to agree strongly that the use of chemical crop protection in food production is harmless to the environment, insects, and humans (1.58). They believe that crop protection products are necessary for the production of food. Further, members of this profile tend to think that products made without the use of pesticides do not necessarily help the environment, nor do they make the product significantly more valuable (-0.11). Moreover, this profile consider themselves to be the most knowledgeable and engaged consumers, meaning their estimates of their level of knowledge and interest in this topic are the highest (1.31).

4.3.3. Step 3: Investigating the Relationship Between the Classifications and External Variables

The inclusion of age, gender, household net income, and level of education as covariates in the final model revealed further insights into the four consumer profiles. We conducted Wald tests to evaluate whether the profiles differed significantly from each other by covariates. Results

shown that profiles differ significantly in terms of age groups ($W = 50.619$, $p < 0.001$), gender ($W = 24.947$, $p < 0.001$) and level of education ($W = 96.043$, $p < 0.001$). In terms of the net household income ($W = 17.840$, $p = 0.27$), a non-significant p-value related to the Wald statistics indicates that the covariate does not discriminate between the profiles in a statistically significant way.

Table 5 shows in detail the distribution of sociodemographic covariates across the four profiles. The *Prospective Consumers* (Profile 3) are characterized by the highest proportion (54.5%) of consumers older than 56 and the lowest proportion of consumers between 16 and 35 (12.2%) compared to profiles 1, 2 and 3 ($p < 0.05$). In turn, younger consumers (16-35 years) are represented with a significantly higher proportion in profile 4 (*Ambivalent Consumers*) ($p < 0.05$). Additionally, the *Ambivalent Consumers* consists of the lowest proportion of older consumers (56 years and older) compared to profiles 1, 2 and 3 ($p < 0.05$). Further, profile 3 is characterized by the highest proportion of females (63.7%) compared to profiles 1, 2 and 4 ($p < 0.05$), whereas the highest proportion of males are reported in profile 4 (59.7%). In terms of net household income, profile 1 has the highest percentage of consumers at the lowest income level, while profile 4 has the highest percentage of consumers at the highest level. Further, as Table 5 shows, the highest education level is represented in profile 4 ($p < 0.05$), while the highest percentage of those with the lowest level of education is found in profile 1.

Table 5

Characterization of each profile based on socio-demographic variables.

Distribution of covariates given profile (%)	Profile 1: Unwilling Consumers (39.3%)	Profile 2: Indecisive Consumers (30.9%)	Profile 3: Prospective Consumers (22.9%)	Profile 4: Ambivalent Consumers (6.9%)	Overall
Age groups					
• 16-35	31.2	23.4	12.2	58.3	26.3
• 36-55	27.1	34.9	33.3	36.9	31.6
• 56 and older	41.7	41.7	54.5	4.8	42.1
Gender					
• Male	54.7	50.9	36.3	59.7	49.7
• Female	45.3	49.1	63.7	40.3	50.3
Net monthly household income (€)					
• Less than 1300	18.2	16.0	13.1	6.3	15.5
• 1301-1700	14.6	7.9	11.8	4.7	11.2
• 1701-2600	23.7	18.2	24.2	29.2	22.5
• 2601-3600	21.3	22.3	17.8	19.8	20.7
• 3601-5000	13.8	23.0	20.7	20.8	18.7
• More than 5000	8.4	12.6	12.4	19.2	11.4
Education level					
• No qualification	3.1	5.0	1.3	0.0	3.1
• Primary school	28.	19.7	23.1	14.8	23.8
• Secondary school	34.5	37.1	32.8	26.5	34.3
• A-levels	33.5	38.2	42.8	58.7	38.8

Note: Significant differences at 5% level. Age groups: The pairwise comparison showed a significant difference between all profiles. Gender: The pairwise comparison showed a significant difference between profile 1 and 3, profile 2 and 3, profile 2 and 4, and profile 3 and 4. Income: The pairwise comparison showed no significant differences. Education level: The pairwise comparison showed a significant difference between profile 1 and 3, profile 1 and 4, profile 2 and 4, and profile 3 and 4. Source: Authors' calculation.

4.4. Willingness to Pay

The overall Wald statistics indicates that the profiles differ significantly in terms of WTP for milk ($W = 12.631$, $p < 0.001$), cheese ($W = 8.241$, $p < 0.001$) and butter ($W = 12.602$, $p < 0.001$). Profile-specific WTP estimates for the three dairy products are presented in Table 6. The highest values for pesticide-free dairy products occur, as expected, under *Prospective Consumers* (Profile 3) and the lowest WTP under the *Unwilling Consumers* (Profile 1). For example, profile 3 would be willing to pay 31% more for pesticide-free milk (conventional: 0.88€ vs. pesticide-free: 1.15€), 23% more for pesticide-free cheese (conventional: 2.69€ vs. pesticide-free: 3.30€) and even 24% more for pesticide-free butter (conventional: 2.09€ vs. pesticide-free: 2.59€), compared to conventional dairy products. Compared to this, profile 1 with the lowest WTP would be willing to pay 18% more for pesticide-free milk, 11% more for pesticide-free cheese

and 14% more for pesticide-free butter, compared to conventional dairy products. For pesticide-free milk and cheese, profile 4 has the second lowest WTP, while profile 2 has about the same WTP for pesticide-free milk and cheese as profile 3. For pesticide-free butter, profile 2 has the second lowest WTP, while profile 4 has the same WTP for pesticide-free butter as profile 3.

Table 6

Results of the willingness to pay analysis.

Willingness to pay (€) (mean values)	Profile 1: Unwilling Consumers[a]	Profile 2: Indecisive Consumers[b]	Profile 3: Prospective Consumers[c]	Profile 4: Ambivalent Consumers[d]
Milk	1.04[b,c]	1.14[a]	1.15[a]	1.09
Cheese	2.99[b]	3.29[a,d]	3.30	3.00[b]
Butter	2.38[d]	2.51[c,d]	2.59[b]	2.59[a,b]

Note: Anchor prices for conventional products: milk: 0.88€, cheese: 2.69€, butter: 2.09 €. Exponents indicate significant differences of the pairwise WTP mean levels (mean a significant difference was found between that profile and the one listed in the column heading). For example, under milk the pairwise comparison showed a significant difference between profile 1 and profile 2 as well between profile 1 and profile 3; and no significance difference were found between profile 1 and profile 4. Source: Authors' calculation.

5. Discussion

This study investigates consumer attitudes toward the use of pesticides in food production and toward products produced by a new pesticide-free farming method. We identified four consumer profiles with different acceptance levels and willingness to pay for pesticide-free products. The profile with the largest representation (39.3%) is the *Unwilling Consumers* in the German population. These consumers show a low acceptance of and no purchase intention for pesticide-free food products, and so would not be potential consumers of products made by the new farming method. However, even the *Unwilling Consumers* shown negative attitudes toward pesticide-free food products, they indicated a higher WTP for those products compared to conventional. However, these results can be attributed to social desirability bias.

The optimal target group represents the *Prospective Consumers*, estimated at 22.9% of the German population. The *Prospective Consumers* have the highest level of acceptance for pesticide-free products, and they are willing to try and would be most likely to purchase pesticide-free products. Our results show that this profile consists of participants with a more pronounced perception of and aversion to risk in the use of pesticides in food production. These consumers favor not using pesticides in food production and see in that practice both health and environmental benefits. Our findings suggest that pesticide-free products target consumers who associate both environmental and health risks with the use of pesticides in food production. Thus,

consistent with previous studies from Yeung and Morris (2001), our results show that the perception of risk has a strong impact on consumer behavioural intention regarding pesticide-free food products.

Accordingly, this group should be the target for producers, policy makers, and food industry marketers creating strategies and policies for the new farming concept and its related products. Note we found a sociodemographic similarity with other studies (Cranfield and Magnusson, 2003; Nandi et al., 2017) that associate gender with openness to buy/consume pesticide-free food products, as we found a significantly higher percentage of *Prospective Consumers* were female (63.65%). Moreover, this profile is characterized by a significantly greater proportion (54.44%) of consumers older than 56 than the other three profiles.

In our investigation of consumer attitudes, we focused on the pesticide-free aspect of the new farming method. Follow-up research could clarify whether the use of mineral fertilizers in the new method would impact marketing the new method. Consumer preferences for pesticide-free products could also apply to those from organic farming, but those products carry a high price premium over conventional foods. In contrast, due to the targeted use of mineral fertilizers and the less stringent conditions for animal husbandry in the novel farming system, prices can be closer to conventionally produced products than to organically grown products, resulting in a clear product differentiation in the sustainability segment. Accordingly, three consumer segments – the *Prospective Consumers*, the *Indecisive Consumers*, and the *Ambivalent Consumers* – could be reached with products that are both sustainable and reasonably priced.

Further, for better decision-making regarding a price segment for pesticide-free products, we solicited WTP values using open-ended questions. The *Prospective Consumers* would be willing to pay 31% more for pesticide-free milk, 23% more for pesticide-free cheese and even 24% more for pesticide-free butter, compared to conventional dairy products. Since there are no studies on WTP for pesticide-free animal food products, we discuss our results with the existing literature on WTP for pesticide-free fruits and vegetables.

Our results are in contrast with Cranfield and Magnusson (2003) who reported that only about 5% of Canadian consumers would be willing to pay more than a 20% premium for pesticide-free foods compared to conventional products. However, our results are in line with other studies investigating WTP for pesticide-free food products in other countries. Khan et al. (2018) reported that 35% of Pakistan consumer were WTP 16 to 20% higher prices for pesticide-free fruits. Another study by Hayati et al. (2017) assessed consumers WTP for pesticide-free fruits and vegetables in Iran, indicating that 33% of the respondents were WTP more than 20% price

premium. However, with the evidence available so far, no general conclusions can be drawn about the differences in WTP between different products, such as between animal and plant products, which could be a research question for future issues. It can be observed that consumers' willingness to pay for milk is higher than for butter and cheese. These differences in the level of WTP between the products can possibly be attributed to the fact that, compared with milk, cheese and butter still require a further processing step. These findings are underlined by Nitzko et al. (2022), indicating consumers pesticide residue intolerance increases with higher food processing degrees. Additionally, environmental and animal welfare aspects as well as the health and safety aspects are probably more tangible for consumers with milk than with cheese and butter, which in turn has an effect on their different WTP. Moreover, it is important to understand whether the premium prices, which the *Prospective Consumers* are willing to pay for pesticide-free animal products, are sufficient to cover the producers' production costs. Pesticide-free farming systems could (at least in the short term) lead to lower crop yields and higher production costs, in particular labour costs. Therefore, measures are necessary to compensate for the lower profitability of pesticide-free farming systems. Results from Böcker et al. (2019) show that direct payments in combination with price premiums compensate losses in revenues and additional costs associated with the pesticide-free farming system.

Though the second largest profile (30.9%), the *Indecisive Consumers,* and the smallest profile (6.9%), the *Ambivalent Consumers* are undecided in their buying intention, this does not exclude the possibility that their attitudes could be changed through targeted measures. In this line, deeper insights into consumer aversion toward pesticide-free products are still lacking. Further investigations on the factors influencing consumer rejection are needed to derive communication strategies that increase the level of acceptance for pesticide-free food products. Such knowledge would be beneficial for marketing departments and product developers seeking market entry opportunities to expand the target group of those products. As consumer awareness reached by social or mass media of pesticide use continues to intensify and communication of sustainable farming methods increases, there may be opportunities to turn *Indecisive Consumers* into *Prospective Consumers.* The *Ambivalent Consumers* are the profile most educated, with the highest income, considering themselves the most knowledgeable and the most engaged. However, they have the highest level of chemophobia but the second-lowest acceptance level of pesticide-free food products, which seems contradictory. This might suggest prudence, wariness, or general uncertainty, especially intensified by media reporting. Overall, however, this result opens avenues for future research.

A limitation of our study is that the stated WTPs are hypothetical and do not necessarily reflect consumer behaviour in real choice scenarios. There is always a bias between a hypothetical and a non-hypothetical study, but it cannot be assessed how large the difference is. Furthermore, it should be considered that our results refer to the German population. It cannot be ruled out that the results may be different in other countries, as the pesticide issue may have different importance in other countries, and thus consumer acceptance and WTP of pesticide-free animal products may not be comparable with German results, pointing to further avenues for future research. Beyond, another limitation of our results is that our questionnaire addressed three specific animal food products, milk, butter, and cheese. It cannot be assumed that our results can be related to all foods, whether animal or plant, or to, say highly processed pesticide-free products. Future research can address a broader pool of products to be able to draw direct comparisons within one study.

Future research should further consider how products should and could be positioned in the market to strengthen positive consumer perceptions of pesticide-free food. The design of packaging and communications strategies (e.g., pesticide-free labels) should be analysed. In this context, the "Zero Pesticide Residue" label, created in 2018 by a collective of farmers in France, could provide useful experience and knowledge applicable to further actions in Germany. In general, it could be assumed that credibility in pesticide-free certification could be better achieved than it would be, for example, with a reduction strategy or organic farming, due to fewer regulations and thus easier controllability (Zheng et al., 2022). However, e.g., the study by Kaczorowska et al. (2021) shows that the increasing number of sustainability certifications leads to information overload. This leads to insufficient consumer trust in sustainability certification and opens avenues for future research (Rupprecht et al., 2020; Kaczorowska et al., 2021). Supplementary, framing studies exploring the effect that the same content information is received differently by the recipient depending on how it is formulated or linked to see how these influence the behaviour of consumers can help to evaluate the impact of diverse communication policies on consumer acceptance of and buying intention for pesticide-free food products.

6. Conclusion

New farming concepts that renunciate the use of pesticides yet still use mineral fertilizer could drive the sustainability transformation forward. But first, a better understanding of potential target groups for this new farming concept is necessary to identify consumers who will value and purchase products resulting from it and it is also crucial for the success of this new farming concept. We found a potential target group of buyers for products from the new farming concept. Approximately 22.9% of German consumers, the *Prospective Consumers*, are willing to try and consume pesticide-free food products and have a high level of acceptance for dairy products made this way.

The target group of *Prospective Consumers* is differentiated by significantly greater proportion of females, older respondents and greater awareness of pesticide residues in food products and possible impacts on the environment and human health. Similarly, they tend to be concerned about impacts of pesticide use in food production on the environment as well as on human health. Further, they consider pesticide-free, but non-organic food products as higher quality, better for the environment and more valuable. Thus, they associate those products with beneficial characteristics and have a high acceptance level. In this line, the *Prospective Consumers* are willing to pay a premium price for the products studied: 31% more compared to conventional dairy for pesticide-free milk, 23% more for pesticide-free cheese, and 24% more for pesticide-free butter.

In conclusion, to create effective marketing strategies to differentiate products from conventional and organic food products, a labelling system must be developed in the middle segment. This can be either initiated within the private sector or by policy makers. Another option would be to establish a sustainability covering several aspects: besides pesticide-free also animal welfare, nutritional value and LCAs. Credibility through independent certification should be achieved with less effort since a complete renunciation of pesticides is easier to control than, for example, a reduction strategy. Whether consumers basically trust a pesticide-free farming system and whether they show an understanding of another new sustainability label are essential aspects to gain opinion leaders' support and acceptance in broad society. In this regard, the success of the "Zero Pesticide Residue" label, which was created by collective of farmers in 2018 in France, will be of interest.

Finally, this farming system can only be established if farmers' production costs are covered. Our results show that a higher willingness to pay for these products exists. However, non-hypothetical willingness to pay should be determined when the farming system is fully mature

and costs along the value chain can be better estimated. In the future, consumers' willingness to pay, and thus the financial incentive for farmers, will have a significant impact on the success of this farming system.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.spc.2023.10.005.

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Teil II: Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion

II.2 Consumer Acceptance of Pesticide-Free Dairy Products in Germany: A Partial Least Square Model

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Abstract

A key challenge in this century is to ensure safe food for a growing global population while limiting environmental impacts and addressing climate change. Although pesticides ensure high yields, there are downsides to their intensive use, including negative effects on the environment, such as water, soil, and air contamination, as well as on biodiversity. To promote a sustainability transition, innovative farming systems that do not require the use of pesticides yet are non-organic can be part of the solution. To explore the attitudes toward a pesticide- free, but non-organic farming system, we examined attitudes and factors that drive German consumers to accept pesticide-free food products, using an online questionnaire to survey 1,010 German consumers. A range of hypotheses were evaluated to determine the factors that influence consumer decisions. Partial least squares structural equation modelling (PLS-SEM) served to assess consumer attitudes and acceptance of pesticide-free milk, butter, and cheese. The study results show that attitudes and acceptance for pesticide-free food products are driven by health consciousness, chemophobia, and perceived consumer effectiveness; they are inhibited by price sensitivity. We find attitudes towards pesticide-free food products to positively moderate the effect of health consciousness, while chemophobic attitudes and perceived consumer effectiveness positively moderate acceptance of pesticide-free food products. Our findings can support researchers, food industry professionals, and regulatory leaders seeking scalable pesticide-free agricultural production methods.

Keywords: Consumer Acceptance, Structural Equation Modelling, Pesticide-Free Farming, Pesticide Residues

1. Introduction

Agricultural systems are significantly linked with a number of sustainability challenges, such as biodiversity loss, climate change, and the provision of safe food for a growing world population (Godfray et al., 2010; Tudi et al., 2021). Ensuring a safe and healthy diet for a growing world population while restricting environmental impact and managing climate change is one of the greatest challenges of this century (Godfray et al., 2010; Mack et al., 2023). Thus, transforming agriculture toward more sustainable, resilient, and at the same time innovative and productive production methods is a crucial policy goal in the UN's Sustainable Development Goals (UN, 2015). In this context, political and social pressure is increasingly pushing for innovative farming systems that do not require the use of pesticides (Zimmermann et al., 2021).

The extensive use of pesticides in agriculture is intended to help safeguard yields and improve product quality (Popp et al., 2012). Their most important contribution is to prevent crop losses and thus significantly increase global food supply (Hedlund et al., 2019). However, many studies have highlighted the negative effects of pesticides on the environment, such as water, soil, and air contamination, as well as on biodiversity (Rockström et al., 2009; Sánchez-Bayo and Wyckhuys, 2019; Pelosi et al., 2021). Köhler and Triebskorn (2013) highlighted excessive pesticide use as a serious barrier to agricultural sustainability.

Beyond its environmental effects, pesticide use has come under consumer scrutiny. There have been previous investigations of consumer concerns regarding pesticide residues in foods (Koch et al., 2017; Nitzko et al., 2022; Simoglou and Roditakis 2022). Overall, these studies show that consumers view pesticide residues as a major threat to their own health and perceive products produced without the use of pesticides as healthier and safer. In this line, several studies indicate major health risks associated with pesticide residues in foods, including the risk of cancer, birth defects, neurological disorders, asthma, and damage to genetic information (Clementi et al., 2008; Baldi et al., 2010; Wickerham et al., 2012). Further, media re- ports on pesticide residues in food increase consumer concern (Koch et al., 2017). Lamichhane et al. (2016) shows that the majority of consumers assume any level of pesticide residue is a significant health risk, regardless of how it compares to the established legal maximum residue level.

One could note that we already have a farming system working without chemical pesticides: organic production. However, several studies report that a globally sufficient food supply in the future from organic farming alone is questionable (Badgley et al., 2007; Muller et al., 2017; Meemken and Qaim, 2018; Joshi and Piya, 2021). Further push for the development of sustainable solutions and innovations in farming systems comes from increasing restrictions on the approval and use of the active ingredients in pesticides, as well as rising pest resistance to current formulas (Zimmermann et al., 2021).

Out of this need, a new agricultural production system was developed. This new farming concept distinguishes itself from existing systems by the renunciation of the standard chemical crop protection used in conventional agriculture (Zimmermann et al., 2021). But the use of mineral fertilizers is not renounced as in organic farming (Möhring and Finger, 2022). Renouncing the use of pesticides while making targeted use of mineral fertilizers, this approach represents a reorientation in arable farming. However, although the system has already been introduced in public and private programs in Europe, it is not yet a regulated and established system. Thus, according to Finger (2024) a harmonized definition of what “pesticide-free” exactly means is still a key challenge and requires clear regulation both at a national and international level.

Researchers highlight various advantages of this system: guaranteeing quantitatively and qualitatively sufficient and affordable food; environmentally and nature-friendly production methods; increased ecosystem services; preservation of agricultural landscapes; protection of biodiversity; prevention of pesticide residues in food; and lower adoption hurdles than organic farming for farmers (Zimmermann et al., 2021; Finger and Möhring, 2022; Jacquet et al., 2022). This pesticide-free farming system can be located between conventional and organic farming systems and offer consumers the opportunity to adapt their eating and shopping habits in the interests of sustainability.

Although this pesticide-free farming concept promises an agricultural production system, one that contributes to several sustainability goals and could significantly drive sustainability transformation, assessing consumer acceptance of the food produced presents an economically important challenge. Whether and to what extent untapped market potential can be developed for these products depends on their acceptance by consumers. Extensive consumer rejection of the new farming system would both undermine its market launch and deny the sustainability transformation an important ally. Therefore, understanding consumer perceptions and attitudes regarding food produced by this new system is of great interest (Zimmermann et al., 2021).

What do we know so far about consumer acceptance of pesticide-free food products? Previous research has determined consumer interest in disseminating information regarding pesticide residues via social media (Rutsaert et al., 2013), to assess how chemophobia affects consumer acceptance of pesticide use (Saleh et al., 2021), to capture public risk perceptions and level of knowledge of pesticide use (Koch et al., 2017; Nitzko et al., 2022), to determine consumer willingness-to-pay (WTP) for pesticide-free vegetables (Magnusson and Cranfield, 2005; Haghiri and McNamara, 2007; Bazoche et al., 2014; Edenbrandt et al., 2017; Nandi et al., 2017; Khan et al., 2018; Cai et al., 2019; Wang et al., 2022), and to investigate consumer preferences for pesticide-free product attributes (Yiridoe et al., 2005; Grebitus et al., 2018; Farías, 2020; Diaz-Siefer et al., 2022; Gatti et al., 2022) as well as consumer segmentation (Wendt and Weinrich, 2023). Most studies have primarily focused on consumer acceptance of pesticide-free fruits and vegetables, but not on animal-based products. Thus, we focused on animal products (milk, butter and cheese) where the animal was fed with pesticide-free feed.

However, factors influencing consumer acceptance of pesticide-free animal food products have not yet been the focus of consumer research. Thus, this study focuses on German con- sumer attitudes and acceptance of pesticide-free, but non-organic animal food products (milk, butter, and cheese) using a maximal representative sample of the German population. This study contributes to the existing literature by providing new evidence of consumer readiness for a cleaner

agricultural production system. Using a partial least squares structural equation modelling (PLS-SEM) approach, we address the following research question:

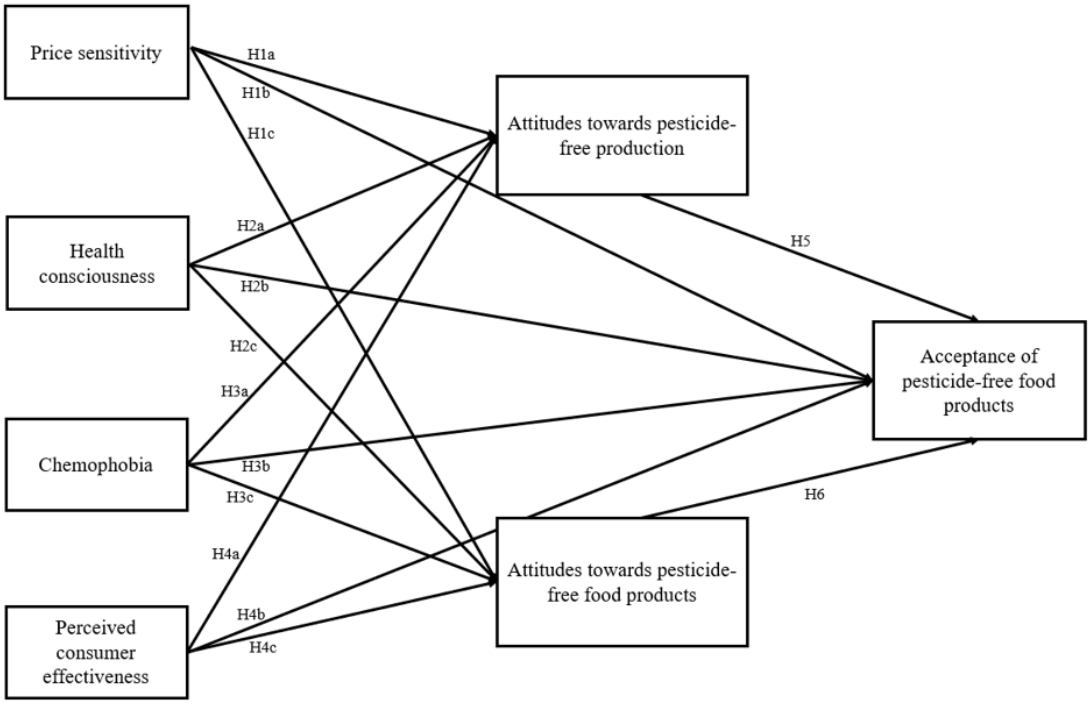
Which factors influence German consumer attitudes and acceptance of pesticide-free, but non-organic animal food products?

The paper is structured as follows: in the next section, we develop hypotheses from a literature review followed by a description of material and methods used to conduct the PLS-SEM study. We then present our statistical results, followed by a discussion of our findings, limitations, and scope for further research. We close the paper with our main conclusions. Our findings are of particular interest for policy makers, professionals in marketing management, and product developers to lever moving the sustainable transition in agricultural production.

2. Literature Review and Hypotheses Development

The present study aims to understand consumer attitudes and acceptance of pesticide-free animal food products.

To assess consumer attitudes and acceptance of pesticide-free food products, influencing factors have to be identified. From the literature, we derived four factors: *price sensitivity*, *health consciousness*, *chemophobia* and *perceived consumer effectiveness.*



Moderating effects:
H7a: Price sensitivity → Attitudes towards pesticide-free production → Acceptance of pesticide-free food products
H7b: Health consciousness → Attitudes towards pesticide-free production → Acceptance of pesticide-free food products
H7c: Chemophobia → Attitudes towards pesticide-free production → Acceptance of pesticide-free food products
H7d: Perceived consumer effectiveness→ Attitudes towards pesticide-free production → Acceptance of pesticide-free food products
H7e: Price sensitivity → Attitudes towards pesticide-free food products → Acceptance of pesticide-free food products
H7f: Health consciousness → Attitudes towards pesticide-free food products → Acceptance of pesticide-free food products
H7g: Chemophobia → Attitudes towards pesticide-free food products → Acceptance of pesticide-free food products
H7h: Perceived consumer effectiveness → Attitudes towards pesticide-free food products → Acceptance of pesticide-free food products

Figure 1. Research model
Source: own figure.

Price Sensitivity

Price sensitivity reflects the extent to which consumer purchasing behaviour can be influenced by changes in the price levels of products (Goldsmith and Newell, 1997; Al-Mamun et al., 2014). According to Han et al. (2001) and Ghali-Zinoubi and Toukabri (2019), consumers with a high price sensitivity primarily consider price when making purchasing decisions. They tend not to buy organic foods, as they are usually more expensive (Ghali-Zinoubi and Toukabri, 2019), and they will respond strongly to price changes. In turn, consumers with little price sensitivity respond weakly to price changes; for these price-insensitive consumers, price tends not to play the primary role in a purchasing decision (Wang et al., 2020). Consumers with low price sensitivity incorporate non-price factors such as food safety and quality into their purchase decisions. Thus, price-insensitive consumers purchase more green products, e.g., organic foods, as they tend to ignore the price premium and adopt a more intentional attitude toward the products themselves (Wang et al., 2020). Accordingly, we established the following hypotheses:

H1a: Higher price sensitivity influences consumer attitudes towards pesticide-free production negatively.

H1b: Higher price sensitivity influences the acceptance of pesticide-free food products negatively.

H1c: Higher price sensitivity influences consumer attitudes towards pesticide-free food products negatively.

Health Consciousness

In recent years, consumers have become more concerned about food-related health issues and more involved in actions to preserve their health and wellbeing (Michaelidou and Hassan, 2010). As a result, many consumers have chosen organic food to avoid healthy issues related to pesticide residues (Koch et al., 2017; Wang et al., 2022; Parashar et al., 2023). In this context, health consciousness has proven to be a significant motive for the consumption of pesticide-free food products (Khan et al., 2018; Gundala and Singh, 2021; Parashar et al., 2023). Health consciousness refers to consumer concern about health issues as well as to consumer efforts to safeguard health (Chen, 2009; Pham et al., 2019). Recently, Farías (2020) and Gatti et al. (2022) have produced evidence that consumers are looking for pesticide-free properties in the foods they buy. This aligns with studies indicating that consumers value pesticide-free food products as healthier because of the absence of chemicals (Yiridoe et al., 2005; Farías, 2020). Consumers with a higher level of health consciousness thus are more likely to maintain a healthy lifestyle and more likely to purchase pesticide-free products (Khan et al., 2018; Gundala and Singh, 2021; Parashar et al., 2023), leading to the following hypotheses:

H2a: Higher health consciousness influences consumer attitudes towards pesticide-free food production positively.

H2b: Higher health consciousness influences the acceptance of pesticide-free food products positively.

H2c: Higher health consciousness influences consumer attitudes towards pesticide-free food products positively.

Chemophobia

The use of chemicals in food production has increasingly been met with public criticism and rejection (Jansen et al., 2020). A strong consumer demand for natural foods has resulted (Saleh et al. 2021). Recent studies have highlighted the absence of pesticides as one of the most important drivers for the purchase of organic foods (Gundala et al., 2021; Zheng et al., 2022). Gundala et al. (2021) state that consumers associate the absence of pesticides in foods with multiple benefits both to the environment and human health, and they consider pesticide-free

products to be more reliable and more natural. Some people be prone to be excessively concerned about the risks associated with chemicals, believing that those cause harm in any concentration. The literature terms this *chemophobia* (Bearth et al., 2019; Saleh et al., 2019; Chalupa and Nesměrák, 2020). Chemophobics, who fear chemicals and avoid contact with them, would likely both favor pesticide-free food products and support banning chemicals in food production. Saleh et al. (2021) showed that chemophobia affects consumer acceptance of pesticide use and predicts the purchase of pesticide-free food products. Based on this, we propose the following hypotheses:

H3a: Higher chemophobia influences consumer attitudes towards pesticide-free food production positively.

H3b: Higher chemophobia influences the acceptance of pesticide-free food products positively.

H3c: Higher chemophobia influences consumer attitudes towards pesticide-free food products positively.

Perceived Consumer Effectiveness

Consumers have increasingly gained awareness of environmental challenges and the motivation to address these problems through environmentally friendly behaviour (Kim and Lee, 2023). The extent to which a consumer thinks that their activities will contribute to tackle an environmental issue can be interpreted as perceived consumer effectiveness (Tan, 2011). Tan (2011) indicated perceived consumer effectiveness to be an important determinant in understanding environmentally friendly behaviour. Perceived consumer effectiveness has also been marked as a significant factor in predicting purchase intention towards sustainable products. It has been detected to be linked directly to attitudes and consumer acceptance of green foods (Sharma and Dayal, 2017; Sharma and Foropon, 2019), and to correlate positively with green purchase intention and behaviour (D'Astous and Legendre, 2008; Gleim et al., 2013). Vermeir and Verbeke (2006) found the higher the perceived consumer effectiveness, the stronger the intention to buy sustainable products. These considerations lead to the following hypotheses:

H4a: Higher perceived consumer effectiveness influences consumer attitudes towards pesticide-free food production positively.

H4b: Higher perceived consumer effectiveness influences the acceptance of pesticide-free food products positively.

H4c: Higher perceived consumer effectiveness influences consumer attitudes towards pesticide-free food products positively.

Attitudes Towards Pesticide-Free Food Production

Studies show that consumers often describe the use of pesticides in food production as unnatural, unsafe, and problematic for human health and the environment. In turn, farming systems that avoid the use of pesticides evoke significantly more positive associations among consumers. Thus, consumers perceive pesticide-free food production as a system which offers food safety, naturalness, and environmental-friendliness (Koch et al., 2017; Simoglou and Roditakis, 2022; Ssemugabo et al., 2023). This leads us to the following hypothesis:

H5: Positive consumer attitudes towards pesticide-free production positively influence acceptance of pesticide-free food products.

Attitudes Towards Pesticide-Free Food Products

Studies have shown that consumer attitudes towards pesticide-free food products are linked to consumer purchase decisions. Farías (2020) highlighted that consumers who are convinced of the environmentally friendly properties of pesticide-free food products and who attribute a higher quality and value to these products indicate a higher purchase intention for pesticide-free food products. Additionally, results indicate that consumers interpret pesticide-free to mean safer, healthier, and less harmful. These positive consumer perceptions lead to a higher purchase intention for pesticide-free food products (Farías, 2020; Sapbamrer and Chittrakul, 2022), which leads to the following hypothesis:

H6: Positive consumer attitudes towards pesticide-free food products positively influence acceptance of pesticide-free food products.

Moderating Factors

This study also proposes attitudes towards pesticide-free production and attitudes towards pesticide-free food products serve as moderators of the relationships between acceptance of pesticide-free food products, and the four variables, *price sensitivity, health consciousness, chemophobia, and perceived consumer effectiveness.* Therefore, the following hypotheses are formulated to test if *attitudes towards pesticide-free production* and *attitudes towards pesticide-free food products* have moderating effects on *acceptance of pesticide-free food products*:

H7a: Positive attitudes towards pesticide-free production moderates the relationship between price sensitivity and acceptance of pesticide-free food products positively.

H7b: Positive attitudes towards pesticide-free production moderates the relationship between health consciousness and acceptance of pesticide-free food products positively.

H7c: Positive attitudes towards pesticide-free production moderates the relationship between chemophobia and acceptance of pesticide-free food products positively.

H7d: Positive attitudes towards pesticide-free production moderates the relationship between perceived consumer effectiveness and acceptance of pesticide-free food products positively.

H7e: Positive attitudes towards pesticide-free foods moderates the relationship between price sensitivity and acceptance of pesticide-free food products positively.

H7f: Positive attitudes towards pesticide-free foods moderates the relationship between health consciousness and acceptance of pesticide-free food products positively.

H7g: Positive attitudes towards pesticide-free food products moderates the relationship between chemophobia and acceptance of pesticide-free food products positively.

H7h: Positive attitudes towards pesticide-free food products moderates the relationship between perceived consumer effectiveness and acceptance of pesticide-free food products positively.

3. Material and Methods

As described below, we conducted an online-based questionnaire of German consumers to explore which factors influence consumer attitudes and acceptance of pesticide-free, but non-organic animal food products.

3.1. Data Collection and Sample

The data collection was administered via a professional online-panel provider in June 2022. According to the distribution of the German population (Federal Statistical Office, 2023), we set quotas for age, gender, household net income, education and German Federal State residency. Further, to ensure the quality of the data, we removed participants with implausible answers (n=1) and those, who always selected the same response category (i.e., “speedliners”) (n=10). The final sample consists of 1,010 Germans respondents. The sample consisted of participants between 18 and 82, of whom 49.7% were male. The average age of the sample was 49. The sociodemographic characteristics can be taken as a maximum representative sample of the German population in terms of age, gender, and region. Thus, this sample allows conclusions to be drawn for the German population. In terms of education and income, participants in our sample had a higher level of secondary and A-level education and a lower net household income compared to the German average (Federal Statistical Office, 2023). According to Kock and Hadaya (2018), we used the suggested inverse square root method to calculate the minimum sample size in PLS path modelling. We assumed a minimum path coefficient level of 0.1, a level of significance of 0.05 and a statistical power of 0.80. This equals a minimum sample size of 618. Having explorative research, we decided to oversample. However, we received path coefficients below 0.1. Thus, the robustness for those paths is limited.

The survey (compare supplementary material)[4] was approved by a data protection officer and was ethically authorized by the ethics committee of the University of Hohenheim. The questionnaire was structured into several sections to separate the sociodemographic variables of age, gender, region, monthly net income, education level, number of household members, and number of children (Federal Statistic Office, 2023). Consumer attitudes towards pesticide-free food products and pesticide-free food production (modified from Voss, 2008; Bruner, 2017), and acceptance of pesticide-free food products (modified from Hocquette et al., 2016; Wilks and Phillips, 2017) were assessed. Further, statements were collected to characterize price sensitivity (Gil and Soler, 2006), environmental awareness (Kim and Choi, 2005; Wesley et al., 2012), health consciousness (Michaelidou and Hassan, 2008), relevance of product information (Grunert et al., 1993) and chemophobia (Saleh et al., 2021).

3.2. Measures

For our statistical analysis, we derived seven measurement scales from the literature as described below[5].

Price sensitivity: Adopted from Gil and Soler (2006), the scale to measure price sensitivity consisted of three items. The five-point Likert scale ranged from 1 (strongly disagree) to 5 (strongly agree).

Health consciousness: The study measured health attitudes using five items adopted from Michaelidou and Hassan (2008) on a five-point Likert scale (strongly disagree (1) to strongly agree (5)).

Chemophobia: Adopted from Saleh et al. (2021), a six-item scale was used to measure chemophobia. Respondents completed the measure using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5).

Perceived consumer effectiveness: The study measured self-efficacy using six items adopted from Kim and Choi (2005) and Wesley et al. (2012) on a five-point Likert scale (strongly disagree (1) to strongly agree (5)).

Attitudes towards pesticide-free production: Nine items to measure attitudes towards pesticide-free production were modified from Voss (2008) and presented using a bipolar response scale with five scale points.

Attitudes towards pesticide-free food products: Attitudes towards pesticide-free food products were measured using six items modified from Bruner (2017) and presented on five-point Likert scales ranging from strongly disagree (1) to strongly agree (5).

Acceptance of pesticide-free food products: Acceptance of pesticide-free food products was measured using 15 items modified from Hocquette et al. (2016) and Wilks and Phillips (2017).

[4] https://zenodo.org/doi/10.5281/zenodo.11382983
[5] The addition "modified" means that we have modified this scale so that it refers to "pesticide-free food products".

Respondents completed the measure using five-point Likert scales (strongly disagree (1) to strongly agree (5)).

The description of the full scales can be found in Appendix A.

4. Statistical Results

Partial least squares structural equation modelling (PLS-SEM) is appropriate for explorative research and hypothesis testing, and it is especially suitable for non-normal distributed data (Hair et al., 2022). Thus, for the statistical analysis, we used the PLS-SEM software SmartPLS4 (Ringle et al., 2022). The analysis consisted of two steps (Hair et al., 2011): first, the assessment of the reliability and validity of the measurement model (outer model, described in section 4.1) and second, the assessment of the structural model's fit (inner model, described in section 4.2). The model is reflective.

4.1. Measurement Model

First, we carried out explorative factor analyses to identify all relevant items for the respective latent variable which are shown in Figure 1. All items with an outer loading of less than 0.4 were removed from the model to avoid double loadings, except cheese with an outer loading of 0.398. Cheese was kept, first because 0.398 is close to 0.4, but primarily for consistency: The respective items for milk and butter were above the threshold and thus included. All other variables were above the threshold of 0.7 (one item each for *acceptance of pesticide-free food products*, *health consciousness* and *chemophobia*) (Hair et al., 2022). Reliability tests showed that removing these items did not improve internal consistency reliability. Thus, we included these items in the analysis.

We applied Cronbach's Alpha (CA) and composite reliability (CR) to test for internal consistency reliability. All constructs are above the threshold for both reliability factors (>=0.7) (Hair et al. 2022). Further, the Average Variance Extracted (AVE) also meets the threshold of 0.5 for all constructs as recommended by Hair et al. (2022). Table 1 shows the results of internal reliability and validity tests for all constructs.

Table 1. Internal reliability and validity

Construct	Number of items	Cronbach's Alpha (CA) (>=0.7)	Composite Reliability (CR) (>=0.7)	Average Variance Extracted (AVE) (>=0.5)
Acceptance of pesticide-free food products (ACC)	15	0.952	0.958	0.631
Attitudes towards pesticide-free production (APFP)	9	0.937	0.948	0.669
Attitudes towards pesticide-free food products (APFF)	6	0.933	0.935	0.751
Perceived consumer effectiveness (PCE)	6	0.917	0.948	0.707
Chemophobia (C)	6	0.863	0.896	0.591
Health consciousness (HC)	5	0.855	0.898	0.640
Price sensitivity (PS)	3	0.847	0.924	0.859

Source: own calculations

Discriminant validity was assessed by the Fornell-Larcker criterion, the Heterotrait-Monotrait ratio of correlations (HTMT) criterion, and cross-loadings. Table 2 shows the results. All assigned variables should explain the variance better than any other latent variables (Fornell and Larcker, 1981). Table 2 reveals that this criterion is met. Henseler et al. (2015) further recommend for the PLS-SEM-based discriminant validity assessment the HTMT criterion. As our HTMT value is below the 0.9 threshold, discriminant validity has been established. Further, we assessed multicollinearity by applying VIF values. All values are below the threshold of 5 (Hair et al., 2022). So, there is no hint for collinearity.

Further, each indicator's loading on its assigned latent variable should be higher than on any other latent variables. The results show there are no cross loadings (data available on request). Thus, the results for the three criteria supports discriminant validity.

Table 2. Discriminant validity (Fornell-Larcker criterion & HTMT matrix)

Construct	*ACC*	*APFP*	*APFF*	*PCE*	*C*	*HC*	*PS*
ACC		0.538	0.714	0.597	0.399	0.481	0.084
APFP			0.580	0.426	0.160	0.220	0.045
APFF				0.656	0.376	0.434	0.043
PCE					0.468	0.537	0.063
C						0.556	0.034
HC							0.092
PS							

Source: own calculations

4.2. Structural Model

We found an adjusted R-squared of 0.534 for *ACC.* This means that 53.4% of the latent variables' variance is explained moderately by the assigned items (Hair et al., 2011). For *APFF* we found adjusted R^2 to be 0.388 and for *APFP* we found 0.162. For f-square, we found a moderate effect for *APFF* on *ACC* (0.175) and a moderate effect for *PCE* on *APFP* (0.143) and a large effect on *APFF* (0.332) (Cohen, 1988). All other effect sizes were smaller. For predictive power, we applied CVPAT following Hair et al. (2022). The IA benchmark provided by PLSpredict (Shmueli et al., 2016, 2019) showed significantly negative average losses and thus indicates predictive power.

We assessed the inner model (structural model) by applying a bootstrapping routine with 5,000 subsamples, a two-tailed testing type and a significance level of 0.05. Table 3 provides the results of the direct effects and Table 4 displays the results for the moderating effects.

Table 3. Structural model (direct effects)

Hypothesis	Direct effect	Beta	Confidence intervals bias corrected	Standard deviation	t-value	P value	Decision
H1a	*PS -> APFP*	0.052	[-0.012, 0.114]	0.033	1.599	0.110	Unsupported
H1b	***PS -> ACC***	**-0.045**	[-0.085, 0.001]	**0.022**	**2.046**	**0.041**	**Supported**
H1c	*PS -> APFF*	-0.005	[-0.056, 0.044]	0.026	0.194	0.846	Unsupported
H2a	*HC -> APFP*	0.023	[-0.044, 0.089]	0.034	0.669	0.503	Unsupported
H2b	***HC -> ACC***	**0.140**	[0.084, 0.193]	**0.028**	**4.957**	**0.000**	**Supported**
H2c	***HC -> APFF***	**0.097**	[0.035, 0.156]	**0.032**	**3.063**	**0.002**	**Supported**
H3a	*C -> APFP*	-0.032	[-0.099, 0.034]	0.034	0.953	0.340	Unsupported
H3b	***C -> ACC***	**0.083**	[0.031, 0.140]	**0.028**	**2.937**	**0.003**	**Supported**
H3c	***C -> APFF***	**0.077**	[0.019, 0.135]	**0.030**	**2.595**	**0.009**	**Supported**
H4a	***PCE -> APFP***	**0.408**	[0.338, 0.474]	**0.034**	**11.859**	**0.000**	**Supported**
H4b	***PCE -> ACC***	**0.145**	[0.075, 0.218]	**0.036**	**3.995**	**0.000**	**Supported**
H4c	***PCE -> APFF***	**0.531**	[0.464, 0.594]	**0.034**	**15.809**	**0.000**	**Supported**
H5	***APFP -> ACC***	**0.195**	[0.132, 0.274]	**0.036**	**5.474**	**0.000**	**Supported**
H6	***APFF -> ACC***	**0.396**	[0.316, 0.473]	**0.040**	**9.972**	**0.000**	**Supported**

Source: own calculations

Ten out of our fourteen hypotheses are supported by our statistical analyses. These are marked 'Supported' in Table 3. Further, in Figure 2, we provide the significant results in a graphical presentation.

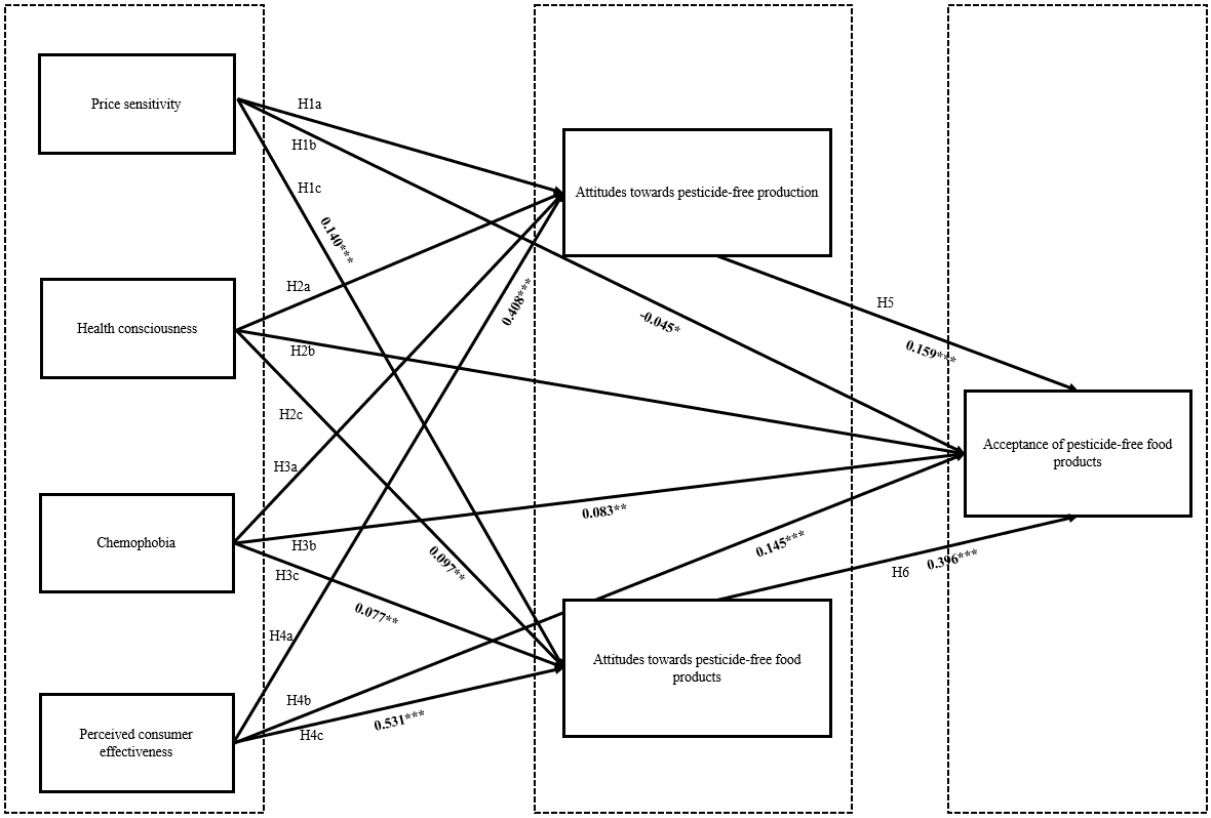


Figure 2. Statistical results
Source: own calculations

Price Sensitivity seems to have a statistically significant influence on *ACC* (beta = -0.045) but influences neither *Attitude*. Thus, if *PS* increases by one unit of standard deviation, *ACC* will decrease, ceteris paribus, by 0.045 units of standard deviation. This means that the more price sensitive respondents are, the weaker their *ACC* for pesticide-free milk, cheese, and butter.

A positive attitude towards *Health Consciousness* positively influences the *ACC* (beta = 0.140) as well as the *APFF* (beta = 0.097) although the influence of *HC* is stronger on *ACC* than on *APFF*. Furthermore, *Chemophobia* shows the same statistically significant positive influence on *ACC* (beta = 0.083) and *APFF* (beta = 0.077) although the influence is weaker than *HC's*. This means that the more chemophobic a person is, the greater effect the phobia has on *ACC* and *APFF*.

Of all the latent variables, *PCE* shows the highest beta coefficients for its influence on *APFP* (0.408), *APFF* (beta = 0.531) and *ACC* (beta = 0.145).

Further, *APFP* and *APFF* both positively influence the *ACC* for pesticide-free produced milk, butter, and cheese (beta = 0.195 and beta = 0.396 respectively).

Table 4. Structural model (specific indirect effects)

Hypo-thesis	Moderating effects	Beta	Standard deviation	t-value	P value	Decision
H7a	*PS -> APFP -> ACC*	0.010	0.007	1.498	0.134	Unsupported
H7b	*HC -> APFP -> ACC*	0.004	0.007	0.658	0.511	Unsupported
H7c	*C -> APFP -> ACC*	-0.006	0.007	0.927	0.354	Unsupported
H7d	***PCE -> APFP -> ACC***	**0.080**	**0.016**	**4.964**	**0.000**	**Supported**
H7e	*PS -> APFF -> ACC*	-0.002	0.010	0.193	0.847	Unsupported
H7f	***HC -> APFF -> ACC***	**0.039**	**0.013**	**2.885**	**0.004**	**Supported**
H7g	***C -> APFF -> ACC***	**0.031**	**0.013**	**2.438**	**0.015**	**Supported**
H7h	***PCE -> APFF -> ACC***	**0.210**	**0.025**	**8.372**	**0.000**	**Supported**

Source: own calculations.

We found statistically significant support for four of the eight moderation paths. Thus, hypotheses H7d ($p<0.001$), H7f ($p<0.01$) as well as H7g ($p<0.05$) and H7h ($p<0.001$) are supported. Of the latent variables, *PCE* shows the strongest moderation effect, with its influence on *ACC* being statistically significant strengthened by both *APFP* and *APFF*. The stronger the *PCE*, the stronger is the moderation effect of *APFP* and also *APFF* on *ACC*. We further found *APFF* to be a moderator for the effect of *C* and *HC* towards *ACC*. Thus, the influence on *ACC* of *HC* and *C* is stronger the more *APFF* is pronounced. However, we highlight that all moderation effects are very small.

5. Discussion

To assess consumer acceptance of an innovative agricultural system that offers pesticide-free production while retaining non-organic fertilizer use, we conducted an online-based survey with 1,010 German consumers. We tested fourteen hypotheses to assess the direct effects of the variables on *ACC*, as well as eight hypotheses to assess the moderating effects.

In terms of the direct effects, we found support for ten of the fourteen hypotheses. H1b, hypothesizing an influence of *PS* on *ACC*, was supported, in agreement with prior findings (Wang et al., 2020). Results in our study highlighted that *PS* has a significant negative effect on *ACC*, meaning the more price-sensitive consumers are, the weaker the *ACC*. As pesticide-free products are expected to be more expensive than conventional ones, these products will be more attractive to the less price sensitive consumer for whom non-price factors such as the absence of pesticides and food safety are primary considerations in purchase decisions. Similarly, Ghali-Zinoubi and Toukabri (2019) reported that the stronger the *PS*, the more likely price-sensitive consumers would not buy pesticide-free food products and would reject the entire concept along with it products. Due to this fact, it is surprising that price sensitivity showed no effect on either attitude (H1a and H1c). We suspect that the participants were not yet fully aware of the pesti-

cide-free farming concept. If these products were to come onto the market, a study could investigate this influence again once awareness and knowledge of this farming system has been raised.

Similarly, health consciousness did not influence attitudes toward food production (H2a). This could also be due to the participants' lack of judgment about the new farming system. *HC* did positively influence attitudes toward food products, however (H2c). And *HC* influenced *ACC*, as hypothesized (H2b), and in agreement with prior findings (Khan et al., 2018; Gundala and Singh, 2021; Parashar et al., 2023). Indeed, our results reveal a strong positive direct effect of *HC* on *ACC*. These findings imply that health consciousness motivates consumers to make purchase decisions to avoid pesticide residues. These consumers would likely be open to buying pesticide-free products. Professionals in the food industry as well as marketing managers creating labelling systems and marketing strategies for pesticide-free food products should consider the effect of health claims on the product's primary display panel. The influence of *HC* on *APFF* is consistent with findings from Parashar et al. (2023) showing that health-conscious consumers tend to pay more attention to products with pesticide-free characteristics. Messaging that links pesticide-free to health-promoting will likely be effective.

Further, although its influence is weaker than *HC's*, chemophobia *C* has a statistically significant, but small, positive direct influence on both *ACC* (H3b) and *APFF* (H3c). This means that the more chemophobic a person is, the stronger the *ACC* and the *APFF*. These influences are probably the outcome of the fact that consumers with a high fear of chemicals consider pesticide-free food products safer due to the absence of pesticide residues, and this acts as a stimulus for the internal factors represented by *APFF* and the response represented by *ACC*. Our findings are in line with other studies that have linked chemophobia to the acceptance of pesticide-free food products (Saleh et al., 2021). Farías (2020) suggests that policymakers could require producers and retailers to openly communicate the presence or absence of pesticides and specific environmental and consumer health impacts. Future research should investigate the design and perception of pesticide-free labelling on the front of products. Further, as mentioned by Saleh et al. (2021), chemophobic consumers support a ban on the use of chemicals in food production and see many benefits associated with pesticide-free food production. Thus, it is surprising that *C* was found to have no significant direct influence on *APFP* in our study (H3a).

The fourth stimulus variable examined in this study is *perceived consumer effectiveness*, the extent to which consumers believe that their individual actions can make a difference in environmental issues. *PCE* was found to have a statistically significant positive direct influence on *APFP* (H4a) as well as *ACC* (H4b) and *APFF* (H4c). This may be attributed to the fact that

consumers who feel responsible for their impact on the environment will take positive steps to support cleaner methods of production, which will then influence their environmental behaviour. In the context of this study, the more individuals believe their actions will contribute to solving an environmental issue, the stronger is their buying intention for pesticide-free food products. Consumers with a strong *PCE* tend to focus more on environmental protection than those who perceive their actions as inconsequential, which results in a preference for and a high rate of adoption of green foods. Our findings are in line with previous findings by Vermeir and Verbeke (2006 and 2008), who reported that *PCE* is an important determinant to explain *ACC* and attitudes towards green foods.

In addition, results show that *APFP* and *APFF* have a statistically significant positive direct influence on *ACC* for pesticide-free food products (H5 and H6). Previous studies (Farías 2020; Wang et al., 2022) have indicated that consumers make a number of positive associations to pesticide-free food products, two prominent of which are causing less harm to human health and the environment. This leads to a greater acceptance of pesticide-free food products. Interestingly, we find the effect of *APFF* on *ACC* is stronger than that of *APFP*. This might be due to the fact that most consumers are not familiar with modern intensive livestock production systems and thus have a clearer idea about the products themselves than about the production processes (Clark et al., 2019). However, for a long-term and successful establishment of pesticide-free farm products in the market, it is essential that consumers understand the basic features of the new farming system and can differentiate among conventional, organic, and pesticide-free methods of food production. Thus, when implementing marketing and labelling strategies, strategic marketing planning should also strongly focus on education campaigns for pesticide-free farming.

The study also examined moderation effects, for which four of the eight hypotheses tested can be supported. *APFF* positively moderates three of the four stimulus variables – *HC, C* and *PCE* – towards *ACC* (H7f, H7g, and H7h). However, the moderation effect of *APFF* is the strongest on *PCE* and *ACC*. Further, H7d, proposing a moderation effect of *APFP* on the effect of *PCE* towards *ACC,* was supported, as the results indicate that the influence on *ACC* of *PCE* is stronger the more pronounced *APFP*. In comparison, H7a, H7b, and H7c, proposing the moderating effect of *APFP* on *PS, HC, C* and *ACC,* were not supported. This might be due to a lack of familiarity with modern intensive livestock production systems. Further, *APFF* does not have a moderating effect on *PS* and *ACC* (H7e). This could be due to the fact that for price-sensitive consumers, it is irrelevant how convinced or unconvinced they are about the product, and thus there is no impact on their acceptance of pesticide-free food products.

In sum, the results of this study have shown that *PS*, *HC*, *C*, *PCE*, *APFP*, and *APFF* are all significant predictors of *ACC* in our study. However, the influence of *APFP* and *APFF* on *ACC* are the strongest. Moreover, *PCE* was found to have a strong influence on *APFP*. Further, *HC* and *PCE* were found to have a statistically significant influence on *APFF*. Within the scope of all direct effects, the effect of *PCE* on *APFF* is the strongest. The found statistically significant effects of *HC*, *C* and *PS* on *ACC* were rather small effects (beta coefficients < 0.1).

The study offers important input for policy makers, producers, and marketers of pesticide-free food products. These findings underscore the necessity of a positive basic attitude towards the new farming system for its successful establishment in the food market. In this line, targeted information about the new farming system can have a significant influence on consumers acceptance and offers the possibility that attitudes and consumers acceptance could be changed. Thus, running campaigns should create awareness for recent intense agricultural production systems and more sustainability-oriented production systems. This implies that marketing campaign messages highlight the benefits of pesticide-free food production for human health and for the environment. Likewise, awareness should be raised among the population that each individual can make a significant contribution to solving climate-related challenges by making careful product choices. Highlighting the benefits of pesticide-free food products over conventional as well as organic foods offers the opportunity to educate consumers and trigger acceptance of pesticide-free food products.

Certain limitations of our study should be kept in mind. First, we have used data generated from an online-based questionnaire, which may have been affected by biases, including a social desirability bias. Second, we focused on German consumer attitudes, which may not be generalizable to other countries and contexts. Third, the study focuses on three animal food products (milk, butter, and cheese), and so results cannot be generalized to the totality of products, whether animal, plant, or processed and non-processed foods. Future research can address these questions by iterating our study in various countries and by examining consumer acceptance of a broader range of products. This would help identify potential acceptance differences between different consumer cultures or product groups.

Moreover, further qualitative studies could clarify consumer conceptions, or misconceptions, of the new pesticide-free farming system. Missing or incorrect information could then be remedied through appropriate communication strategies.

Additionally, for marketing strategies for pesticide-free food products to be effective in promoting this new farming concept, they require deeper insights into the effect of product packaging on consumer buying behaviour. These could inform design of packaging for pesticide-free food products and so position these products in the market to evoke positive associations among those consumers who would be likely to avoid pesticide residues in their food.

6. Conclusion

The current use of pesticides in modern agriculture calls for a system change. The intensified application of pesticides puts a heavy burden on the environment, which causes negative effects on water, soil, and air contamination as well as biodiversity (Rockström et al., 2009; Sánchez-Bayo and Wyckhuys, 2019; Pelosi et al., 2021). For an innovative pesticide-free farming system to contribute to the transition to cleaner agricultural production, consumer acceptance of food produced by this system is essential. We assessed consumer attitudes and acceptance using partial least squares structural equation modelling (PLS-SEM) to address the following research question:

Which factors influence German consumer attitudes and acceptance of pesticide-free, but non-organic animal food products?

Analysing influencing factors shows that price sensitivity is an inhibitor of the acceptance of these products. Thus, when planning to introduce pesticide-free food into retail channels, marketing management should concentrate on emphasizing the benefits of the production system for human health and the environment, e.g., by providing information at the point of sale. Positive drivers for the acceptance of pesticide-free foods are health consciousness, chemophobia and perceived consumer effectiveness. Those core drivers should be addressed in communication strategies and incorporated into future consumer research as well as marketing strategies.

Further, it needs to be made clear to consumers by marketing communication tools such as labelling on the products' front display that this is a market segment between conventional and organic farming, such as the planet score does. This multi-level label rates, e.g., use of pesticides and biodiversity. For animal welfare, a product segment between conventional and organic has already been established, which has increased animal welfare. This could also be the future of products for pesticide-free food: being a solid offer on supermarket shelves and relieving the burden that the intensified use of pesticides puts on the environment. Beyond that, the advantages of the production system, highlighted by several researchers, and the products

themselves need to be clear to the consumer. This is also a task for policy: consumers' disconnection from the realities of modern farming leads to less awareness of modern agriculture and, consequently, to less informed decision-making by consumers if they are not aware of the use of pesticides in agriculture.

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Appendix

Appendix A. Scales

Price sensitivity

1. I try to buy food that is on sale.
2. I look out for good deals.
3. I compare the prices of different brands of food.

Health consciousness

1. I take care of my health.
2. I maintain a healthy lifestyle.
3. I value a healthy lifestyle.
4. I think a lot about my health.
5. I notice changes in my health.

Chemophobia

1. I am afraid of chemical substances that I can't even pronounce.
2. Chemical substances scare me.
3. I would like to live in a world where there are no chemicals.
4. The chemical industry is responsible for more and more people getting cancer.
5. In a world without chemicals, there would be no environmental disasters.
6. I do everything I can to avoid contact with chemical substances in my everyday life.

Perceived consumer effectiveness

1. Every consumer can have a positive impact on society by buying environmentally friendly products.
2. Each individual can influence the quality of the environment by choosing products carefully.
3. I can protect the environment by buying products that are environmentally friendly.
4. I feel able to contribute to solving environmental problems by buying environmentally friendly products.
5. I feel able to contribute to solving environmental problems.
6. What I buy as a consumer has an impact on the environmental problems of the country of origin.

Attitudes towards pesticide-free production

1. Healthy – Unhealthy

2. Rural – Industrial
3. Modern – old-fashioned
4. Environmentally friendly – Environmentally unfriendly
5. Close to nature – far from nature
6. Unproblematic – problematic
7. Harmless – questionable
8. Safe – unsafe
9. animal-friendly – not animal-friendly

Attitudes towards pesticide-free food products

1. Milk, cheese, and butter produced without the use of pesticides are good for the environment.
2. Milk, cheese, and butter produced without the use of pesticides can effectively reduce environmental impact.
3. Environmental relief can contribute to an intact ecosystem.
4. Environmental relief would have many benefits, such as the reduction of insect mortality and the relief of water bodies.
5. Milk, cheese, and butter produced without the use of pesticides would make the product more valuable.
6. Milk, cheese, and butter produced without the use of pesticides would I find good.

Acceptance of pesticide-free food products

1. I would buy milk using feed produced without pesticides.
2. I would taste milk using feed produced without pesticides.
3. I would regularly drink milk using feed produced without pesticides.
4. I would recommend milk produced without pesticides to my friends and family.
5. I would prefer milk using feed produced without pesticides if the product is identified by an independent label.
6. I would buy cheese using feed produced without pesticides.
7. I would taste cheese using feed produced without pesticides.
8. I would regularly eat cheese using feed produced without pesticides.
9. I would recommend cheese produced without pesticides to my friends and family.
10. I would prefer cheese using feed produced without pesticides if the product is identified by an independent label.
11. I would buy butter using feed produced without pesticides.
12. I would taste butter using feed produced without pesticides.
13. I would regularly eat butter using feed produced without pesticides.
14. I would recommend butter produced without pesticides to my friends and family.
15. I would prefer butter using feed produced without pesticides if the product is identified by an independent label.

Appendix B. Descriptive Results

Table B.1. Descriptive results for the question “How would you rate your level of knowledge on this topic?” (N = 1010)

Very poor	Rather poor	Neither	Rather good	Very good	$\bar{x}$

9,9 (100)	28,3 (286)	28,6 (289)	27,7 (280)	5,4 (55)	-0,10

Source: own calculations

Table B.2. Descriptive results for the question "How often have you heard, seen or read about pesticide residues in food in the last 12 months?" (N = 1010)

Never	Rarely	Occasionally	Often	Very often	$\bar{x}$
19,3 (195)	28,0 (283)	34,6 (349)	14,5 (146)	3,7 (37)	-0,45

Source: own calculations

Table B.3. Descriptive results for the question "How interested are you personally in the possible risks of pesticide residues in food?" (N = 1010)

Not at all	Less strongly	Undecided	Strongly	Very strongly	$\bar{x}$
5,9 (60)	10,0 (101)	35,1 (355)	34,9 (352)	14,1 (142)	0,41

Source: own calculations

Table B.4. Descriptive results for the question “What is your opinion on the following statements?” (N = 1010)

Statement	Strongly disagree	Disa-gree	Neither agree or disagree	Agree	Strongly agree	I can-not not assess	$\bar{x}$
Pesticides increase ag-ricultural productivity.	2,7 (27)	5,4 (55)	19,3 (195)	32,9 (332)	32,6 (329)	7,1 (72)	0,94
Pesticides are harmless to humans when used properly.	13,6 (137)	18,7 (189)	30,3 (306)	18,1 (183)	10,5 (106)	8,8 (89)	-0,07
Pesticides are harm-less to the environment when used properly.	16,5 (167)	24,7 (249)	25,4 (257)	15,4 (156)	9,4 (95)	8,5 (86)	-0,26
Pesticides are harm-less to insects when used properly.	20,8 (210)	24,6 (248)	23,7 (239)	13,7 (138)	8,2 (83)	9,1 (92)	-0,40
Pesticides are necessary for the production of food.	15,6 (158)	19,5 (197)	32,1 (324)	15,1 (153)	8,8 (89)	8,8 (89)	-0,20

Source: own calculations

Table B.5. Descriptive results for the question “What is your opinion on the following statements?” (N = 1010). Milk, cheese and butter produced without the use of pesti-cides ...

Statement	Strongly disagree	Disa-gree	Neither agree or disagree	Agree	Strongly agree	$\bar{x}$
… are good for the environ-ment.	1,1 (11)	2,7 (27)	12,3 (124)	33,6 (339)	50,4 (509)	1,3
... can help preserve the eco-system.	1,2 (12)	2,6 (26)	15,9 (161)	35,9 (363)	44,4 (448)	1,2
... can effectively reduce en-vironmental impact.	1,5 (15)	2,3 (23)	17,4 (176)	33,9 (342)	45,0 (454)	1,19
I would find milk, cheese, and butter produced without the use of pesticides good.	1,0 (10)	2,5 (25)	13,7 (138)	30,9 (312)	52,0 (525)	1,3
... would have many benefits.	1,0 (10)	2,3 (23)	15,1 (153)	35,2 (356)	46,3 (468)	1,24
... would make the product more valuable.	1,8 (18)	3,8 (38)	15,2 (154)	32,1 (324)	47,1 (476)	1,19

Source: own calculations

Table B.6. Descriptive results for the question "What is your opinion on the following statements?" (N = 1010). I find the production of milk, butter and cheese without the use of pesticides...

	Very	Some-what	Unde-cided	Some-what	Very		$\bar{x}$
unhealthy	4,0 (40)	5,1 (52)	11,9 (120)	24,4 (246)	54,7 (552)	healthy	1,21
industrial	4,9 (49)	7,0 (71)	19,6 (198)	26,3 (266)	42,2 (426)	rural	0,94
old-fashioned	3,1 (31)	7,0 (71)	19,9 (201)	24,3 (245)	45,7 (462)	modern	1,03
environmen-tally unfriendly	4,2 (42)	4,9 (49)	13,1 (132)	23,7 (239)	54,3 (548)	environmen-tally friendly	1,19
far from nature	5,0 (51)	5,3 (54)	10,6 (107)	24,3 (245)	54,8 (553)	close to nature	1,18
problematic	4,3 (43)	10,1 (102)	29,6 (299)	24,6 (248)	31,5 (318)	unproblematic	0,69
questionable	4,0 (40)	7,0 (71)	20,3 (205)	26,4 (267)	42,3 (427)	harmless	0,96
unsafe	3,8 (38)	5,8 (59)	19,8 (200)	27,5 (278)	43,1 (435)	safe	1,0
not animal friendly	4,2 (42)	5,0 (51)	15,6 (158)	22,4 (226)	52,8 (533)	animal friendly	1,15

Source: own calculations

Table B.7. Descriptive results for the question "What is your opinion on the following statements?" (N = 1010)

Statement	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	$\bar{x}$
I would buy milk produced without pesticides.	1,9 (19)	3,4 (34)	19,1 (193)	30,2 (305)	45,4 (459)	1,14
I would taste milk produced without pesticides.	1,6 (16)	2,6 (26)	10,7 (108)	27,2 (775)	57,9 (585)	1,37
I would regularly eat milk pro-duced without pesticides.	3,5 (35)	4,6 (46)	25,0(252)	30,6 (309)	36,4 (368)	0,92
I would recommend milk pro-duced without pesticides to my friends and family.	2,2 (22)	4,3 (43)	20,8 (210)	29,9 (302)	42,9 (433)	1,07
I would prefer milk produced without pesticides if the prod-uct were identified by an inde-pendent label.	3,1 (31)	4,5 (45)	20,1 (203)	31,4 (317)	41,0 (414)	1,03

Source: own calculations

Table B.8. Descriptive results for the question "What is your opinion on the following statements?" (N = 1010)

Statement	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	$\bar{x}$
I would buy cheese produced without pesticides.	1,6 (16)	4,1 (41)	18,8 (190)	30,9 (312)	44,6 (451)	1,13
I would taste cheese produced without pesticides.	10,3 (104)	20,1 (203)	11,9 (120)	16,3 (165)	41,4 (418)	0,58
I would regularly eat cheese produced without pesticides.	2,1 (21)	4,4 (44)	23,1 (233)	31,0 (313)	39,5 (399)	1,01
I would recommend cheese produced without pesticides to my friends and family.	2,1 (21)	3,2 (32)	20,5 (207)	32,0 (323)	42,3 (427)	1,09
I would prefer cheese produced without pesticides if the product were identified by an independent label.	2,6 (26)	4,2 (42)	20,5 (207)	31,4 (317)	41,4 (418)	1,05

Source: own calculations

Table B.9. Descriptive results for the question "What is your opinion on the following statements?" (N = 1010)

Statement	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	$\bar{x}$
I would buy butter produced without pesticides.	1,5 (15)	3,5 (35)	19,5 (197)	31,6 (319)	44,0 (444)	1,13
I would taste butter produced without pesticides.	1,5 (15)	3,2 (32)	10,6 (107)	29,4 (297)	55,3 (559)	1,34
I would regularly eat butter produced without pesticides.	3,0 (30)	4,2 (42)	23,8 (240)	29,7 (300)	39,4 (398)	0,98
I would recommend butter produced without pesticides to my friends and family.	2,5 (25)	3,7 (37)	20,8 (210)	30,4 (307)	42,7 (431)	1,07
I would prefer cheese produced without pesticides if the product were identified by an independent label.	13,3 (134)	16,7 (169)	22,2 (242)	19,3 (195)	28,5 (288)	0,33

Source: own calculations

Diskussion und Schlussbetrachtung

Das gegenwärtige Agrar- und Ernährungssystem steht unter einem erheblichen Transformationsdruck. Eine der zentralen Herausforderungen dieses Jahrhunderts besteht darin, ausreichende und sichere Lebensmittel für eine wachsende Weltbevölkerung zu produzieren. Gleichzeitig sollten die negativen Umweltauswirkungen begrenzt und dem Klimawandel entgegengewirkt werden (Agovino et al., 2019; Ortiz et al., 2021; Kumar et al., 2022). In diesem Zusammenhang sind innovative und nachhaltige Strategien für das Agrar- und Ernährungssystem entscheidend, um globale Herausforderungen wie Treibhausgasemissionen, Biodiversitätsverlust und Ernährungsunsicherheit zu bewältigen. Auf diese Weise kann eine umfassende Transformation der Produktions- und Konsummuster vorangetrieben werden (FAO, 2017; Herrero et al., 2020). Für den erfolgreichen Markteintritt von innovativen und neuartigen Produkten und Technologien ist die Sicherstellung der Verbraucherakzeptanz unerlässlich (Kühne et al., 2010). Vor diesem Hintergrund war das Ziel der vorliegenden Dissertation, die Verbraucherakzeptanz von neuartigen und innovativen Lebensmitteltechnologien und Landbausystemen mittels empirischen Verbraucherbefragungen zu untersuchen. Diesbezüglich wurden exemplarisch zwei Themenbereiche untersucht. Themenbereich I analysierte in den Beiträgen I.1 und I.2 die Bedeutung der Food Technology Neophobia Scale (FTNS) für die Verbraucherakzeptanz technologischer Lebensmittelinnovationen sowie die Rolle des Verbrauchervertrauens bei der Akzeptanz von kultiviertem Fleisch. Themenbereich II untersuchte in den Beiträgen II.1 und II.2 die Verbraucherakzeptanz eines Landbausystems, das mineralische Düngung nutzt, aber auf chemisch-synthetischen Pflanzenschutz verzichtet. Die untersuchten Forschungsfragen lauteten:

1) Welche Rolle spielt die Food Technology Neophobia bei der Akzeptanz innovativer Lebensmitteltechnologien und welche Verbrauchersegmente lassen sich hinsichtlich des Vertrauens in kultiviertes Fleisch identifizieren? (Themenbereich I)

2) Welche Faktoren beeinflussen die Verbraucherakzeptanz von tierischen Lebensmitteln, die aus einem innovativen Landbausystem, das auf den Einsatz von chemisch-synthetischen Pflanzenschutzmitteln verzichtet, hervorgehen und wie groß ist eine potenzielle Zielgruppe für diese Produkte? (Themenbereich II)

In den folgenden Abschnitten werden die grundlegenden und übergreifenden Ergebnisse der Studien zusammengefasst und in den Kontext der vorhandenen Literatur eingeordnet. Basierend auf den Ergebnissen werden Implikationen für den Agrar- und Ernährungssektor abgeleitet sowie Empfehlungen für politische Entscheidungsträgerinnen und Entscheidungsträger und

Marketingabteilungen gegeben. Zudem werden die Limitationen der Arbeit sowie der zukünftige Forschungsbedarf aufgezeigt. Die Dissertation schließt mit einem Schlusswort.

Themenbereich I: Verbraucherakzeptanz von technologischen Lebensmittelinnovationen

Die Ergebnisse der Beiträge I.1 und I.2 beantworten die erste Forschungsfrage. Beitrag I.1 der Dissertation bietet einen systematischen Literaturüberblick über die Food Technology Neophobia Scale (FTNS) und zeigt, dass Markteintrittsmöglichkeiten von Innovationen in der Lebensmittelindustrie durch das Phänomen der „Food Technology Neophobia“ (FTN), d. h. die Abneigung der Verbraucherinnen und Verbraucher gegenüber neuartigen Lebensmitteltechnologien, blockiert werden können (Cox und Evans, 2008). Die Ergebnisse verdeutlichen, dass Verbraucherinnen und Verbraucher mit einer hohen FTN eine ausgeprägte Abneigung gegenüber neuen Lebensmitteltechnologien haben und weniger bereit sind, Produkte zu konsumieren, die unter Verwendung solcher Technologien hergestellt wurden. Beitrag I.1 bestätigt, dass die FTNS ein valides und zuverlässiges Instrument zur Messung der FTN darstellt und als wesentlicher Prädiktor für die Verbraucherakzeptanz von innovativen Produkten und Technologien herangezogen werden kann. Wie Beitrag I.1 zeigt, werden neuartige Produkte von Verbraucherinnen und Verbrauchern mit einer höheren FTN als tendenziell ungesund, unsicher, unnatürlich und nicht vertrauenswürdig wahrgenommen (Chen et al., 2013; Chen, 2018; Coutinho et al., 2021). Diese Einschätzung kann sich auf eine Vielzahl von technologischen Innovationen beziehen, wie beispielsweise kultiviertes Fleisch oder der Einsatz von Nanotechnologie in Lebensmitteln. Bereits Rozin et al. (2004) und Rozin (2005) stellten fest, dass Verbraucherinnen und Verbraucher technologischen Innovationen im Lebensmittelbereich misstrauisch gegenüberstehen und grundsätzlich bekannte, traditionelle und „natürliche“ Lebensmittel bevorzugen. Diese Tatsache erklärt, warum Innovationen im Lebensmittelbereich häufig ein hohes Maß an Marktversagen aufweisen (Chen et al., 2013; Nucci und Hallmann, 2015; Cattaneo et al., 2019; Egolf et al., 2019).

Die Ablehnung entsprechender Produkte hat zur Folge, dass viele der gesundheitlichen und ökologischen Vorteile technologischer Innovationen ungenutzt bleiben, wodurch die Nachhaltigkeitstransformation erheblich beeinträchtigt werden kann (Siegrist und Hartmann, 2020a). Basierend auf den Erkenntnissen des Beitrags I.1 kann geschlussfolgert werden, dass die Einschätzung der FTN vor der Produkteinführung von entscheidender Bedeutung für die Produktentwicklung sowie die Marktforschung sein kann. Dadurch kann die Erfolgsquote innovativer Lebensmittelprodukte auf dem Markt abgeschätzt, potenzielle Risiken bei der Einführung neuer Lebensmitteltechnologien frühzeitig erkannt und zielgerichtete Strategien zur Überwindung bzw. Reduzierung der FTN entwickelt werden.

Für eine zielgruppenorientierte Marketing- und Kommunikationsarbeit ist eine detaillierte Beschreibung des soziodemografischen Profils der Verbraucherinnen und Verbrauchern mit hoher bzw. geringer FTN wünschenswert. Allerdings zeigt Beitrag I.1, dass die bisherige Datenlage keine konsistenten Schlussfolgerungen über das soziodemografische Profil zulässt, was auf zukünftigen Forschungsbedarf hinweist. Lediglich hinsichtlich des Bildungsniveaus ist anzunehmen, dass ein geringeres Bildungsniveau mit einer höheren FTN einhergeht (Evans et al., 2010; Verbeke et al., 2015a, Jeżewska-Zychowicz und Królak, 2015; Vidigal et al., 2015; De Steur et al., 2016; Martins et al., 2019; Cattaneo et al., 2019; Rabadán, 2021; Rabadán und Bernabéu, 2021; Ortega et al., 2022).

Diese Erkenntnis deutet darauf hin, dass die Informationsvermittlung über neuartige Lebensmitteltechnologien einen wesentlichen Beitrag leisten kann. Der systematische Literaturüberblick (Beitrag I.1) zeigt jedoch, dass die Studienlage zur Wirkung der Informationsbereitstellung auf die FTN uneinheitlich ist. Während einigen Studien (Evans et al., 2010; Brunner et al., 2018; Demartini et al., 2018) berichten, dass zusätzliche Informationen über neue Technologien keinen Einfluss auf die Akzeptanz innovativer Lebensmitteltechnologien sowie das Niveau der FTN hatten, berichteten andere Studien (Vidigal et al., 2015; Deegan et al., 2015; Cattaneo et al., 2019) über positive Effekte der Informationsbereitstellung auf die FTN und die Akzeptanz neuer Technologien. Weitere Forschung ist erforderlich, um zu verstehen, welche Informations- und Kommunikationsstrategien dazu beitragen können, verfestigte Neophobien gegenüber Lebensmitteltechnologien sowie die Einstellungen und Überzeugungen der Verbraucherinnen und Verbraucher gezielt zu beeinflussen.

Aus den Erkenntnissen des Beitrags I.1 können verschiedene Kritikpunkte, die bei der Verwendung und Interpretation der FTNS berücksichtigt werden sollten, herausgestellt werden. Gleichzeitig werden auf dieser Grundlage weitere Forschungslücken aufgedeckt. Wie der Beitrag I.1 zeigt, wurden in verschiedenen Studien Modifikationen (wie Änderungen in der Anzahl der Items sowie der Likert-Skalen) an der ursprünglichen FTNS vorgenommen. Zudem wurde die Skala in verschiedene Sprachen übersetzt, um ein einheitliches Skalenkonzept, unter Beachtung sprachlicher und kultureller Gegebenheiten, auch in unterschiedlichen Ländern einsetzen zu können. Diese Anpassungen führten zu unterschiedlichen Versionen der FTNS, deren Validität jedoch häufig nicht ausreichend geprüft wurde (Beitrag I.1). Replikationsstudien mit größeren und repräsentativen Stichproben sind notwendig, um die Aussagekraft bisheriger Ergebnisse sicherzustellen.

Ein weiterer Kritikpunkt betrifft die Eindimensionalität der FTNS. Wie in Beitrag I.1 deutlich wird, fokussiert sich die FTNS überwiegend auf die Angst und Abneigung der Verbraucherinnen und Verbraucher gegenüber innovativen Lebensmitteltechnologien. Die Erfassung wesentlicher Nuancen, die diese Angst bzw. Abneigung begünstigen, wie beispielsweise das Wissen über die Technologie, Vertrauen in die Herstellerinnen und Hersteller oder ethische Überlegungen, werden unzureichend berücksichtigt. Es lässt sich ableiten, dass eine Weiterentwicklung der Skala, die zusätzliche Dimensionen einbezieht, die Genauigkeit und Aussagekraft der FTNS erhöhen würde. Damit könnten die Hintergründe der Verbraucherängste genauer erfasst werden. Diese Informationen würden insbesondere für politische Entscheidungsträgerinnen und Entscheidungsträger und für die Marketingforschung relevant sein. So könnten die Verbraucherängste mittels vertrauensbildenden Kommunikationsmaßnahmen gezielt reduziert werden. Vor dem Hintergrund wäre es ebenfalls hilfreich, die Effektgröße der FTN im Vergleich zu anderen Akzeptanzfaktoren innovativer Lebensmitteltechnologien in zukünftigen Forschungsarbeiten zu untersuchen.

In Beitrag I.2 wird die Bedeutung der FTN und des Verbrauchervertrauens bei der Akzeptanz von kultiviertem Fleisch aufgegriffen. Schon Frewer et al. (2003) wiesen darauf hin, dass das Vertrauen in Informationsquellen, Regulierungsbehörden und insbesondere in Institutionen, die für Werbung, Verwaltung und Regulierung zuständig sind, einen entscheidenden Einfluss darauf hat, wie Verbraucherinnen und Verbraucher auf innovative Produkte und Technologien reagieren. Studien belegen, dass Verbraucherinnen und Verbraucher derzeit ein geringes Vertrauen in die Lebensmittelkette haben, was auf verschiedene Faktoren wie bspw. Lebensmittelskandale, Sicherheitsvorfälle, Veränderungen in der Lebensmittelproduktion und die zunehmende Globalisierung des Lebensmittelmarktes zurückführen ist (Agnoli et al. 2016; Wu et al., 2021). Diese Entwicklungen haben dazu geführt, dass Verbraucherinnen und Verbraucher zunehmend von wesentlichen Produktionsschritten der Lebensmittel uninformiert bleiben. Um die Qualität und Sicherheit von Lebensmitteln zu bewerten, müssen sich die Verbraucherinnen und Verbraucher im Allgemeinen auf die Informationen verlassen, die von verschiedenen Akteurinnen und Akteuren in den verschiedenen Phasen der Wertschöpfungskette bereitgestellt werden (Wu et al., 2021). Dies gilt insbesondere bei innovativen Lebensmitteltechnologien, wie z. B. kultiviertem Fleisch. Aufgrund begrenzter Kenntnisse über die Technologie, z. B. hinsichtlich des Herstellungsprozesses und langfristigen Auswirkungen auf Umwelt und Gesundheit, kann eine eventuell vorhandene Vertrauenslücke noch weiter vergrößert werden. Es wird deutlich, dass Vertrauen die Akzeptanz, das Kaufverhalten sowie die Wahrnehmung der Sicherheit und Qualität von kultiviertem Fleisch beeinflussen kann (Verbeke et al., 2015a; Siegrist und Hartmann, 2020a).

Vor diesem Hintergrund haben vorherige Studien gezeigt, dass mangelndes Vertrauen in kultiviertes Fleisch und der am Prozess beteiligten Akteurinnen und Akteure eine bedeutende Barriere für die Akzeptanz von kultiviertem Fleisch durch die Verbraucherinnen und Verbraucher darstellt (Verbeke et al., 2015a; Shaw und Mac Con Iomaire, 2019; Wilks et al., 2019; Siegrist und Hartmann, 2020a; Zhang et al., 2020; Lewisch und Riefler, 2023; Kühn et al., 2023; Lin-Hi et al., 2023). In Beitrag I.2 werden deutsche Verbraucherinnen und Verbraucher entsprechend ihres Vertrauens in kultiviertes Fleisch und die entsprechenden Akteurinnen und Akteure segmentiert. Bestehende Literatur in diesem Forschungsbereich wird somit ergänzt. Beitrag I.2 liefert differenzierte Einblicke in das Vertrauen der deutschen Bevölkerung, welches verschiedene Verbrauchersegmente prägt, und bietet dadurch einen wesentlichen Mehrwert für Politik und Marketing. Diese Erkenntnisse ermöglichen die Entwicklung zielgerichteter Marketingstrategien und politischer Maßnahmen, die spezifisch auf die Bedürfnisse und Bedenken der jeweiligen Segmente eingehen.

Es konnten vier verschiedene Verbrauchersegmente identifiziert werden, die sich hinsichtlich ihres Vertrauens in die European Food Safety Authority (EFSA), kultiviertes Fleisch, Lebensmittelherstellerinnen und Lebensmittelhersteller, ihrem zwischenmenschlichen Vertrauen sowie ihrem Misstrauen in die EFSA und ihrem zwischenmenschlichen Misstrauen unterscheiden. Darüber hinaus unterscheiden sich die Segmente im Hinblick auf ihre Angaben zur Akzeptanz bzw. Kaufbereitschaft von kultiviertem Fleisch, ihrem Involvement bzw. Wissensstand sowie dem Niveau der FTN. Schließlich zeigen sich zwischen den Verbrauchersegmenten auch soziodemografische Unterschiede hinsichtlich Alter, Geschlecht, Einkommen und Bildung.

Beitrag I.2 zeigt, dass das Verbrauchervertrauen in kultiviertes Fleisch in der deutschen Bevölkerung relativ gering ist, wobei das Verbrauchersegment der vertrauensvollen Verbraucherinnen und Verbraucher mit 17,5 % das kleinste Segment bildet. Es zeigt sich, dass Verbraucherinnen und Verbraucher, die kultiviertes Fleisch akzeptieren, tendenziell jünger sind, ein hohes Bildungsniveau und ein höheres Einkommen haben. Zudem besteht das Segment der vertrauensvollen Verbraucherinnen und Verbraucher aus Personen mit dem höchsten Involvement. Im Einklang mit den Ergebnissen von Klöckner et al. (2022) erhöht ein höherer Wissensstand über die Technologie die Akzeptanz von kultiviertem Fleisch. Die Tatsache, dass in diesem Segment die Verbraucherinnen und Verbraucher die geringste FTN aufweisen, unterstreicht die Annahme, dass das Ausmaß der FTN von weiteren Dimensionen beeinflusst wird. Darunter fällt der Wissensstand der Verbraucherinnen und Verbraucher sowie das Vertrauen in die Lebensmittelsicherheit, Regulierungsbehörden und Lebensmittelherstellerinnen und Lebensmittelhersteller. Beitrag I.2 knüpft somit an die in Beitrag I.1 diskutierten Forschungslücken bezüglich

der Eindimensionalität der FTNS an. Weitere Forschungsarbeiten sollten diese Zusammenhänge vertiefend untersuchen.

Ein entgegengesetztes Muster zeigen die misstrauischen Verbraucherinnen und Verbraucher (24,3 %). Ein geringes Vertrauen in kultiviertes Fleisch weisen Verbraucherinnen und Verbraucher ab 56 Jahren, mit geringerer formeller Bildung und niedrigerem Einkommensniveau auf. Dieses Segment zeigt hinsichtlich der Thematik ein geringeres Involvement, was darauf hindeutet, dass ein Mangel an Interesse bzw. Wissen zum allgemeinen Misstrauen der Verbraucherinnen und Verbraucher gegenüber kultiviertem Fleisch beiträgt. Die Ergebnisse aus Beitrag I.2 legen zudem nahe, dass grundlegendes Misstrauen der Verbraucherinnen und Verbraucher mit einem höheren Maß an FTN verbunden ist. Basierend auf diesen Erkenntnissen kann geschlussfolgert werden, dass die Ansprache dieses Segments eine transparente Kommunikation und umfassende Aufklärungskampagnen erfordert. Vorteile von kultiviertem Fleisch sollten verständlich vermittelt werden. Zudem könnten vertrauensbildende Maßnahmen wie unabhängige Zertifizierungen, die Einbindung vertrauenswürdiger Meinungsführer und partizipative Ansätze relevant sein, um Bedenken gezielt zu adressieren. Frühere Studien haben gezeigt, dass die Bereitstellung von Informationen die Akzeptanz für kultiviertes Fleisch erhöhen kann (Bekker et al., 2017; Rolland et al., 2020).

Weiterhin nimmt ein Großteil der deutschen Bevölkerung eine ambivalente Vertrauenshaltung ein. In Bezug auf das Vertrauen und die Kaufabsicht für kultiviertes Fleisch zeigen sich fast 60 % der deutschen Bevölkerung unentschlossen. Sie schlüsseln sich in vorsichtige Verbraucherinnen und Verbraucher (37,5 %) und skeptische Verbraucherinnen und Verbraucher (20,7 %) auf. Diese Ambivalenz kann darauf zurückzuführen sein, dass viele Verbraucherinnen und Verbraucher womöglich die technologische Innovation schätzen und als zukunftsweisend ansehen, gleichzeitig aber aufgrund von mangelnder Kenntnis über den Regulierungsprozess, Sicherheitsstandards, den Herstellungsprozess sowie die langfristigen Auswirkungen und potenziellen Risiken auf die Umwelt und die menschliche Gesundheit Vertrauenslücken und Sicherheitsbedenken haben. Diese Schlussfolgerungen werden von Verbeke et al. (2015b) gestützt. Dies deutet darauf hin, dass die Sicherstellung einer Vertrauensbasis eine wesentliche Voraussetzung für die Akzeptanz von Innovationen darstellt. Die Ergebnisse legen nahe, dass die Ermittlung vertrauensbildender Kommunikationsmaßnahmen besonders für dieses Segment relevant ist. Damit bietet sich die Chance, die Zahl der potenziellen Käuferinnen und Käufer zu erhöhen und somit einen erfolgreichen Markteintritt für kultiviertes Fleisch in Deutschland zu erleichtern (Beitrag I.2).

Basierend auf den Ergebnissen lässt sich ableiten, dass kultiviertes Fleisch einen Imagewandel vollziehen muss, bei dem Vertrauen und die Produktsicherheit in den Vordergrund gestellt werden. Zum Imagewandel gehört auch, die Kommunikation von der Fixierung auf „Fleisch aus der Petrischale“ und weiteren negativen Assoziationen zu lösen und stattdessen das Gesamtprodukt mit den ökologischen, gesundheitlichen und ethischen Vorteilen hervorzuheben. Für Marketingabteilungen könnte die Zusammenarbeit mit Wissenschaftlerinnen und Wissenschaftlern und Expertinnen und Experten erfolgsversprechend sein. So könnte die in der deutschen Bevölkerung vorherrschende Vertrauenslücke durch unabhängige, transparente und glaubwürdige Informationen reduziert werden. Transparenz hinsichtlich des Produktionsprozesses sowie der Einhaltung höchster Sicherheits- und Qualitätsstandards sind von wesentlicher Bedeutung. In diesem Sinne zeigen Zhang et al. (2020), dass die Bereitstellung von Informationen über die Vorteile von kultiviertem Fleisch durch unabhängige Institutionen die Akzeptanz erhöhen könnte. Darüber hinaus weisen Verbeke et al. (2015a) darauf hin, dass die Bereitstellung von Informationen über die Produktion und den Zertifizierungsprozess sowie strenge Vorschriften und eine vertrauenswürdige Kennzeichnung das Vertrauen erhöhen können. Zukünftige Forschungsarbeiten könnten im Rahmen von Framing-Studien untersuchen, wie Informationen am effektivsten vermittelt werden können, um das Vertrauen und damit die Akzeptanz von kultiviertem Fleisch zu erhöhen.

Themenbereich II: Verbraucherakzeptanz von Nachhaltigkeitsinnovationen in der Primärproduktion

Während Themenbereich I die Verbraucherakzeptanz von technologischen Lebensmittelinnovationen betrachtet hat, wird in Themenbereich II die Akzeptanz eines innovativen Landbausystems untersucht. Das zweite exemplarische Themenfeld ermöglicht die Spannbreite von Akzeptanzforschung im Zuge notwendiger Transformationsprozesse im Agrar- und Ernährungssektor abzubilden.

Die Verbraucherakzeptanz eines Landbausystems, das sich durch einen vollständigen Verzicht auf chemisch-synthetische Pflanzenschutzmittel bei gleichzeitiger Beibehaltung von Mineraldüngern auszeichnet, wird in den Beiträgen II.1 und II.2 der vorliegenden Dissertation behandelt. Damit wird die zweite Forschungsfrage beantwortet. Zunächst ist es zur Abschätzung des Marktpotenzials notwendig, die Beschreibung einer potenziellen Zielgruppe vorzunehmen. Dabei liegt der Fokus der Beiträge II.1 und II.2 auf tierischen Produkten (Milch, Butter, Käse). Nitzko et al. (2024) haben bereits die Einstellungen der deutschen Verbraucherinnen und Verbrauchern zu pflanzlichen Produkten, die aus diesem Landbausystem hervorgehen, untersucht.

Studien zeigen, dass die Sensibilität der Verbraucherinnen und Verbraucher gegenüber Pflanzenschutzmittelrückständen mit zunehmendem Verarbeitungsgrad der Lebensmittel abnimmt (Nitzko et al., 2022; Nitzko et al., 2024). Bei der Einführung eines neuen Landbausystems ist jedoch ein ganzheitlicher Ansatz entscheidend, der eine breite Produktpalette berücksichtigt. Untersuchungen belegen, dass Pflanzenschutzmittelrückstände über das Futtermittel der Milchkühe aufgenommen werden können. Diese Rückstände können sich im Körpergewebe der Kühe anreichern und zu kontaminierten Milchprodukten führen (Jeong et al., 2012; Bedi et al., 2018; Penagos-Tabares et al., 2023). Dies unterstreicht die Relevanz der Beiträge II.1 und II.2.

Der Beitrag II.1 zeigt, dass 22,9 % der deutschen Bevölkerung als potentielle Zielgruppe für diese Produkte angesehen werden können. In diesem Verbrauchersegment befindet sich ein höherer Anteil weiblicher und älterer Konsumenten. Weiterhin zeichnet sich dieses Verbrauchersegment durch eine grundlegende Ablehnung gegenüber dem Einsatz von Pflanzenschutzmitteln in der Lebensmittelproduktion aus. Basierend auf den Ergebnissen des Beitrags II.1 kann angenommen werden, dass diese Produkte insbesondere die Verbraucherinnen und Verbraucher ansprechen, die ein ausgeprägtes Bewusstsein für Pflanzenschutzmittelrückstände in Lebensmitteln und den damit verbundenen potenziellen Umwelt- und Gesundheitsrisiken haben. Diese Ergebnisse werden von Cranfield und Magnusson (2003) sowie Nandi et al. (2017) gestützt.

Zudem weist das Verbrauchersegment eine Mehrzahlungsbereitschaft für pflanzenschutzmittelfreie Milch (31 %), Käse (23 %) und Butter (24 %) im Vergleich zu konventionellen Vergleichsprodukten auf. Dabei ist auffällig, dass die Zahlungsbereitschaft für Milch höher als für Butter und Käse ist, was möglicherweise auf die für Butter und Käse zusätzlichen Verarbeitungsschritte zurückzuführen ist. Diese Ergebnisse werden von Nitzko et al. (2024) unterstrichen, wonach die Mehrzahlungsbereitschaft bei unverarbeiteten / geringfügig verarbeiteten Produkten im Vergleich zu Lebensmitteln mit höherem Verarbeitungsgrad höher ausfällt.

Die Studie von Nitzko et al. (2024) zeigt, dass die Mehrzahlungsbereitschaft der deutschen Verbraucherinnen und Verbraucher für pflanzliche pflanzenschutzmittelfreie Produkte zwischen 38,3 % und 93,7 % liegt und je nach Verarbeitungsgrad der Produkte variiert. Die Ergebnisse deuten darauf hin, dass die Akzeptanz und Zahlungsbereitschaft für pflanzliche Produkte aus diesem Landbausystem höher sind. Dies unterstreicht die Notwendigkeit, differenzierte Marketingstrategien zu entwickeln, die auf den Verarbeitungsgrad der Produkte abgestimmt sind bzw. zwischen pflanzlichen und tierischen Produkten unterscheiden. Zukünftige Forschun-

gen sollten die Akzeptanzunterschiede zwischen verschiedenen Produktgruppen in einer umfassenden Studie untersuchen, um direkte Vergleiche anzustellen und die bisherigen Ergebnisse zu validieren.

Limitierend ist anzuführen, dass die angegebenen Zahlungsbereitschaften hypothetisch erfasst wurden und daher nicht zwangsläufig das tatsächliche Verbraucherverhalten unter realen Kaufszenarien widerspiegeln. Die Einschätzung sollte daher um nicht-hypothetische Zahlungsbereitschaftsanalysen ergänzt werden, sobald das Landbausystem vollständig ausgereift ist und die Produkte auf dem Markt verfügbar sind. Es kann nicht ausgeschlossen werden, dass die Zahlungsbereitschaften aufgrund sozialer Erwünschtheit überschätzt werden (Vlaev, 2012). Das könnte erklären, warum die unwilligen Verbraucherinnen und Verbraucher (39,3 %) angeben, eine Mehrzahlungsbereitschaft aufzuweisen, obwohl sie das System und Produkte grundsätzlich ablehnen.

Studien belegen, dass der Verzicht auf chemisch-synthetische Pflanzenschutzmittel zu einem niedrigeren Produktionsniveau, höheren Produktionskosten (z. B. durch mechanische Beikrautregulierung), ausgeprägteren Ertragsschwankungen und insgesamt zu höheren Produktionsrisiken führt (Zimmermann et al., 2021; Möhring und Finger, 2022; Mack et al., 2023). Um diese Mehrkosten (im Vergleich zur konventionellen Landwirtschaft) auszugleichen, müssten pflanzenschutzmittelfreie Lebensmittel in einem mittleren Marktsegment zwischen konventionellen und ökologischen Produkten positioniert werden. Diese Einschätzung wird auch von Nitzko et al. (2024) unterstützt, die darauf hinweisen, dass die Mehrzahlungsbereitschaft der Verbraucherinnen und Verbraucher eine erfolgreiche Positionierung in diesem Marktsegment ermöglichen könnte. Insbesondere könnten staatliche Ausgleichszahlungen, die direkte Zahlungen mit marktbasierten Preisprämien kombinieren, während der Umstellungsphase negative Einkommensauswirkungen für Landwirtinnen und Landwirte abmildern (Böcker et al., 2019; Mack et al., 2023). Der Übergang und die Etablierung dieses Landbausystems könnten dadurch in der landwirtschaftlichen Praxis erleichtert werden. Insgesamt bleibt festzuhalten, dass die Mehrzahlungsbereitschaft der Verbraucherinnen und Verbraucher die Machbarkeit und Rentabilität einer solchen Marktpositionierung entscheidend beeinflusst. Die vorliegende Dissertation hebt daher die Bedeutung der Akzeptanzforschung zur erfolgreichen Nachhaltigkeitstransformation im Agrar- und Ernährungssektor hervor.

Die unentschlossenen Verbraucherinnen und Verbraucher (30,9 %) und das kleinste Segment (6,9 %), die ambivalenten Verbraucherinnen und Verbraucher, sind hinsichtlich ihrer Akzeptanz und Kaufabsicht pflanzenschutzmittelfreier tierischer Produkte unentschieden. Diese Ambivalenz könnte durch zielgerichtete Kommunikationsmaßnahmen reduziert werden, um diese

Segmente zu potenziellen Käuferinnen und Käufern zu entwickeln. Damit könnte die Marktdurchdringung dieser Produkte verbessert werden. Daher sind weitere Untersuchungen notwendig, um die Faktoren zu ermitteln, die die Verbraucherakzeptanz dieser Produkte beeinflussen könnte. Dieser Forschungsbedarf wird in Beitrag II.2 ausgeführt.

Mittels eines Strukturgleichungsmodells wurde in Beitrag II.2 untersucht, welche Faktoren die Akzeptanz des innovativen Landbausystems beeinflussen. Die Ergebnisse verdeutlichen, dass Gesundheitsbewusstsein, Chemophobie, Perceived Consumer Effectiveness (PCE), Einstellungen zum Landbausystem und zu den Produkten die Akzeptanz pflanzenschutzmittelfreier tierischer Produkte positiv beeinflussen. Die Präferenz für pflanzenschutzmittelfreie Produkte wird hingegen durch die Preissensibilität der Verbraucherinnen und Verbraucher beeinträchtigt, wie auch von Ghali-Zinoubi und Toukabri (2019) festgestellt wurde.

Basierend auf den Erkenntnissen aus den Beiträgen II.1 und II.2 lassen sich für politische Entscheidungsträgerinnen und Entscheidungsträger sowie Marketingabteilungen Empfehlungen für ein Vermarkungskonzept pflanzenschutzmittelfreier Lebensmittel ableiten. Das innovative Landbausystem kombiniert die Vorteile konventioneller und ökologischer Landwirtschaft und bietet somit eine dritte Produktkategorie. Damit wird die Produktpalette für Verbraucherinnen und Verbraucher erweitert. Basierend auf den Ergebnissen, spricht dieses Segment insbesondere gesundheitsbewusste Verbraucherinnen und Verbraucher an, die Wert auf Lebensmittelsicherheit, umweltfreundliche Anbaumethoden und nachhaltig produzierte Lebensmittel legen, jedoch gleichzeitig preisbewusst sind und die höheren Kosten von Bio-Produkten nicht tragen können oder wollen. Eine gezielte Marktpositionierung der Produkte als nachhaltige, aber erschwinglichere Alternative zu Bio-Produkten kann dazu beitragen, dieses innovative Landbausystem für eine breite Verbraucherbasis attraktiv zu machen.

Weiterhin ist abzuleiten, dass Verbraucherinnen und Verbraucher die grundlegenden Merkmale des neuen Landbausystems verstehen und zwischen konventionellen, ökologischen und pflanzenschutzmittelfreien Methoden der Lebensmittelproduktion unterscheiden müssen. Eine langfristige und erfolgreiche Etablierung kann ohne das Wissen der Verbraucherinnen und Verbraucher nicht sichergestellt werden (Nitzko et al., 2024). Dies stellt auch eine Herausforderung für die Politik dar. Die Entfremdung der Verbraucherinnen und Verbraucher von der Lebensmittelproduktion und den damit verbundenen potenziellen Umweltauswirkungen führt zu einer weniger informierten Entscheidungsfindung (Siegrist und Hartmann, 2020b; Hartmann et al., 2021). Gezielte Aufklärungskampagnen und ein transparenter Dialog über den Produktionsprozess könnten das Bewusstsein für nachhaltigere Produktionssysteme schaffen. Weiterhin könnten so die Vorteile einer pflanzenschutzmittelfreien Lebensmittelproduktion hervorgehoben

und Informationslücken geschlossen werden. Dies bedeutet, dass Marketingkampagnen die gesundheitlichen Vorteile, Sicherheitsaspekte sowie die Nachhaltigkeit dieses Landbausystems gegenüber den konventionellen und ökologischen Systemen betonen sollten. Auch Nitzko et al. (2024) betonen die Notwendigkeit zusätzlicher Informationen über pflanzenschutzmittelfreie Produkte, um die Verbraucherakzeptanz und Zahlungsbereitschaft zu erhöhen. So können Informationen über die Grundzüge einer pflanzenschutzmittelfreien Landwirtschaft (Verzicht auf chemisch-synthetische Pflanzenschutzmittel, Verwendung von Mineraldünger) eine Mehrzahlungsbereitschaft im Vergleich zu konventionellen Produkten generieren (Nitzko et al., 2024).

Um pflanzenschutzmittelfreie Produkte erfolgreich als Marktsegment zwischen konventioneller und ökologischer Produktion zu positionieren, könnten Zertifizierungen und Labels sowie eine einheitliche Defintion des Landbausystems hilfreich sein. Ein mehrstufiges Umweltlabel, ähnlich dem Planet Score, das den Pflanzenschutzmitteleinsatz berücksichtigt, könnte eine Option darstellen. Nitzko und Spiller (2023) deuten darauf hin, dass Angaben zur Pflanzenschutzmittelvermeidung (z. B. „pflanzenschutzmittelfrei“ oder „ohne Pflanzenschutzmittel angebaut“) eher zum Kauf von pflanzenschutzmittelfreiem Gemüse beitragen würden als nachhaltigkeitsbezogene Kennzeichnungen (z. B. „zum Schutz der Umwelt“ oder „zum Schutz der Bienen“). Zukünftige Forschungsarbeiten sollten sich daher darauf konzentrieren, wie Kennzeichnungselemente auf der Produktverpackung und die Definition des innovativen Landbausystems die Einstellungen der Verbraucherinnen und Verbraucher beeinflussen. Dabei sollte die Wirkung der Kennzeichnung in Abhängigkeit vom Verarbeitungsgrad berücksichtigt werden.

Limitationen der vorliegenden Dissertation

Im Folgenden werden verschiedene Limitationen der vorliegenden Dissertation dargestellt, die bei der Interpretation der Ergebnisse Berücksichtigung finden sollten. Es ist hervorzuheben, dass die vorliegende Dissertation zwei wesentliche Themenbereiche der Transformationsprozesse im Agrar- und Ernährungssektor abdeckt. Dennoch kann damit nicht die gesamte Spannbreite und Vielfalt der für eine umfassende Transformation notwendigen Aspekte berücksichtigt werden.

Eine Einschränkung des Beitrags I.1 besteht darin, dass systematische Literaturüberblicke auf einen spezifischen Zeitrahmen beschränkt sind. Studien, die nach Abschluss der Literatursuche (in der vorliegenden Dissertation: Dezember 2021) veröffentlicht wurden, werden nicht berück-

sichtigt. Weiterhin wird die Validität und Generalisierbarkeit der Schlussfolgerungen eines systematischen Literaturüberblicks durch die divergierende Qualität der eingeschlossenen Studien beeinträchtigt. Dies wurde bereits umfassend in Beitrag I.1 diskutiert.

Die Beiträge I.2, II.1 und II.2 basieren auf online-basierten Verbraucherumfragen, bei denen Effekte der sozialen Erwünschtheit nicht zwangsläufig ausgeschlossen werden können. Somit besteht die Möglichkeit, dass die Akzeptanz der betrachtenden Produkte überschätzt wurde (Vlaev, 2012). Zudem waren die Verbraucherumfragen auf die deutsche Bevölkerung beschränkt, was die Übertragbarkeit der Ergebnisse auf andere Länder und kulturelle Kontexte einschränkt. Des Weiteren ist anzuführen, dass die Stichproben in den Studien zwar maximal repräsentativ für die deutsche Bevölkerung waren, gleichzeitig aber Verzerrungen aufgrund eines tendenziell höheren Bildungsniveaus nicht ausgeschlossen werden können.

Eine weitere Einschränkung besteht darin, dass kultiviertes Fleisch sowie Produkte aus dem innovativen Landbausystem auf dem deutschen Markt noch nicht kommerzialisiert sind. Dadurch wurden die Verbraucherakzeptanz und die Zahlungsbereitschaft hypothetisch erfasst. Dies kann die Aussagekraft der Schlussfolgerungen beeinträchtigen.

Zudem wurde die Untersuchung in den Beiträgen II.1 und II.2 auf drei Produkte (Milch, Butter, Käse) begrenzt. Dadurch ist die Übertragbarkeit der Ergebnisse auf andere Produktkategorien einschränkt. Die spezifischen Einstellungen und Zahlungsbereitschaften der Verbraucherinnen und Verbraucher zu diesen drei Produkten können daher nicht repräsentativ für eine allgemeine Einstellung gegenüber einer breiten Produktpalette stehen, wie bereits diskutiert wurde.

Insgesamt können diese Limitationen zu einer Diskrepanz zwischen den geäußerten Einstellungen zu den innovativen Produkten und dem tatsächlichen Verhalten führen, bekannt unter dem Begriff Attitude-Behavior Gap (Ajzen und Fishbein, 1977). Dadurch kann ein verzerrtes Bild der tatsächlichen Marktchancen und der Akzeptanz der betrachteten innovativen Lebensmittel entstehen. Diese Aspekte sollten bei der Betrachtung der Ergebnisse berücksichtigt werden.

Schlusswort

Aus der vorliegenden Dissertation wird ersichtlich, dass die Akzeptanzforschung eine bedeutende Rolle bei der Nachhaltigkeitstransformation des Agrar- und Ernährungssystems einnimmt. Sie dient als „Stimmungsbarometer“ für die Marktchancen innovativer Produkte. Es wird deutlich, dass die Transformation zu einem nachhaltigen Agrar- und Ernährungssystem nur erfolgreich sein kann, wenn sie von einem breiten gesellschaftlichen Konsens getragen wird. Die vorliegende Dissertation zeigt, dass die in der Gesellschaft vorliegenden Vertrauens-

und Wissenslücken zu Unsicherheiten führen und sich in einer weit verbreiteten Ambivalenz in der deutschen Bevölkerung gegenüber Innovationen im Lebensmittelbereich manifestieren.

Die gewonnenen Erkenntnisse liefern wertvolle Impulse für die Gestaltung politischer Maßnahmen sowie zukünftiger Kommunikations- und Vermarktungsstrategien für kultiviertes Fleisch und tierische Produkte, die aus dem innovativen Landbausystem hervorgehen. Basierend auf den Erkenntnissen lässt sich schlussfolgern, dass die Steigerung der Verbraucherakzeptanz einen integrativen Ansatz erfordert. Aufklärung, Transparenz und regulatorische Maßnahmen könnten hierzu kombiniert werden. Regierungen, Bildungseinrichtungen und Unternehmen sollten zusammenarbeiten, um ein kohärentes und vertrauenswürdiges Umfeld zu schaffen, in dem Innovationen als positive und notwendige Entwicklungen wahrgenommen werden.

Weiterhin zeigen die Ergebnisse der Dissertation, dass zielgruppenorientierte Botschaften die spezifischen Bedenken der verschiedenen Verbrauchersegmente gezielt adressieren sollten. Auf diese Weise kann der Mehrwert der Innovationen klar vermittelt werden. Insgesamt lässt sich ableiten, dass ein kultureller Wandel und ein angepasster Dialog zwischen Wissenschaft, Politik, Gesellschaft und dem gesamten Agrar- und Ernährungssektor erforderlich sind.

Die vorliegende Dissertation legt eine fundierte Grundlage für richtungsweisende Maßnahmen, die den Weg zu einem nachhaltigeren und zukunftsfähigeren Agrar- und Ernährungssystem ebnen können.

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