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More Than Just a Pretty Package: How Marketing Cues Shape
Consumer Judgments of Health, Naturalness, and Taste.

verfasst von | submitted by

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The idea of starting a PhD took shape during the pandemic, a time marked by lockdowns and a severely restricted social life. I figured: if not now, when? It felt like the perfect time to explore the interesting questions that had arisen throughout my professional work in marketing, and to explore them through the lens of academic research. It's still hard to believe that what began as a personal interest and a strong desire to return to university has resulted in a completed dissertation. Even though it was often challenging to reconcile work and research, I always found the proximity to science and access to the current state of research very enriching.

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Abstract

In today's fast-paced world, consumers make food choices with limited deliberation and often rely on visual cues, such as packaging colors. As interest in healthy and sustainable diets grows, understanding how packaging color influences perceptions of healthiness, naturalness, and taste becomes increasingly important. However, previous research is inconclusive and lacks a coherent theoretical framework to explain these effects. This dissertation introduces the Cognitive Ecological Color Theory, developed based on a systematic literature review, to help explain how packaging color influences consumer perceptions. The theory proposes three distinct psychological pathways through which color can shape health expectations: explicit color use, belief activation, and mental simulation. To test hypotheses derived from this model, four experimental studies examined the influence of color saturation on health, naturalness and taste expectations. The results show that high color saturation increases both health and taste expectations, but only when the packaging color matches the color of the product's main ingredient. We further applied the model to plant-based meat alternatives, examining how color saturation influences naturalness perceptions in this product category. For these products, low saturation led to higher perceptions of naturalness because it signaled a lower degree of processing, without negatively affecting taste expectations. This research contributes to consumer research literature by offering a foundational theory for further research on the effects of packaging color on perceptions of health, naturalness and taste, harmonizing previous inconsistent findings. Practically, it provides actionable design recommendations for marketers of healthy products and plant-based meat alternatives.

German Abstract

In der heutigen schnelllebigen Zeit treffen Konsument*innen ihre Kaufentscheidungen häufig unter Zeitdruck und werden dabei von visuellen Verpackungsmerkmalen, wie der Verpackungsfarbe, beeinflusst. Aufgrund des steigenden Interesses an gesunder und nachhaltiger Ernährung wird es zunehmend relevanter zu verstehen, wie Verpackungsfarben die Wahrnehmung von Gesundheit, Natürlichkeit und Geschmack beeinflussen. Bisherige Forschungsergebnisse sind jedoch nicht immer konsistent. Außerdem gibt es keine umfassende Theorie mit zugrundeliegenden psychologischen Mechanismen, welche diesen Effekt erklärt. Aufbauend auf einer systematischen Literaturrecherche wurde die Cognitive Ecological Color Theory entwickelt, welche eine Basis für die Erklärung des Einflusses von Verpackungsfarbe auf die Produktwahrnehmung bildet. Die Theorie beschreibt drei unterschiedliche, kontextabhängige psychologische Mechanismen, durch welche Farbe Produkterwartungen beeinflussen kann: explizite Nutzung als Information, Aktivierung von Überzeugungen und mentale Simulation. Zur Testung der aus diesem Modell abgeleiteten Hypothesen wurden vier experimentelle Studien durchgeführt. Die Ergebnisse zeigten, dass eine hohe Farbsättigung sowohl die Gesundheits- als auch die Geschmackserwartungen steigerte, wenn die Verpackungsfarbe der Farbe der Hauptzutat entsprach. Außerdem haben wir das Modell auf pflanzliche Fleischalternativen angewandt und untersucht, wie die Farbsättigung die Wahrnehmung der Natürlichkeit in dieser Produktkategorie beeinflusst. Gering gesättigte Farben ließen pflanzliche Fleischalternativen natürlicher und weniger verarbeitet wirken, ohne die Geschmackserwartung zu mindern. Diese Arbeit leistet einen theoretischen Beitrag zur Konsumentenforschung, indem sie ein neues Rahmenmodell liefert und bisherige widersprüchliche Befunde erklärt. Gleichzeitig bietet sie praxisrelevante Handlungsempfehlungen für die Verpackungsgestaltung gesunder Produkte und pflanzlicher Fleischalternativen.

Introduction

Grocery shopping is part of the daily life of most Austrian consumers, with the majority visiting a supermarket daily or at least once a week (Statista, 2019). With an average shopping time of just 13 minutes in supermarkets with more than 10,000 products (Statista, 2024), consumers spend only 2-3 seconds to select a product on the shelf (ISPO, 2015). Therefore, the first impression of a product, often derived from its packaging, significantly influences product perception and purchase decisions. Especially when consumers are unfamiliar with the product and cannot evaluate it before purchase, visual cues are essential (Mai et al., 2016). Numerous studies have investigated the influence of different visual cues on consumer perception and product evaluation (e.g. Becker et al., 2011; Karnal et al., 2016; Kunz et al., 2020; Schnurr, 2019; Steenis et al., 2017; Velasco et al., 2014). For example, they found that consumers perceived colorful packages as tastier than neutral packages (Schnurr, 2019) and transparent packages as more sustainable than non-transparent packages (Steenis et al., 2017). The important role of packaging color was further demonstrated by Matthews et al. (2019) and Plasek et al. (2021), who found that packaging color is a dominant design cue compared to other visual cues such as background patterns or country of origin labels. This makes packaging color a critical element for marketing and product design.

Therefore, this dissertation focuses on how packaging color, specifically color saturation, influences consumers' product evaluations. Besides taste, which is often recognized as the most influential factor in consumers' food choices (Becker et al., 2011; Raghunathan et al., 2006), a product's perceived healthiness and naturalness also play crucial roles (Ferrer, 2021; Frey & Büning-Fesel, 2023; Mai et al., 2014). While the influence of color on taste expectations has been widely studied (see Spence, 2015 for a review), its influence on perceptions of healthiness and naturalness is less clear (e.g., Kunz et al., 2020; Mai et al., 2016; Schifferstein et al., 2019; Zhang et al., 2024). Thus, this dissertation investigates how packaging color saturation influences health and naturalness perceptions

while simultaneously considering its effect on taste expectations. Furthermore, it provides a theoretical framework that helps explain both established and conflicting findings in the literature.

In recent years, consumers have consistently reported a strong interest in healthy and balanced diets (Ferrer, 2021; Frey & Büning-Fesel, 2023). Sustainable consumption has also become increasingly important. According to the annual report on food trends, sustainable and plant-based consumption are the top two food trends, and healthy consumption is also among the top ten (Frey & Büning-Fesel, 2023). These topics are relevant not only on an individual level but also on a societal level. Obesity is a major risk factor for non-communicable diseases (Okunogbe et al., 2021) and animal protein production contributes significantly to greenhouse gas emissions (Vermeulen et al., 2012). Therefore, it is crucial to understand how packaging color influences consumer attitudes toward healthy and sustainable products. However, research on this topic is limited.

Most of the available studies have shown that color influences consumers' health perceptions of a product (e.g., Hallez et al., 2023; Huang & Lu, 2016; Kunz et al., 2020; Mai et al., 2016; Mead & Richerson, 2018; Plasek et al., 2021), but the direction of the observed effect is inconsistent. More concretely, studies varying color saturation of products yielded diverging results. In a study by Kunz et al. (2020), consumers expected soft drinks in highly saturated packaging to be healthier and tastier than those in lowly saturated packaging. In contrast, participants in a study by Mead and Richerson (2018) rated potato chips and nutrition bars in highly saturated packaging as less healthy than those in lowly saturated packaging. There is even less research on the effect of color on the perception of a product's naturalness (Schifferstein et al., 2019; Zhang et al., 2024). Since naturalness is an important decision criterion and can provide a competitive advantage (Rozin et al., 2004), it is crucial to understand how color influences the perception of naturalness. Previous research has found that lowly saturated products, such as carrots, are perceived as more natural but less appealing

than highly saturated products (Schifferstein et al., 2019). However, more research is needed to understand how packaging color affects perceptions of naturalness in the context of packaged foods. Previous studies have found that low packaging color saturation leads to lower taste expectations than high saturation (Kunz et al., 2020; Mai et al., 2016; Tijssen et al., 2017). Therefore, if low saturation enhances the perception of naturalness, it may come at the expense of tastiness. Conversely, using high saturation to signal taste may undermine perceived naturalness. Thus, it is essential to gain a deeper understanding of how packaging color influences naturalness and taste expectations. Moreover, previous research has not provided a profound theory with underlying psychological mechanisms that can explain the influence of color on consumers' perceptions of health and naturalness.

Therefore, the first objective of this dissertation is to provide a comprehensive review of current research on how packaging color influences adults' health perceptions of packaged foods. In addition, it seeks to establish a theoretical foundation with the Cognitive Ecological Color Theory to develop a more robust framework for constructing hypotheses about the relationship between packaging color and food health expectations, while encouraging further research in this area. The second objective of this dissertation is to test the implications of the theoretical framework in an experimental study and further extend the framework. By introducing color match as a moderator variable, I aim to explain how previous conflicting findings on the influence of color saturation on health expectations can coexist. The third objective is to extend the implications of the introduced Cognitive Ecological Color Theory to the field of naturalness perceptions. This is especially relevant in the case of plant-based meat alternatives, which are often perceived as highly processed and unnatural (Hoek et al., 2011; Michel et al., 2021). Since taste is also a key driver of consumer choice, and lower taste expectations are a major barrier of plant-based meat alternatives (Hoek et al., 2011) I seek to explain how packaging color saturation influences naturalness and taste judgments. In

addition, possible mediator variables are tested, and individual differences are considered.

Table 1 provides an overview of the research questions, research gaps and objectives.

Table 1

Overview of Research Questions, Research Gaps and Objectives

	Research Questions	Research Gaps	Objectives
1.	What are the psychological mechanisms through which packaging color influences consumer perceptions of product healthiness?	Lack of coherent theory of underlying psychological mechanisms explaining the influence of packaging color on health perceptions.	Conduct a systematic literature review and develop a theoretical framework that explains the effect of packaging color on health perceptions.
2.	How does packaging color saturation influence consumers' health and taste expectations, and what role does color match play in moderating these effects?	Explanation of inconsistent findings regarding the influence of color saturation on health perception.	Empirically test the proposed framework and examine color match as a potential moderator variable.
3.	How does packaging color saturation influence consumer perceptions of naturalness, and to what extent is this relationship mediated by the perceived processing level of the product?	Potential negative interference of color saturation as a naturalness cue on taste expectation.	Extend the theoretical framework to the field of naturalness perception. Test perceived processing level as a mediator and color hue and positive affect intensity as potential moderators.

To address these research questions, my colleagues and I conducted a systematic literature review and developed a theoretical model based on theories from cognitive psychology. To test the model, we conducted several online studies with German-speaking consumers. The research is reported in three related research articles, two of which have been published. In all three studies, I took the lead in developing the research and preparing the manuscripts. A detailed overview of the individual author contributions is provided in the appendix (Table 2). We followed the principles of open science by pre-registering most of the studies and providing detailed descriptions of all study procedures.

The first objective of my dissertation, and the foundation for my further research, was to review the literature and develop a theoretical model of the influence of color on consumer health perceptions, which is addressed in *Article I* and summarized in this dissertation in Chapter 1, “Psychological mechanisms underlying the influence of color on health perceptions.” We conducted a systematic literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009) for studies that analyzed the influence of packaging color on consumer health perceptions of packaged foods for adults. Based on these findings, we proposed the Cognitive Ecological Theory of Color as a starting point for explaining the influence of packaging color on consumers’ health perceptions with three, not mutually exclusive, mechanisms: (1) color as an explicit signal for health; (2) color as trigger of beliefs that indirectly influence health perception; (3) color as trigger of mental stimulation that influence health perceptions.

Article II addressed the second objective and is summarized in this dissertation in Chapter 2, “How color match moderates the influence of color saturation on health perceptions.” Building on existing research on the influence of color saturation on consumers’ health expectation and the introduced Cognitive Ecological Theory of Color, we propose that the influence of color saturation on health expectation depends on the color match between the packaging color and the color of a product's main ingredient. Two studies with German-speaking consumers confirmed that moderate versus low color saturation increases consumers' health and taste expectations when the packaging color matches the color of the product's main ingredient. The positive effects of saturation on health and taste expectations were reduced or even disappeared when there was no color match.

In *Article III*, I addressed the third objective and summarized the findings in Chapter 3 of this dissertation, entitled “How color saturation shapes naturalness perceptions of plant-based meat alternatives.” We proposed that naturalness perceptions of plant-based meat alternatives are influenced by packaging color saturation and that perceived processing level

plays a mediating role in this effect. We conducted two studies with German-speaking consumers and found that products with low versus high color saturation were perceived as more natural, without negatively affecting taste expectations. Furthermore, this relationship was mediated by the perceived processing level of the product, and the strength of the effect differed between hues. In addition, we observed individual differences between subjects with different levels of positive affect intensity.

Table 3

Overview of Articles, Key Results and Research Designs

Article	Key Results	Research Design
<i>Article I: Steiner & Florack (2023)</i>	Based on the summary of empirical findings, the Cognitive Ecological Theory of Color with three context-dependent and not mutually exclusive pathways was developed: (1) color as explicit signal, (2) color as trigger of beliefs and (3) color as trigger of mental stimulations	Systematic literature review following PRISMA guidelines
<i>Article II: Steiner, Kunz & Florack (2024)</i>	Color match moderates influence of packaging color on consumers health and taste expectation. Moderate versus low color saturation increases consumers health and taste expectation, when the packaging color matches the color of the product's main ingredient.	Two online experiments with a 2×2×3 within-subjects design were conducted in Germany, Austria and Switzerland (total $N = 648$).
<i>Article III: Steiner, Kunz & Florack (2025)</i>	Low versus high packaging color saturation for plant-based meat alternatives increases perceived naturalness, mediated by perceived processing level and moderated by color hue. No influence of color saturation on taste expectations was observed.	Two online experiments with a 2×2×2 mixed-design were conducted in Germany, Austria and Switzerland (total $N = 762$).

This dissertation contributes to consumer research by providing a comprehensive review of the literature on how packaging color influences health perceptions. It creates a theoretical foundation for a more comprehensive framework to explain the impact of color on consumer perceptions. In addition, it introduces hue as a moderating variable, highlights its

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contextual dependence, and offers a possible explanation for previous inconclusive findings.

This dissertation provides valuable insights for future research and essential guidance for marketers of healthy and sustainable products.

Chapter 1 – Psychological Mechanisms Underlying the Influence of Color on Health Perceptions

Healthy eating is of considerable importance to consumers, as can be seen in current food consumption trends and the increased willingness to pay for healthy products (Frey & Büning-Fesel, 2023; Nielsen, 2015). Packaging design and its visual cues significantly influence consumers' attitudes and expectations towards a product (Labrecque et al., 2013; Matthews et al., 2019; Plasek et al., 2021). In particular, color is a dominant visual cue and numerous studies have investigated the influence of color on taste expectations, but research on the influence of color on health perceptions remains limited and yields conflicting results (Huang & Lu, 2015; Kunz et al., 2020; Mai et al., 2016; Mead & Richerson, 2018; Plasek et al., 2021). Furthermore, previous studies have not provided a coherent theory with underlying psychological concepts to explain the influence of package color on health perceptions.

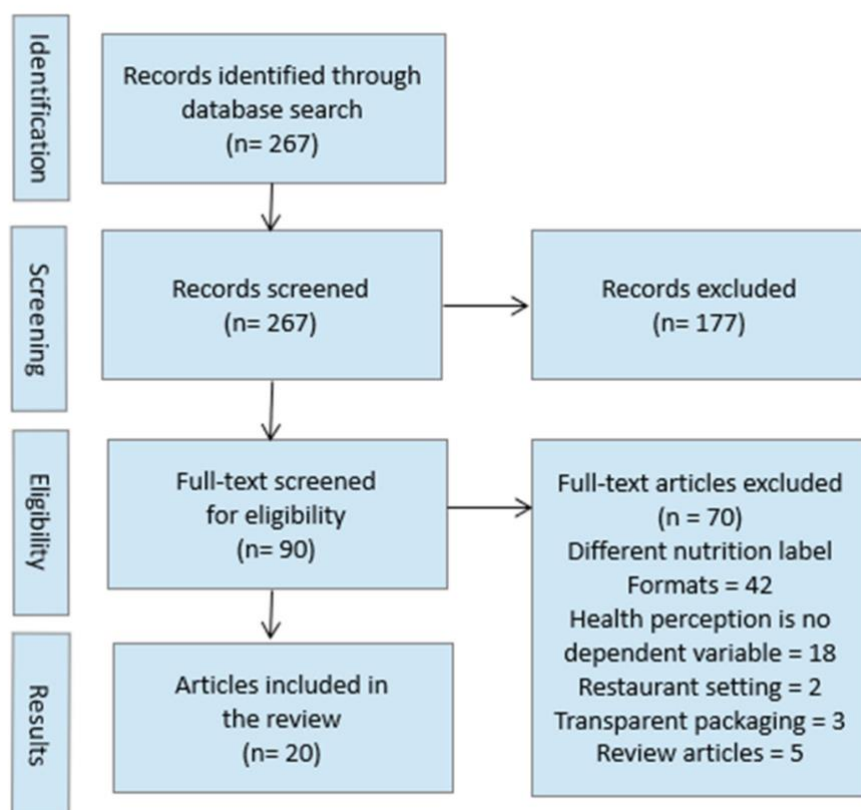
Therefore, the objective of *Article I* (Steiner & Florack, 2023) was to systematically review the literature on the influence of packaging color on health perceptions, develop a theoretical framework with underlying psychological mechanisms, and identify potential moderating variables and suggestions for future research. We observed that most of the reviewed studies found that different aspects of packaging color, such as hue, saturation, and brightness, influence consumers' health perceptions. However, the direction of the effect was not consistent. We suggested that context plays a crucial role and may help explain the varying findings. Based on the reviewed literature, we proposed the Cognitive Ecological Color Theory, a model with three context-dependent pathways that can help explain how color influences consumer perceptions of health: (1) the explicit use of color as information, (2) color as a trigger of beliefs, and (3) color as a mental stimulus.

In the first part of *Article I*, we conducted a literature search using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009) (see Figure 1). We defined eligibility criteria, focusing on studies that examined

packaging color as an independent variable and health ratings as a dependent variable, and observed the effects on adult consumers for packaged foods. A systematic search of Scopus yielded 267 results, which we screened in several steps to identify 20 articles with 35 individual studies that examined the influence of packaging color on health perceptions.

Figure 1

PRISMA Chart of Search Strategy (Article 1)



To report the findings, we grouped the relevant studies based on the manipulated color aspects. The first strand of literature examined how *warm hues*, such as red, versus *cool hues*, such as blue or green, influence consumers' health expectations of a product. In most studies, consumers associated cool packaging hues with higher health expectations compared to warm packaging hues (Hallez et al., 2023; Karnal et al., 2016; Plasek et al., 2021; Sant'anna et al., 2022). In contrast to these studies, Marque de Rosa et al. (2019) found that participants rated cookies in red-to-yellow packages as healthier compared to blue-to-green packages, and Sucapane et al. (2021) found no differences between green and red hues on healthiness

ratings. Huang and Lu (2016) distinguished between hedonic products, which are mainly consumed for affective pleasure, and functional products, which are consumed to satisfy psychological needs. In their study, the influence of color hues on healthiness perceptions was only observed for the functional product category. Furthermore, in Wąsowicz's (2015) focus groups, participants stated that color associations are context dependent. According to the research, in the pizza category, red was associated with fruits and vegetables and therefore perceived as healthy. In comparison, in the yogurt category, red was associated with artificial flavors and perceived as unhealthy (Wąsowicz et al., 2015). Overall, most of the reviewed studies found that cool hues led to higher health perceptions than warm hues. However, some studies found no effect or an inverse effect of packaging color hue on healthiness judgments. These results suggest that the meaning of color hues varies across product categories and contexts.

The second strand of literature analyzed the influence of color characteristics other than hue, such as *saturation and brightness*, on consumers' healthiness expectations. Higher compared to lower color brightness was associated with higher healthiness perception (Mai et al., 2016). Results regarding the influence of color saturation on healthiness perceptions have been mixed. While Mead and Richerson (2018) found that high compared to low color saturation led to a lower healthiness perception, Kunz et al. (2020) found that high compared to low color saturation led to a higher healthiness perception, and this effect was mediated by perceived product freshness. These findings suggest that high color saturation may enhance or diminish health perceptions, depending on the context and other moderator variables.

The third strand of literature manipulated *more than one aspect of color*. Participants associated packages with cool colors (blue, green), higher brightness and lower saturation as healthier, but less attractive than packages with warmer colors (red), lower brightness and higher saturation (Tijssen et al., 2017). Schnurr's (2019) study demonstrated that colorful packaging elements (such as colored bubbles) on food products can influence consumers'

expectations of healthiness and taste, with colored packaging leading to lower perceived healthiness and higher expected enjoyment, especially when paired with health-focused messaging. In sum, the findings imply that consumers' health perceptions are influenced by multiple color attributes, and that contextual factors, such as consumption motives, moderate this effect.

The last strand of literature examined the *effect of color of front-of-pack nutrition labels*. Researchers demonstrate that color coding, particularly the use of red and green, can help consumers identify healthier food options (Aschemann-Witzel et al., 2013; Pettigrew et al., 2020). In addition, label color can directly influence perceived healthiness. In Schuldt's (2013) study, participants rated chocolate bars with a green calorie label as healthier than chocolate bars with a red calorie label. However, these findings could not be replicated in the Vasiljevic et al. (2015) study. Cabrera et al. (2017) examined the effects of warning label color and shape on health perceptions and found that color had a stronger influence than shape. Products with a red octagonal warning label were perceived as the least healthy combination, likely due to its association with stop signs. Overall, the findings demonstrate that color-coded labels, whose meanings are often learned or derived from other contexts, can aid decision-making.

A Cognitive Ecological Color Theory

The conducted literature review confirmed that most studies found an influence of packaging color on consumers' health perceptions. The effects of color vary depending on the context, product category, country, and individual differences (Huang & Lu, 2016; Mai et al., 2016; Pettigrew et al., 2020; Schnurr, 2019; Wąsowicz et al., 2015). In the absence of theoretical explanations for these effects, *Article I* introduced the Cognitive Ecological Color Theory as a starting point for developing a more comprehensive theory.

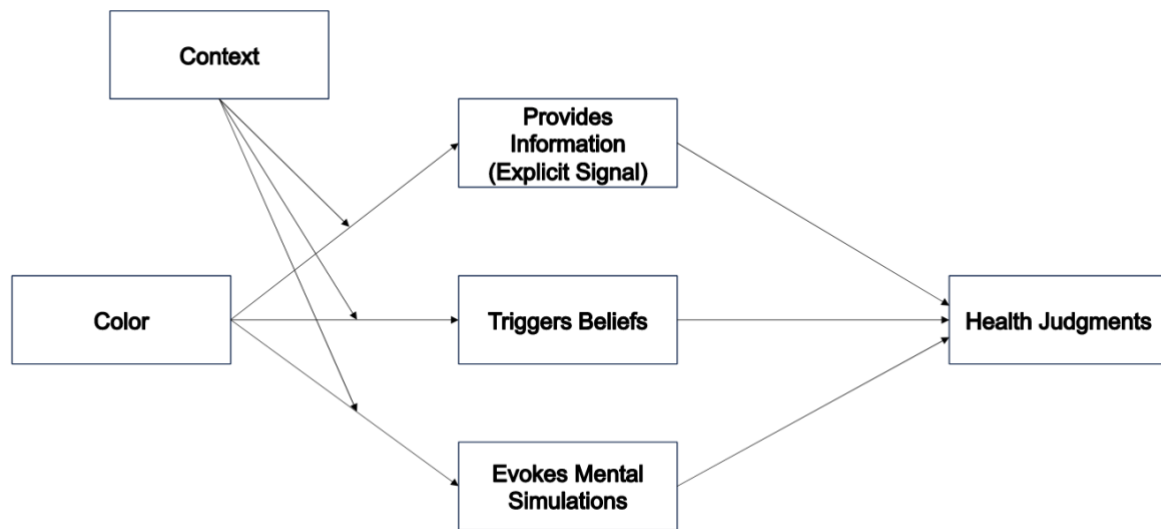
The proposed approach is based on cognitive ecological theories, which suggest that color triggers intrapsychic processes that are influenced by environmental, cultural, and

product-specific factors (Fiedler, 2014; Kunz et al., 2023). Like the color-in-context theory (Elliot & Maier, 2012), it suggests that the meanings of colors vary depending on the situation. For example, red may signal danger in competitive situations but attractiveness in romantic contexts. While the color-in-context theory (Elliot & Maier, 2012) explains how color meanings shift across contexts through direct biological and learned associations, the Cognitive Ecological Color Theory also incorporates indirect effects, such as colors triggering beliefs and mental stimulation. Furthermore, it emphasizes these effects' influence on consumer perceptions. The Cognitive Ecological Color Theory suggests that while humans have certain biological predispositions to associate colors with attributes, they also adapt and refine color meanings through learning and experience. This learning can be declarative, as consumers acquire explicit knowledge about the meaning of a color through communication or observation. In addition, implicit meanings of colors are learned through associative learning, which is driven by principles such as contiguity, frequency, and distinctiveness (Amsteus et al., 2015; Grossman & Wisenblit, 1999).

Building on the cognitive ecological framework, we propose that packaging color can influence consumers' health perceptions through three possible pathways: explicitly as an informational cue (e.g., green signals healthiness), indirectly by triggering beliefs (e.g., fun colors may imply enjoyment, and because of the unhealthy = tasty belief consumers associate it with unhealthiness), and implicitly by evoking mental stimulation (e.g., dark colors produce feelings of heaviness that translate into unhealthiness perceptions). A single color can influence perceptions of health through multiple pathways, which can be either congruent or conflicting. While congruent pathways enhance the color effect, conflicting effects can reduce the overall impact on perception.

Figure 2

Model Showing Three Pathways of Color Effects on Perceptions of Healthiness (Article I)



The Use of Color as Information: Using this pathway, consumers consciously or unconsciously associate a color with learned meanings. They use color information to make health-related decisions, as demonstrated by the effectiveness of colored traffic light nutrition labels (Pettigrew et al., 2020). Consumers have acquired the meaning of a color as declarative knowledge, e.g., they know that green means “go” and would be able to recall and articulate the meaning of the color when needed. These meanings are learned through the repeated presence of a color hue with health cues, as well as through social learning and communication (Cabrera et al., 2017; Hanss et al., 2012; Wąsowicz et al., 2015). Such meanings represent shared knowledge that may vary across cultures and product categories (Pettigrew et al., 2021; Wąsowicz et al., 2015). For example, consumers may have learned that a black package design signals high-protein content and healthiness in the context of yogurt, but signals indulgence and unhealthiness in the context of chocolate.

Colors as Triggers of Beliefs: Colors can influence health judgments by triggering lay beliefs. These beliefs may arise from personal experience (Kunz et al., 2023), media, cultural norms (Turnwald et al., 2022), or the application of higher-order beliefs. For example, colorful and vivid packaging designs may lead to the application of the unhealthy = tasty

belief (Raghunathan et al., 2006) because such design cues signal fun and enjoyment. This, in turn, may reduce health perceptions (Schnurr, 2019) by activating the belief that healthy eating requires effort rather than enjoyment, reflecting the belief that morally good goals require sacrifice.

Colors Influencing Mental Stimulations: The third pathway proposes that color can also influence mental stimulations that evoke specific feelings or associations (Huang & Lu, 2016; Kunz et al., 2020; Schnurr, 2019). We suggest that consumers mentally simulate the eating experience when choosing a product (Muñoz-Vilches et al., 2020), as for example participants potentially imagined drinking fruit juices in Kunz et al.'s (2020) study. In this study, color saturation served as a cue for freshness. Imagining consuming fresh, highly saturated fruits can elicit pleasant taste expectations and positive health perceptions simultaneously. This is because taste and health judgments likely rely on the same simulation mechanism. Imagining eating a fresh fruit leads to high health and taste expectations, while imagining eating an unripe or rotten fruit triggers feelings of disgust. Therefore, high color saturation can enhance taste and health perceptions by facilitating the simulation of fresh fruit (Kunz et al., 2020). Furthermore, colors can evoke emotions similar to those associated with healthy or unhealthy eating. Cool colors, such as green and blue, evoke feelings of safety and relaxation (Clarke & Costall, 2008), emotions often associated with healthy eating. In comparison, warm colors, such as red and orange, evoke feelings of arousal and excitement (Clarke & Costall, 2008), emotions more likely to be associated with indulgent and unhealthy eating. Imagining the consumption of a product presented in a calming green hue may evoke feelings associated with wellness and self-care, thereby enhancing perceived healthiness. This may explain the findings of previous studies that cool colors are perceived as healthier than warm colors (Hallez et al., 2023; Huang & Lu, 2015; Schuldt, 2013). Furthermore, colors can influence weight perceptions, with lighter colors such as light blue evoking a sense of lightness, which translates into healthier product perceptions (Mai et al., 2016).

Discussion Chapter 1

The main objectives of *Article I* were to review the current literature on the influence of color on consumers' health perceptions and to propose a theoretical model with underlying psychological principles that explains these effects. Although most studies have demonstrated that packaging color influences consumers' health perceptions, the direction of the influence has been inconsistent, and research has lacked a comprehensive theory to explain these effects. Based on existing findings, *Article I* introduces the Cognitive Ecological Color Theory as a foundational framework with underlying psychological mechanisms upon which to build. We propose three context-dependent pathways that explain how color influences health perceptions: (1) the use of color as information; (2) beliefs triggered by color; (3) and mental stimulation evoked by color. The Cognitive Ecological Color Theory proposes that color effects are not universal but context-dependent. It describes psychological mechanisms that can explain how color influences product perceptions and provides a basis for reconciling previously inconsistent findings. As a foundational framework, it allows for the generation of further hypotheses.

A strength of *Article I* is that it provides a comprehensive and methodologically sound overview of empirical research by following the PRISMA guidelines and including studies across various product categories and countries. Furthermore, the introduced Cognitive Ecological Color Theory can help to clarify previously inconsistent findings in the literature and encourages a more nuanced understanding of context-dependent effects. For example, the study by Kunz et al. (2020) found that high versus low color saturation of soft drinks led to higher freshness expectations, which in turn led to higher health and taste ratings. However, other studies have found that higher saturation can lead to lower health expectations (Mai et al., 2016; Mead & Richerson, 2018). We argue that it is important to consider which pathway was activated during the evaluation. If the color of the soft drink represents the color of the main ingredient of the product, there may be a simulation of the consumption experience, and

therefore higher saturation may signal higher freshness and lead to higher healthiness and higher tastiness expectations. If the packaging color does not match the ingredient color, simulation does not occur, and a different pathway is activated. For example, in previous studies that found a negative influence of color saturation on health perceptions for potato chips (Mead & Richerson, 2018), the saturated color may have been used to signal fun and enjoyment, and the "unhealthy = tasty" belief may have been activated. Another strength of the Cognitive Ecological Color Theory is that it allows for the development and empirical testing of new hypotheses. For example, we predict that the use of color as information emerges when consumers have learned specific color-health associations through repeated exposure (e.g., light blue = low fat for milk products). Belief-based effects may occur when color triggers lay beliefs, such as the belief that more expensive products are healthier (Haws et al., 2017) and therefore color attributes that signal premiumness (e.g. black or gold) may lead to higher health perceptions. Simulation effects may occur when a light color, such as light beige, creates a feeling of lightness, and this feeling is transferred to the product perception, leading to a higher judgment of healthiness.

Article I contributes to the existing literature by focusing specifically on the influence of packaging color on health perceptions, a topic that has received limited research attention. It further advances theoretical development by proposing a multi-pathway framework grounded in cognitive psychology to understand and make predictions about how color may affect health judgments. In addition, it attempts to provide explanations for inconsistent findings, suggests moderating variables, and lays the groundwork for future research.

One limitation of *Article I* is that the majority of the reviewed studies rely on self-report measures, such as questionnaires or focus group discussions, which may not fully capture implicit or spontaneous consumer responses. Physiological and behavioral data are also underrepresented, limiting insights into unconscious mechanisms. Moreover, the

proposed theoretical pathways (e.g., mental simulation, belief triggering) require further empirical validation.

In conclusion, our findings demonstrate that packaging color plays a critical role in shaping consumers' health perceptions, often guiding decisions made under time constraints and limited information. It is critical for marketers to gain a deeper understanding of these effects in order to make healthy products more appealing. Cognitive Ecological Color Theory provides a foundational framework for understanding how color influences health judgments across products, contexts, and cultures. Further research was needed to empirically validate the proposed framework and explore its broader implications. We applied the framework and addressed the proposed research questions in *Article II*.

Chapter 2 – How Color Match Moderates the Influence of Color Saturation on Health Perceptions

While the main objectives of *Article I* were to conduct a thorough literature review of empirical studies that investigated the influence of color on health perception and to develop a theoretical model as a foundation for explaining this effect, in *Article II* (Steiner et al., 2024) we attempted to test the implications of the theoretical framework in an experimental study. In doing so, I addressed the second objective of my dissertation, which was to propose possible explanations for the inconsistent findings regarding the influence of color saturation on consumers' health and taste perception (Kunz et al., 2020; Mai et al., 2016; Tijssen et al., 2017). Building on the Cognitive Ecological Color Theory, we propose that the same color cue (e.g., saturation) might activate different pathways under different conditions, resulting in different effects. For instance, the mental simulation pathway is activated when there is a color match between the packaging and the product's main ingredient. In such cases, consumers are likely to mentally simulate the consumption experience, using a high color saturation as a cue for freshness. Since fresh fruits are typically perceived as healthier and tastier than unripe or spoiled ones, we hypothesize that higher saturation will lead to higher healthiness and tastiness expectations. Conversely, when there is no color match, other mechanisms than simulation may occur, and the influence of saturation on health and taste expectations is expected to be reduced or absent.

To test these assumptions, we conducted two experimental studies with low- and high-processed drinks. Our objective was to investigate how color saturation influences health and taste expectations, and whether this effect is moderated by color match. Specifically, we proposed that consumers apply a saturation-freshness association when the packaging color matches the color of the product's main ingredient (Kunz et al., 2020). In this case, we expected that moderate versus low saturation would lead to higher tastiness and healthiness ratings. In contrast, when the packaging color did not match the main ingredient, we expected

that an alternative pathway, such as learned associations or lay beliefs, would be used rather than simulation. These hypotheses are based on Cognitive Ecological Color Theory, which identifies context-dependent psychological processes that may explain how color influences health perceptions.

While many studies have found a positive influence of color saturation on consumers' taste perception, findings on the influence of color saturation on health expectations are mixed (Kunz et al., 2020; Mai et al., 2016; Mead & Richerson, 2018; Tijssen et al., 2017). Kunz et al. (2020) observed that highly saturated packaging colors lead to higher health and taste expectations than less saturated packaging colors, and that this effect is mediated by a saturation-freshness association. They argue that consumers have learned through evolution that foods with high nutritional content and flavor have a higher saturation compared to unripe or spoiled foods and therefore expect highly saturated products to be healthier and tastier than lowly saturated products (Kunz et al., 2020).

In contrast, another stream of research found that a high versus low packaging color saturation leads to lower healthiness expectations (Mai et al., 2016; Mead & Richerson, 2018; Tijssen et al., 2017). Consumers expected products such as cream cheese, cereal bars, potato chips, and sausages in highly saturated packages to be tastier but less healthy than those in less saturated packages (Mai et al., 2016; Mead & Richerson, 2018). In these studies, the saturation-freshness association cannot explain the influence of color saturation on taste expectations and other mechanisms apply. An alternative explanation is that color is used as a metaphor and reduced color saturation signals reduced content, such as reduced fat or sugar. Because these ingredients enhance flavor but are considered unhealthy, their perceived absence could make the product appear healthier but less tasty (Mai et al., 2016). In addition, consumers may have learned through experiences that lowly saturated colors are commonly used for healthy but not indulgent products (Steiner & Florack, 2023). Another possible explanation is that highly saturated colors are associated with excitement and pleasure

(Labrecque et al., 2013). Since enjoyment is often seen as incompatible with valued societal goals such as healthy eating (Raghunathan et al., 2006), this may weaken health perceptions of highly saturated products. Overall, while previous research has shown that saturation increases taste expectations, its effects on health judgments remain mixed.

We introduced color match as a possible moderator to explain the divergent effects. Within the framework of the Cognitive Ecological Color Theory, we suggest that repeated sensory experiences shape associations between visual cues, such as color saturation, and product perceptions, such as taste and health expectations. This idea is supported by the phenomenon of cross-modal correspondences (Spence, 2011), which suggests that associations between different sensory modalities, such as visual cues and taste, develop through repeated experiences of these senses interacting. For example, observing how food color saturation changes during ripening or spoilage shape associations between color attributes and food qualities, such as taste and freshness (Maga, 1974; Tu et al., 2016). When the packaging color matches the color of the product's main ingredient, the mental simulation pathway is likely to be activated, and the learned associations between color saturation and health and taste expectation are applied. Conversely, when there is no color match, simulation is less likely to occur, and we expect other cues conveyed by color saturation to play a more important role in shaping health and taste expectations.

In *Article II*, we investigated how packaging color saturation influences consumers' health and taste perceptions, and whether these effects are moderated by a color match between the packaging and the product's main ingredient. Two studies were conducted with adults from Germany and Austria using fruit juices (low processed product group) and hydration drinks (high processed product group). Both studies used a 2 (color saturation: low vs. medium) x 2 (color match: match vs. no match) x 3 (flavor: orange vs. mango vs. apple) within-subject design. Participants viewed drink packages of three different flavors with either medium or reduced (~30%) color saturation and a matching or mismatching hue (e.g.,

orange juice in orange vs. red packaging). In two separate rating blocks, they rated the healthiness and tastiness of each presented product on a 10-point scale. A linear mixed model analysis was used to account for the nested and intercorrelated ratings of multiple drink packages by the same participants, in terms of healthiness and tastiness. In addition, we controlled for age, gender, body mass index, and socioeconomic status in both studies.

In Study 1 ($N = 250$), we examined whether high versus low packaging color saturation of fruit juices leads to higher health and taste expectations, as well as the moderating role of color match. Participants rated the juices in medium-saturated packages as healthier than those in less saturated packages when the packaging color matched the color of the product's main ingredient. When there was no match, no effect of color saturation on health expectations was observed. Regarding taste expectations, participants rated the fruit juices with medium versus low saturation as tastier in both the matching and non-matching conditions. However, the effects were greater in the matching condition. Thus, Study 1 demonstrated the moderating role of color match on effects of color saturation on health and taste expectations.

Study 2 ($N = 398$) aimed to strengthen the findings of Study 1 by replicating the procedure with hydration drinks. Since Study 1 focused on fruit juices, a minimally processed product group in which the freshness-healthiness/tastiness link may be more relevant, it was important to analyze whether consumers also rely on color associations in more processed product groups, such as hydration drinks. In line with Study 1, consumers expected medium-versus low-saturated hydration drinks to be healthier if there was a color match. However, when the packaging color did not match the color of a product's main ingredient, medium-saturated packages were rated as less healthy than low-saturated packages. These results demonstrate that color saturation can either enhance or reduce perceived healthiness, depending on color match. Furthermore, medium- versus low-saturated packages were expected to be tastier if a color match existed. In the non-match condition, no influence of

color saturation on taste expectation was observed. Study 2 confirmed the moderating role of color match on the influence of color saturation on consumer health and taste expectations.

This research is consistent with the cross-modal correspondence principle, suggesting that the effect of color saturation depends on its hue and is learned through repeated associations with beverage taste.

Discussion Chapter 2

An important implication of the Cognitive Ecological Color Theory was that the influence of packaging color on product perception is context-dependent and different psychological pathways may be activated. This perspective helps to reconcile inconsistent findings on how color saturation affects consumers' health perceptions. Previous studies have found mixed results regarding the influence of color saturation on consumers' health perceptions (Kunz et al., 2020; Mai et al., 2016; Mead & Richerson, 2018; Tijssen et al., 2017). While some studies found that consumers perceive products in highly saturated packages to be healthier than those in lowly saturated packages (Kunz et al., 2020), other studies reported the opposite, indicating that low color saturation leads to higher health perceptions (Mai et al., 2016; Mead & Richerson, 2018; Tijssen et al., 2017).

In the present study, we found evidence supporting the idea that the mental simulation pathway is activated if there is a match between the packaging color and the color of the product's main ingredient. In this case, participants simulate the consumption experience and use color saturation as a cue for freshness, which influences their health perceptions and tastiness expectations. This is in line with the study by Kunz et al. (2020), who found that consumers perceived highly saturated colors as healthier and tastier than lowly saturated colors, and that this effect was mediated by the perceived freshness of a product. Results from two experimental studies suggest that the influence of color saturation on healthiness and taste expectations depends on color match. Medium versus low color saturation led to higher healthiness and tastiness expectations, but only when the packaging color matched the color

of the product's main ingredient. When there was no color match, color saturation effects were reduced or even reversed. We propose that in this case, simulation will not occur. Instead, a different pathway may be activated, such as color serving as a trigger for lay beliefs. Saturated colors may be associated with fun, and this association may activate the lay belief that fun is linked to unhealthiness. These findings highlight that color saturation can have both positive and negative effects on health expectations depending on color match and thus provide a possible explanation for previous conflicting results.

The methodological strengths of our studies in *Article II* include the controlled manipulation of color saturation and color match across conditions and the use of realistic drink packaging stimuli. This allowed us to effectively isolate the effects of color on healthiness and tastiness ratings, while ensuring ecological validity. We tested our hypotheses across two distinct product groups (fruit juices and hydration drinks), differing in levels of processing, to increase the generalizability of the results. For Study 2, a pretest confirmed that hydration drinks were perceived as less natural than fruit juices, in line with the study's hypothesis regarding product group differences. Furthermore, the preregistration of Study 2 increased transparency and minimized biases in hypothesis testing.

One limitation of *Article II* is that although we analyzed products with different processing levels, there are many more product categories. As consumers' learned associations with color hue and saturation may vary across categories (Huang & Lu, 2016), the findings need to be confirmed across a broader range of product categories. Moreover, we only measured participants' expectations of healthiness and tastiness and did not examine how these expectations translate into actual purchase behavior. Future research should investigate these effects across a broader range of product types and incorporate choice tasks or behavioral measures to assess the relevance of these effects to purchase decisions.

Overall, *Article II* adds to the literature on color effects by demonstrating that saturation can serve as an overlapping cue influencing both health and taste expectations. It

tests an important implication of the Cognitive Ecological Color Theory, suggesting that saturation effects depend on color match by activating different psychological pathways. The findings suggest that previous mixed findings can be partially explained by considering the moderating role of color match.

Chapter 3 – How Color Saturation Shapes Naturalness Perceptions of Plant-Based Meat Alternatives

In *Article III* (Steiner et al., 2025), I aimed to further extend the Cognitive Ecological Color Theory established in *Article I*, focusing on the simulation pathway. We propose that color saturation can serve as a metaphor and help consumers judge abstract product attributes such as naturalness or processing degree. Unlike the previous articles, *Article III* shifted the focus from health to naturalness perceptions, specifically concentrating on plant-based meat alternatives. Despite their potential as a sustainable alternative to meat products, these products face lower consumer acceptance because they are often perceived as unnatural and less tasty (Hoek et al., 2011). To address the third objective of my dissertation, *Article III* examines how packaging color influences consumers' naturalness perceptions and taste expectations for plant-based meat alternatives, and whether perceived processing degree mediates the effect on naturalness perception. In addition to its theoretical contribution, *Article III* addresses a relevant practical question by exploring how packaging design can support consumer acceptance of plant-based meat alternatives. Before conducting the study, we interviewed marketing professionals and analyzed packaging designs of such products in Austria, focusing on color saturation. Our analysis revealed neither a strong preference among professionals nor a consistent design strategy, indicating uncertainty within the industry about the most effective use of color saturation.

We addressed the research question in two studies, assuming that for the relatively novel category of plant-based meat alternatives the simulation path will be activated, and consumers use color like a metaphor. We believe that higher color saturation signals "more," such as "more ingredients and flavors", which may increase taste expectations, or "more processing", which may decrease perceived naturalness. Additionally, metacognitive experiences, such as processing fluency, may play a role as well. Color hues strongly associated with nature, such as green, may be processed more fluently when making

judgments about naturalness, leading to higher overall evaluations. We also investigated whether perceived processing degree mediates the influence of color saturation on naturalness perceptions. Since the color green is often associated with nature (Clarke & Costall, 2008), we hypothesized that increased green saturation may increase naturalness perception by signaling "more nature". Furthermore, we believed that individuals with higher positive affect intensity, who are more sensitive to sensory stimuli (Moore & Konrath, 2015), would experience stronger effects of color saturation on their naturalness and taste expectations.

Despite the shift in consumer preferences towards sustainable and reduced meat consumption (Cloppenburg, 2024), meat alternatives are perceived more negatively than their meat counterparts and represent a niche market (Hoek et al., 2011; Lea & Worsley, 2003; Michel et al., 2021). They face major consumption barriers, including lower sensory appeal compared to traditional meat products and the perception of being overly processed and less natural (Hoek et al., 2011; Michel et al., 2021). Since consumers often prefer natural products because they associate them with healthiness, sustainability, and moral superiority (Rozin et al., 2004), the perceived unnaturalness of plant-based meat alternatives negatively affects consumer acceptance and limits their market success. It is important to note that perceptions of naturalness are often more strongly influenced by a product's perceived processing history and methods than by its actual content (Rozin, 2005, 2006).

Packaging elements such as color saturation may function as visual metaphors that simplify the mental representation of a product's naturalness or processing level, thereby shaping how plant-based meat alternatives appear to consumers. We assumed that color saturation would influence consumer perceptions like a metaphor for extent and intensity, based on previous research that found high saturation to be associated with greater weight, size, and potency (Hagtvedt, 2020; Hagtvedt & Adam Brasel, 2017; Labrecque et al., 2025; Walker et al., 2010). We argue that highly saturated packaging creates a stronger impression of human intervention and use of more resources, leading consumers to perceive the product

as more processed and less natural. Only a few studies have investigated the influence of saturation on the perception of naturalness. They found that images of carrots and tourism materials with low saturation were rated as more natural than those with high saturation (Schifferstein et al., 2019; Zhang et al., 2024). Furthermore, a product's perceived processing degree plays a central role in shaping naturalness judgments. Consumers associate high levels of processing with lower levels of naturalness, even when the content of the product remains unchanged (Rozin, 2006). We argued that high color saturation may signal a greater degree of human intervention and processing. Therefore, high compared to low color saturation should lead to a higher perceived level of processing, which in turn would mediate the influence of color saturation on naturalness judgments.

Although naturalness is generally associated with positive taste expectations (Rozin, 2006), research suggests that higher color saturation may enhance taste expectations by signaling greater ingredient concentration and flavor intensity. Studies have shown that consumers perceive products with more saturated packaging as tastier than products with less saturated packaging (Kunz et al., 2020; Mai et al., 2016; Tijssen et al., 2017). We hypothesized that higher saturation would trigger the perception of higher ingredient and flavor content, leading to higher taste expectations.

Previous research has shown that the effect of color saturation on taste expectation is influenced by hue, with higher saturation increasing flavor perception when the color matches the expected flavor (Spence et al., 2010). We argued that different hues carry distinct meanings and that these meanings are strengthened by higher color saturation. Specifically, green is associated with naturalness (Clarke & Costall, 2008), so high saturation of green packaging may increase naturalness perceptions, whereas high saturation of unrelated colors, such as yellow, may signal artificial ingredients and decrease naturalness perceptions. Thus, we hypothesized that the impact of color saturation on naturalness and taste expectations would be weaker or reversed when using a green versus yellow packaging hue.

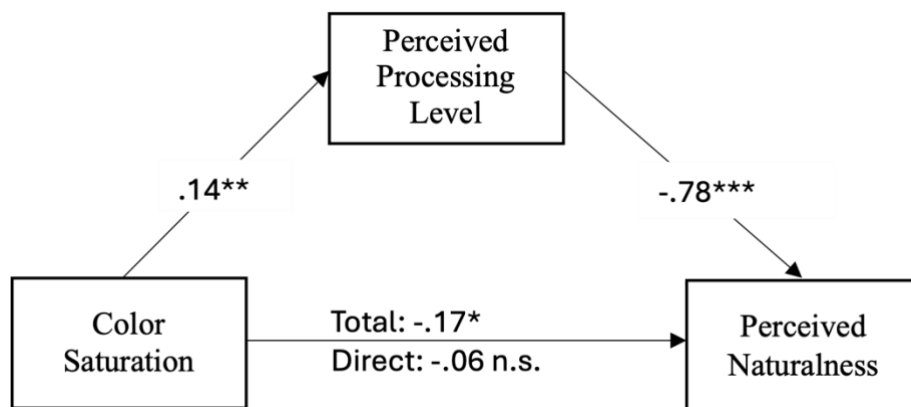
Furthermore, we expected that the effects of color saturation would vary across individuals. Research by Moore and Konrath (2015) showed that individuals with high affect intensity, particularly positive affect intensity, are more susceptible to vivid advertisements and visual stimuli. These individuals experience emotions more deeply, engage in greater mental elaboration, and derive more enjoyment from sensory-rich experiences (Larsen et al., 1996; Larsen & Diener, 1987; Moore & Homer, 2000). As a result, they are more influenced by visual cues, such as packaging color (Moore & Konrath, 2015). Given the relevance of positive affect intensity in food evaluations, we expected the influence of packaging color on naturalness and taste expectations to be stronger for individuals with high versus low affect intensity.

In *Article III*, we examined how packaging color saturation influences naturalness and taste expectations and whether these effects are moderated by color hue and mediated by perceived processing degree. In addition, in Study 2, we also investigated the moderating role of positive affect intensity. We conducted two studies with participants from Germany, Austria, and Switzerland using plant-based meat alternatives from widely consumed product groups. The studies employed a 2 (color saturation: high vs. low) $\times$ 2 (color hue: green vs. yellow) $\times$ 2 (brand A vs. brand B) experimental design, with color saturation as a within-subject factor and color hue as a between-subject factor. Depending on the condition, participants viewed plant-based meat alternatives in green or yellow packaging hues of both high and low saturation. In separate rating blocks, they had to rate the naturalness, processing level, and tastiness of each shown product on a 5-point scale. Furthermore, we included a choice task between the high and low saturated product at the end of Study 2. We analyzed the results with a repeated measures ANOVA and used the MEMORE macro for the mediation and moderation analysis. We also controlled for age, gender, consumption habits and socioeconomic status in both studies.

Study 1 ($N = 261$) investigated how packaging color saturation and hue influence consumers' naturalness perceptions and taste expectations for plant-based burger patties, as well as the mediating role of perceived processing level. The study found that products in lowly saturated packages were perceived as more natural than those in highly saturated packages, but this effect was only found for yellow, not green colored packages. This indicates that the influence of color saturation on consumers' judgments of naturalness depends on hue. In addition, perceived processing level mediated the influence of color saturation on naturalness judgments (see Figure 3). Consumers perceived highly versus lowly saturated products as more processed, which reduced naturalness judgments. Contrary to our hypothesis, there was no overall effect of saturation on tastiness.

Figure 3

Mediation Model of Color Saturation, Perceived Processing, and Naturalness Perception in Plant-Based Burgers (Article III)

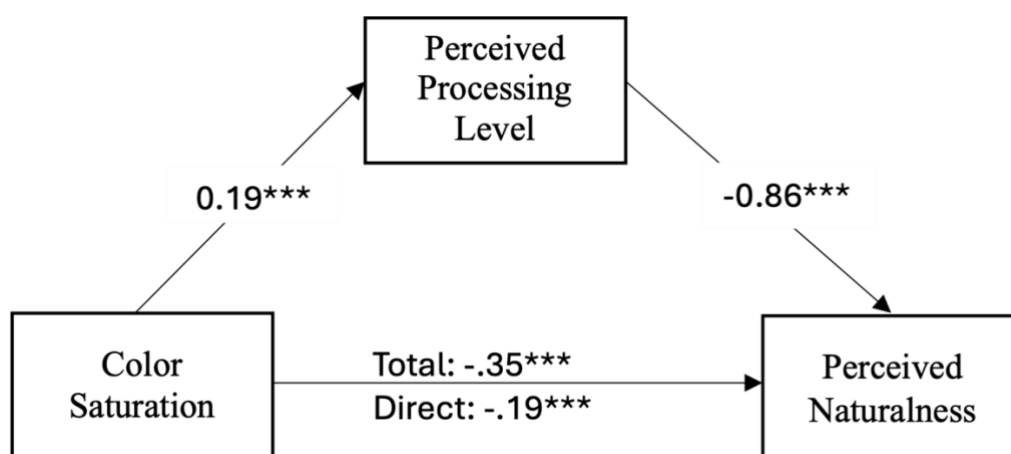


Study 2 ($N = 501$) replicated the design of Study 1 for a further product group of meat alternatives, plant-based sausages, and extended it by including positive affect intensity as an additional moderator variable in the relationship between saturation and naturalness judgments. Furthermore, we included a measure of relative preference between highly and lowly saturated packages at the end of the study. In line with previous research (Schifferstein et al., 2019; Zhang et al., 2024) and Study 1, we found that consumers perceived products in lowly versus highly saturated colors as more natural. In Study 2, the interaction between

saturation and hue was significant. High saturation reduced naturalness perceptions less strongly for green than for yellow packaging. In addition to Study 1, Study 2 considered individual differences in positive affect intensity. This trait moderated the relationship between saturation and naturalness only in the green hue condition and consumers with higher positive affect intensity perceived a greater difference in naturalness between packages with low and high color saturation. No moderating effect of positive affect intensity was observed for yellow packaging. Furthermore, perceived processing level mediated the relationship between saturation and naturalness judgments (see Figure 4). Replicating the findings of Study 1, high saturation increased perceived processing level, which reduced naturalness judgments. Contrary to our hypothesis and previous research, we did not find a significant influence of saturation on taste expectations. When asked which product they prefer, participants chose low-saturation packaging overall, but this preference was significant only in the green hue condition, with no clear preference in the yellow hue condition.

Figure 4

Mediation Model of Color Saturation, Perceived Processing, and Naturalness Perception in Plant-Based Sausages (Article III)



Discussion Chapter 3

There is limited research on the influence of color saturation on naturalness perceptions (Schifferstein et al., 2019; Zhang et al., 2024). As naturalness perception is

particularly relevant for plant-based meat alternatives (Hoek et al., 2011; Michel et al., 2021), we aimed to deepen the understanding in this area. *Article III* builds on the Cognitive Ecological Color Theory and extends its application from health to naturalness perceptions. We propose that the simulation pathway may be activated and that color saturation is used like a metaphor. Based on the assumption that high saturation is used as a signal for "more ingredients and flavors" or "more processing," we hypothesized that high saturation would lead to lower naturalness judgments but higher taste expectations. Since the color green is associated with naturalness (Clarke & Costall, 2008), we hypothesized that possible negative effects of high saturation on perceived naturalness would be weakened or reversed for a green hue. Furthermore, because perceived naturalness is related to processing degree (Rozin, 2005, 2006), we proposed that perceived processing degree would mediate this relationship. In addition, individuals with higher positive affect intensity, who are more sensitive to sensory cues, were expected to be more influenced by saturation. It could be argued that color associations could also be learned and that the color as an explicit cue path was activated. However, we believe that this is unlikely in the plant-based meat alternative category because our prior market observation revealed that no consistent design strategy regarding color saturation currently dominates the market. Additionally, the category is new and still niche, so it is unlikely that learned color associations exist on a broader level.

Two studies confirmed that lowly saturated packages are generally perceived as more natural than highly saturated packages. Perceived processing degree mediated the relationship between saturation and naturalness, supporting Rozin's (2005, 2006) findings on the influence of perceived processing level on naturalness perception. Study 2 found a negative effect of color saturation on naturalness perception also for green hues, although this effect was smaller than for yellow hues. This indicates that saturation effects are dependent on hue. Study 2 also explored individual differences in positive affect intensity and found a moderating effect only for green, but not for yellow, packaging. One possible explanation is that the stronger overall

effect of color saturation in the yellow hue condition left less room for individual differences to influence judgments, whereas the weaker effect in the green condition allowed such differences to emerge, although this remains speculative. Unlike prior studies (Kunz et al., 2020; Mai et al., 2016; Tijssen et al., 2017), we found no effect of color saturation on taste expectations. This may be because our color hues were not taste-related, whereas previous research often used hues linked to flavor or key ingredients (Mai et al., 2016; Steiner et al., 2024; Tijssen et al., 2017), enhancing sensory simulation.

A methodological strength of *Article III* was that we conducted a pretest to ensure that the low and high saturated colors were perceived accordingly. Furthermore, we used the CIE LAB color system to ensure that our saturation manipulations reflect human visual perception as accurately as possible, thereby increasing the validity and interpretability of our findings (Schiller et al., 2018). To ensure ecological validity, we used images of real product packaging, changing only the background color and, in Study 2, also the brand name. We also adhered to the principles of open science by pre-registering both studies and making the data and analysis files publicly available.

Despite the valuable findings, *Article III* also has limitations that must be considered. First, we included only two color hues in our studies, which limits generalizability to other hues that may have different associations. Second, the between-subjects design may have reduced hue effects because participants could not directly compare hues. Third, only two types of plant-based meat alternatives were tested. Future research should extend these findings to a broader range of products and include less processed items and conventional meat products for comparison. Finally, participants were drawn from German-speaking countries, so cultural differences in color interpretation and naturalness perceptions may limit broader applicability. Addressing these limitations in future studies could further enhance our understanding of how visual packaging cues shape consumer responses to plant-based meat alternatives.

Article III extends existing research on color effects by showing that low packaging color saturation leads to higher perceptions of naturalness for plant-based meat alternatives, and that this effect is mediated by perceived processing degree. Furthermore, we did not observe negative effects of low color saturation on taste expectation.

General Discussion

There has been a steady rise in consumer interest in healthy and sustainable diets (Ferrer, 2021; Frey & Büning-Fesel, 2023; International Food Information Council, 2022; Nielsen, 2015). Packaging plays a crucial role in shaping product perceptions, and color in particular has been shown to influence consumer expectations of a product (Matthews et al., 2019; Plasek et al., 2021). However, research on the influence of color on consumer health and naturalness perceptions is limited (Hallez et al., 2023; Kunz et al., 2020; Mai et al., 2016; Zhang et al., 2024). While numerous studies have examined how color affects taste perception (Spence, 2015), far fewer have investigated its effect on health perception, and the results have been mixed (Kunz et al., 2020; Mai et al., 2014; Tijssen et al., 2017). Furthermore, the existing research lacks a cohesive theoretical framework to explain the psychological mechanisms underlying these effects. Although Spence (2015) proposed a theory of how color shapes taste perception, there is no comparable framework for health perception. Therefore, the objective of this dissertation was to develop a framework as the foundation for a more coherent theory that could explain how packaging color influences consumers' health perceptions. In addition, this dissertation aimed to empirically test the framework and extend it to the domain of naturalness.

By conducting a systematic literature review following the PRISMA model, we first provided an overview of the current literature on the influence of packaging color on consumers' health perception. We observed that most studies found an influence of packaging color on consumers' health perception, but findings on the direction of the relationship were inconclusive (Kunz et al., 2020; Mai et al., 2016; Mead & Richerson, 2018). Drawing on concepts from social cognition literature, we proposed a theoretical model (*Objective 1*) with three possible, context-dependent, and not mutually exclusive pathways to explain the influence of color on consumers' health perception. Packaging color can (1) be used as an explicit cue for (un)healthiness, (2) trigger pre-existing beliefs that shape health evaluations,

or (3) evoke mental stimulation that influences health evaluations. Since different pathways may be activated depending on the context, this model also helps to explain previous inconsistencies in empirical findings regarding the influence of packaging color on health perceptions. For example, Kunz et al. (2020) found that higher color saturation led to increased health and taste expectations for fruit juices, likely because the packaging color matched the color of the product's main ingredient and consumers learned to associate the saturated color with freshness and naturalness. In contrast, Mead and Richerson (2018) observed that consumers rated highly saturated packages of products, such as potato chips and cereal bars, as less healthy than packages with low saturation. In this case, the saturated colors may have been used as a signal of indulgence, activating the lay belief that "fun" or "tasty" foods are less healthy. The introduced model provides a possible explanation for such discrepancies, taking into account the contextual activation of different psychological mechanisms.

To address the inconsistent findings in previous research on the influence of color saturation on health expectations and to test hypotheses based on the introduced Cognitive Ecological Color Theory (*Objective 2*), we investigated the moderating role of color match between the packaging and the product's main ingredient. Results from two experimental studies indicated that moderate versus low color saturation led to higher health and taste expectations, but only when the packaging color matched the color of the product's main ingredient. In contrast, when there was no color match, the positive effects of moderate saturation were reduced or even reversed. These findings highlight the importance of context in shaping how visual cues such as saturation influence health perceptions. They support our hypothesis that different psychological mechanisms (e.g., mental simulation vs. belief activation) are activated depending on the match or mismatch between the packaging color and the color of the product's main ingredient.

Extending the theoretical framework to the domain of naturalness perceptions (*Objective 3*), we demonstrated that high versus low packaging color saturation was negatively associated with consumer perceptions of naturalness for plant-based meat alternatives. This effect was mediated by the expected processing level of the product, suggesting that higher saturation may signal a greater degree of processing and thus reduce perceived naturalness. In addition, the effect of saturation was moderated by hue. The negative impact of high saturation on naturalness was more pronounced for yellow than for green packaging. We also examined individual differences and found that consumers with high levels of positive affect intensity were more sensitive to changes in color saturation, but only when evaluating products in green packaging.

This dissertation contributes both theoretically and empirically to the literature on consumer perception and packaging design. First, drawing on theories from social cognition, it introduces the Cognitive Ecological Color Theory, which explains how packaging color influences consumer perception through three distinct, context-dependent pathways: explicit information, belief activation, and mental simulation. Second, it provides a possible explanation for previously inconsistent findings by demonstrating that the effect of color saturation on health perceptions and taste expectations depends on the color match between the packaging and the product's main ingredient. Third, it extends the framework to the context of naturalness by showing that higher color saturation reduces perceived naturalness by increasing perceived processing degree, with the effect moderated by color hue. Finally, we found indications that individual differences, such as positive affect intensity, shape consumers' sensitivity to color cues.

A key strength of this dissertation is its holistic approach to understanding how packaging color, particularly saturation, influences consumers' health, naturalness, and taste perceptions. It combines a systematic review of the literature with the development of the Cognitive Ecological Color Theory, which explains contextual effects through three

psychological pathways. Another strength is the empirical testing of hypotheses developed from the proposed theoretical model with multiple experimental studies that included moderating variables (e.g., color match, hue), mediating variables (e.g., perceived processing level), and individual differences (e.g., positive affect intensity). The dissertation's methodological rigor, use of realistic product images, and adherence to open science principles further enhance its robustness and relevance for both academic research and practical marketing applications.

Future research could examine how color influences perception through the proposed psychological pathways. The color-as-information pathway could be tested through self-report measures that examine whether individuals consciously use color cues in their evaluations. In addition, associative learning paradigms can be used to experimentally test whether specific color associations are learned over time and subsequently influence product judgments. The belief-based pathway could be examined through mediation analyses. Because direct measures of beliefs may inadvertently influence participants' responses by drawing attention to them, a two-step design should be employed. Relevant beliefs are assessed at Time 1, and the influence of color is tested experimentally at Time 2. In this approach, belief strength should mediate the effect of color, as color cues are expected to activate associated beliefs only in individuals who hold them. The simulation pathway could be examined using experimental designs that make simulation more difficult in one condition than in another. For example, participants may be required to hold a heavy object while evaluating a product. If the effect of color on product judgments is reduced under such conditions, this would suggest that mental simulation is a necessary mechanism.

A key limitation of our studies is that the generalizability of our findings is limited because to two product segments, drinks and plant-based meat alternatives, whereas food packaging spans a much broader range of categories. Prior research suggests that packaging color effects vary across categories (Huang & Lu, 2016), and consumers may learn

associations between specific hues, saturation levels, and specific product types. Future studies should examine whether color saturation effects generalize across a broader range of categories. In addition, our study focused on only a limited number of hues. Given that different hues can carry distinct symbolic meanings and product associations (Clarke & Costall, 2008), expanding the scope to include a broader range of colors would provide more comprehensive insights. Furthermore, in *Article III*, hue was manipulated between participants. As color perception is context-dependent, a within-subject design that allows for direct comparison of hues may enhance the detection of subtle perceptual effects. Another limitation is the reliance on digitally manipulated product images rather than real, physical products. As a result, the findings reflect participants' expectations and intentions rather than actual sensory experience or purchase behavior. While this approach is consistent with real-world shopping contexts, where consumers often make decisions based on visual impressions alone, it limits the ecological validity of the conclusions. Future research should include actual product tests or choice tasks to assess how packaging color influences behavior in more naturalistic settings.

Practical Implications

As consumer interest in healthier and more sustainable foods continues to grow (Ferrer, 2021; Frey & Büning-Fesel, 2023), identifying effective packaging design strategies for these products becomes increasingly important. However, there is no consensus on how best to design the packaging of such products. One key challenge is the observed tension between healthiness perception and tastiness expectation. Previous studies have shown that packaging cues that signal healthiness can unintentionally reduce expected tastiness and, in turn, lower purchase intentions (Mai et al., 2016; Mead & Richerson, 2018; Tijssen et al., 2017). This highlights the need for packaging elements that can communicate health benefits without compromising taste expectations. In line with the study by Kunz et al. (2020), our findings suggest that color saturation can serve as an overlapping cue, positively influencing

both health and taste expectations, but only when the packaging color matches the color of the product's main ingredient. For example, a highly saturated orange package for an orange-flavored product can simultaneously enhance expectations of healthiness and tastiness. This insight provides a clear and actionable strategy for marketers of health-focused products. By ensuring a color match between the packaging and the main ingredient, a moderate to high level of saturation can increase health and taste expectations simultaneously.

Despite the growing interest in sustainable eating, plant-based meat alternatives still face significant consumption barriers because they are perceived as overly processed and less natural or tasty. Therefore, it is essential to identify packaging strategies that enhance perceived naturalness and sustainability without compromising taste expectations. Currently, there is limited research on the influence of packaging color saturation on naturalness perceptions, especially for packaged foods. Our initial market analysis revealed considerable variation in saturation levels across plant-based product packaging, indicating uncertainty among brands about effective design strategies. The results of our studies suggest that lower packaging color saturation increases the perception of naturalness and reduces the perceived processing degree without negatively impacting taste expectations. This makes muted or less saturated packaging a promising approach for brands seeking to position their products as more natural and minimally processed. Such a strategy can help overcome consumer concerns and support the wider adoption of plant-based meat alternatives. By bridging theoretical inconsistencies and providing practical guidance, this research contributes to a more nuanced understanding of packaging color in consumer perceptions of health and naturalness.

Conclusion

The purpose of this dissertation was to investigate how packaging color influences consumer expectations of health, naturalness, and taste. In doing so, it not only addresses a practical challenge for marketers of healthy and sustainable products but also contributes to

the academic understanding of how visual cues, particularly color, influence product perception.

Through a systematic literature review and the introduction of Cognitive Ecological Color Theory, the dissertation offers a nuanced, multi-pathway explanation of how color can influence consumer expectations. Subsequent empirical studies showed that color saturation can enhance both health and taste expectations, but only when the packaging color matches the color of the product's main ingredient. In contrast, for plant-based meat alternatives, lower color saturation increased perceived naturalness, and this effect was mediated by perceived processing degree. These findings contribute to explaining inconsistent results in previous research and highlight the importance of contextual and individual factors.

Overall, this dissertation provides implications for the development of packaging design strategies for healthy and sustainable foods. It also provides a foundation for future research into the psychological mechanisms behind color cues.

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Appendix

Credit Author Statement

This dissertation consists of three articles: two have been published, and one has been submitted for publication. All articles were developed in collaboration with multiple authors, which is why the pronoun we is predominantly used throughout the dissertation when referring to the research and writing process. Table 2 outlines the specific contributions to each article.

Table 2

Articles Included in the Dissertation and Author Contributions

Article	Contribution
Article I: Steiner, K., & Florack, A. (2023). The Influence of Packaging Color on Consumer Perceptions of Healthfulness: A Systematic Review and Theoretical Framework. <i>Foods</i> , 12(21), 3911. https://doi.org/10.3390/foods12213911	Katharina Steiner: Conceptualization, Methodology, Data curation, Writing – Original Draft, Review & Editing, Visualization Arnd Florack: Conceptualization, Writing – Review & Editing, Supervision
Article II: Steiner, K., Kunz, S., & Florack, A. (2024). How can health look tasty? Effects of packaging color saturation on beverage health and taste expectations depend on color match. <i>British Food Journal</i> , 127(13), 1-19. https://doi.org/10.1108/BFJ-06-2024-0651	Katharina Steiner: Conceptualization, Methodology, Formal analysis, Writing – original draft & editing, Visualization, Funding acquisition. Sonja Kunz: Methodology, Validation, Writing – review & editing. Arnd Florack: Conceptualization, Methodology, Resources, Writing – review & editing, Supervision.
Article III: Steiner, K., Kunz, S., & Florack, A. (2024). Less is More: How Package Color Saturation Influences Naturalness Perceptions of Plant-Based Meat Alternatives. [Manuscript submitted for publication].	Katharina Steiner: Conceptualization, Methodology, Formal analysis, Writing – original draft & editing, Visualization, Funding acquisition. Sonja Kunz: Methodology, Validation, Writing – review & editing. Arnd Florack: Conceptualization, Methodology, Resources, Writing – review & editing, Supervision.

Reprint of Article I

Steiner, K., & Florack, A. (2023). The Influence of Packaging Color on Consumer Perceptions of Healthfulness: A Systematic Review and Theoretical Framework. *Foods*, 12(21), 3911. <https://doi.org/10.3390/foods12213911>

The Influence of Packaging Color on Consumer Perceptions of Healthfulness: A Systematic Review and Theoretical Framework

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Abstract: When consumers evaluate a new product, packaging design plays a critical role. In particular, packaging color is a dominant design cue that influences consumer perception of a product. Several studies have investigated the influence of color on taste. However, there is limited research on the influence of packaging color on consumer health perception. As healthy eating is a focus for many consumers and public decision-makers, more knowledge is needed. The aim of this review is to provide an overview of empirical studies that have investigated the influence of packaging color on consumers' health perceptions and to provide a psychological explanation for the observed effects. The systematic review includes 20 empirical studies across different product groups. The results show that packaging color influences consumers' health perceptions. We argue that the influence of packaging color on consumer health perceptions can be explained by the following mechanisms, which are not mutually exclusive: (1) consumers rely on a color as an explicit signal for health; (2) colors are associated with beliefs that indirectly influence health assessments; and (3) colors trigger mental simulations that influence health assessments. In addition, we provide suggestions for further research that will contribute to a better understanding of when and how packaging color can help consumers make healthier food choices.

Keywords: color; packaging; health perception; consumer; design; product evaluation



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1. Introduction

In today's fast-paced environment, consumers have an average of only 2.5 s to select a product from a wide range of options on the shelf [1]. Therefore, the first impression of a product, which often comes from the product's packaging, plays a critical role in product evaluation and purchase decisions. Time constraints prevent consumers from processing detailed product information, and they often rely on visual cues for product evaluation. Several studies have investigated the influence of different visual cues on product evaluation and perception [2–5]. In particular, packaging color is often used as a marketing tool, and various studies have demonstrated an influence of packaging color on product evaluation, e.g., [5–8]. Indeed, color is one of the most dominant design cues on product packages [7].

While the influence of packaging color on taste perception has been the subject of many studies (see [9] for a review), research on the influence of packaging color on health perception is scarce. Accordingly, reviews on this topic are limited [10]. Given the high rates of obesity among adults and children in developed countries and obesity as a high-risk factor for noncommunicable diseases and disability [11], it is necessary to better understand the factors that influence consumer perceptions of health. Understanding how consumers use and understand color cues to form perceptions of a product's healthiness can help marketers of healthy product alternatives successfully design their products and local governments identify interventions.

The aim of this paper is to provide a summary of the current state of the literature on how packaging color influences consumers' perceptions of healthiness. Because there is

a lack of coherent theory explaining the effects of packaging color on health perception, we discuss psychological concepts that may explain the influence of packaging color on consumers' health perceptions and subsequently build a theoretical framework. Also, we will identify variables that moderate the influence of packaging color on consumer health perceptions and offer research suggestions based on the results of this review.

2. Method

To conduct an objective review of the current state of the literature, we used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [12].

2.1. Study Eligibility Criteria

This review included studies that investigated the effect of packaging color on consumer health perceptions of packaged foods. Specific inclusion criteria were as follows: (a) manipulation of packaging color while holding the other factors constant in at least one other condition; (b) healthiness rating as the dependent variable; (c) investigation of the effect for packaged foods, excluding studies on the design of restaurant menus, dietary supplements, and addictive substances such as cigarettes and drugs; (d) observation of the effect for adults, not children. Studies that did not systematically vary color or color variations as a single cue were excluded because these studies would not allow inferences about the effect of color. In addition, studies that examined the effect of transparent versus non-transparent packaging were excluded, as seeing a product goes beyond the effects of varying the color of a product's packaging.

2.2. Search Strategy

A systematic literature search was conducted in the abstract and citation database of peer-reviewed literature, Scopus, which covers worldwide research in science, technology, medicine, the social sciences, and the arts and humanities from 1970 to the present. The objective was to find research that investigated the influence of packaging color on consumer health perception. Therefore, the following keyword combinations were used: 'health' OR 'healthiness' OR 'healthy' OR 'healthfulness' AND 'color' AND 'package' OR 'packaging' and 'food' and 'consumer'. The restriction was English language.

2.3. Study Selection and Results

A search of Scopus using the keywords described above returned 267 results. The relevance of these results was assessed in two steps. First, all titles and abstracts were screened, and clearly irrelevant studies were removed. Second, the full text of the remaining 90 studies was evaluated, and studies that did not meet the eligibility criteria were excluded. The final sample consisted of 20 articles with $K = 35$ individual studies that were included in the final qualitative synthesis (Figure 1). To provide an overview of the results and make them more readily understandable, sample characteristics, research design, and main findings are presented in Table 1.

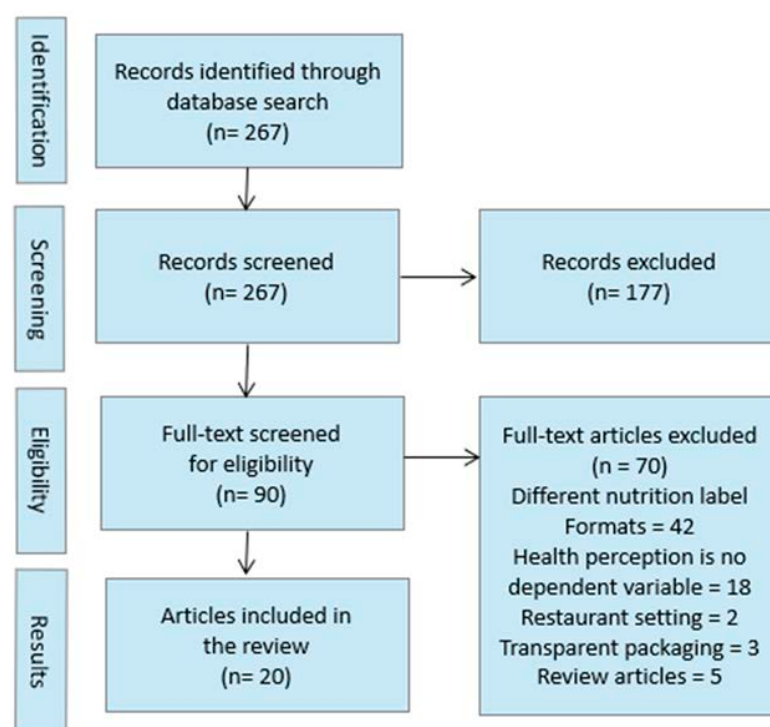


Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) chart of search strategy.

3. Results

To describe the results of the selected studies, we grouped them according to the different color stimuli they manipulated to observe the influence of packaging color on consumer perceptions of healthfulness.

The studies reviewed used different methods, such as focus groups and questionnaires, to measure the influence of packaging color on consumers' health perceptions, with congruent results. However, the studies did not apply physiological measures.

3.1. Warm vs. Cool Color Hues

One strand of literature analyzed the influence of long-wavelength, or warm, color hues such as red and yellow vs. short-wavelength, or cool, color hues such as blue and green on consumers' health perceptions of products. The differentiation between warm and cold colors is not new in advertising. Researchers have studied the impact of warm and cool colors in several settings [13]. A basic idea in this research is that consumers respond with a positive feeling of calmness to cool colors, whereas warm colors are more likely to be associated with arousal and attention. Correspondingly, cool packaging colors have been associated with higher health perceptions than warm packaging colors in most but not all studies examining health perceptions [6,14–17]. Below, we describe the studies comparing the effects of warm vs. cool colors on health perceptions in detail.

The study of Hallez et al. [16] investigated how packaging design with warm vs. cool colors and the presence vs. absence of nutritional and ecological claims influenced consumer evaluations. They demonstrated that green and blue packaging designs, representing cool colors, led to higher health and sustainability perceptions [16]. These findings are consistent with the study of Plasek et al. [14], who observed that the color combination white-blue is perceived as healthier than white-red and white-green, but white-green is perceived as healthier than white-red. In addition to color, this study also observed the influence of shape, the presence or absence of health claims, claims related to product ingredients, and country of origin on consumer health perceptions. Of these extrinsic product cues examined, color had the strongest influence on consumer health perceptions [14].

Karnal et al. [4] analyzed the influence of soft drink packaging color (yellow vs. red) on consumers' health perceptions. Participants perceived products with yellow-colored packaging as healthier than those with red-colored packaging. They also perceived yellow as less heavy, less warm, and less arousing than red. However, the direct effects of color on heaviness and health remained even after controlling for arousal and warmth [4].

Sant'Anna et al. [17] studied the effects of package color on health perceptions and consumer choices. They found that consumers associated blue packaging with healthier products when shopping for products with reduced sodium. In their study, the blue packaging color compared to red, combined with the phrase indicating the percentage of sodium reduction, increased the likelihood that participants chose a cracker with reduced sodium when searching for such products [17].

In contrast to the described studies that found a positive influence of green and blue versus red packaging colors on consumers' perceptions of healthiness, in Marque de Rosa et al.'s [18] study, participants rated cookies in red-to-yellow packaging as healthier than those in blue-to-green packaging. Another study found no effect of warm vs. cold color on healthiness. In a study by Sucapane et al. [19], adding a green color to a "plant-based" product and a red color to a "meat alternative" did not increase the differences in healthiness perceptions between the two product options.

There are some indications that the effect of warm and cool colors may vary depending on the food category. Based on a qualitative study, Wąsowicz et al. [20] concluded that, depending on the food category, consumers can associate the cold colors blue and green but also the warm colors yellow and red with healthiness. For example, in the frozen pizza category, participants associated the color red with healthiness. According to the researchers, this was presumably because it was perceived to indicate the presence of fruits and vegetables. However, in the yogurt category, red was associated with artificial coloring and regarded as a signal of low healthiness [20].

Huang and Lu [6] studied the hedonic quality of products as another moderator of the influence of warm and blue packaging colors on consumers' health perceptions. In some product categories, such as ice cream or potato chips, products primarily serve hedonic goals such as affective pleasure, while in others, such as milk, they serve functional goals such as satisfying physical needs (e.g., thirst). For products that serve utilitarian goals, the researchers found that blue packaged products were perceived as healthier than red packaged products. For products that serve hedonic goals, however, they did not observe an influence of packaging color on the healthiness assessments of the products [6].

3.2. Color Brightness and Saturation

Another stream of literature investigated the influence of other aspects of color beyond hue, such as brightness and saturation. Researchers found that consumers perceive product packages with higher brightness and lower saturation as healthier, e.g., [21,22].

Mai et al. [21] found an association between light-colored packaging and health perceptions. In their study, subjects had to rate product packaging from different food categories, including healthy and unhealthy categories, that differed in color lightness. All other packaging parameters, such as hue, saturation, and package size, were held constant. Light-colored packaging led to higher healthiness perceptions but lower tastiness perceptions and purchase intention. Mead and Richerson [22] were able to replicate these findings, showing across four experiments in different food categories (healthy and unhealthy) and across a variety of hues that consumers associate highly saturated packaging colors with unhealthy foods.

In contrast to these findings, Kunz et al. [5] (Study 2) found a positive relationship between packaging color saturation and perceived product healthiness. In this study, the researchers experimentally varied the saturation of 20 images of non-alcoholic beverages (e.g., juices and smoothies) by increasing or decreasing the saturation of the original packaging by 25 percent. They found that participants perceived the products as fresher and healthier when the packages were more saturated than when they were less saturated.

3.3. Variations of More Than One Aspect of Color

Other authors compared experimental conditions varying in more than one specific aspect of color. Tijssen et al. [23], for example, compared packages of a dairy drink and a sausage with varying color hues (blue, green, red, purple), brightness (high vs. low), and saturation (high vs. low) of the packaging color. All other attributes of the packaging were kept constant. This resulted in 12 different tested packaging images for each product. The researchers observed that packaging with less vibrant, cooler colors (e.g., blue), higher brightness, and lower saturation was implicitly associated with healthiness and explicitly perceived as healthier but less attractive than product packaging with warmer colors (red), lower brightness, and higher saturation.

In one study, Schnurr [24] (Study 1) varied the packaging of nuts as a snack and measured health and taste perceptions and expected enjoyment of the product. In one condition, the packaging was presented with bubbles of different colors (e.g., green, yellow, pink, and blue). In a control condition, there were no bubbles on the package. Participants rated the product as less healthy and tastier in the colored bubbles condition. In a mediation analysis, these effects were mediated by the expected enjoyment of eating the product, with more enjoyment expected when the colored package was presented than when the plain package was presented. In another study [24] (Study 3), the researchers presented participants with a cereal package and compared a control condition with a plain package to a condition in which bubbles of different shades of pink were printed on the package. They also evaluated whether the consumption motive played a moderating role and presented the packages with text related to enjoyment (e.g., unique pleasure) or health (e.g., reduced calories). The color variation only had an effect on health ratings when the text focused on health. In this condition, participants rated the healthiness of the product lower when the colored bubbles were on the product packaging compared to the plain packaging.

3.4. Color Coding of Front-of-Pack Nutrition Labels

Another line of research has examined the effect of the color of the front-of-pack (FOP) nutrition label, such as the calorie label, on consumer perceptions of healthiness. In this line of research, studies have often but not exclusively compared the effects of the warm color red and the cool color green. In addition, a few studies have used different variations of a color or control groups with black and white labels. We present this research as a separate category because it is clear that the goal of using these colors is to support understanding of the calorie content label. A common finding is that the use of green- (or red-) colored FOP nutrition labels helped consumers identify a healthy product [25–28].

Aschemann-Witzel et al. [25] found that German consumers who were instructed to select healthy products made more healthy choices when the nutrition label was color-coded according to a traffic light system (red = not healthy, amber = moderately healthy, green = healthy) compared to monochromatic nutrition labels (different levels of blue saturation with lower saturation associated with the healthier product), while holding nutritional values constant. Nutrition labels with monochromatic variations led to healthier food choices compared to uncolored nutrition labels. However, color variations only had an impact on the choice of healthier products in Germany, not in Poland, and only when participants were asked to choose a healthy product [25].

Pettigrew et al. [26] presented participants with choices of three breakfast cereals and asked them to choose the healthiest product. They found that traffic-light-colored versus black and white nutrition labels facilitated the correct choice. Interestingly, the researchers found this effect of traffic-light-colored labels in almost all countries observed. In Australia, China, India, New Zealand, the United Kingdom, and the United States, colored labels outperformed uncolored labels in correctly choosing the healthiest product. Only in Canada did participants understand the health information better with monochrome labels than with colored labels.

While Aschemann-Witzel et al. [25] and Pettigrew et al. [26] studied the classic traffic light nutrition label, Nyilasy et al. [29] investigated with US consumers whether coloring

individual nutrients could confuse consumers because healthy products often contain healthy and unhealthy nutrients. The authors hypothesized that in such a situation, a color scheme might draw undue attention to unhealthy nutrients and less attention to healthy nutrients marked in green. In the study, the researchers presented participants with product images for bread, rice, cereal, and potato chips. In one condition, they presented the product packaging with healthy nutrients (e.g., protein and vitamins) colored green and unhealthy nutrients (e.g., fat and sugar) colored red. In the second condition, they reversed the colors. Finally, in a third condition, they used black and white labels. In line with their expectations, the researchers found that participants showed the strongest differentiation between healthy and unhealthy products when a black and white color scheme was used. This effect was only found for healthy foods, but not for unhealthy foods.

While the studies reported above examined whether colored labels aided in the understanding of nutritional information, Schuldt [27] investigated whether colored labels could directly affect health perceptions. The researcher compared conditions in which the color of a chocolate candy bar label varied while the calorie content remained the same and found that consumers rated the chocolate candy bar as healthier when presented with a green vs. red calorie label. When comparing a green calorie label to a white calorie label, only individuals who generally focused on healthy eating perceived the candy bar with the green calorie label as healthier. However, these findings could not be replicated in Vasiljevic et al.'s [30] study, which also held calorie content constant. In this study, the researchers found that participants rated cereal and chocolate bars with a white label and a smiling emoticon as healthier than those with green or red labels.

In another study, Cabrera et al. [15] varied the color and shape of a warning label and examined the effect on health perceptions and attention. The researchers used three different conditions of shape (triangle, triangle with vertex, and octagon) and two conditions of color (red and black). Overall, color had a greater effect on health perception than the variation in shape [15]. The researchers observed that participants perceived products with a black label as less healthy than products with a red label. Furthermore, they found that the combination of a red FOP warning label with an octagonal shape, which is often used in traffic signals to communicate risk or danger, was perceived as the least healthy combination compared to other color and shape combinations.

Meng and Chan [31] investigated whether gender moderates the influence of colored nutrition labels on perceptions of product healthiness. They held the nutritional information constant across color conditions and found that men were more responsive to color, perceiving crackers with a green-colored nutrition label as healthier and crackers with a red-colored nutrition label as less healthy compared to a black-colored label. For women, label color had no effect on their perceptions of product healthiness [31].

Table 1. List of studies exploring the influence of packaging color on consumers healthiness perception and their key findings.

Reference	Analytical Method	Product	Country	Key Findings
Aschemann-Witzel et al. [25]	choice task and questionnaire	20 sweet and 20 salty snacks	Germany and Poland	When German consumers were explicitly instructed to make healthy food choices, color-coded nutrition labels led to healthier food choices compared to uncolored nutrition labels. This effect was stronger when the nutrition label was color-coded according to a traffic light system (green = healthy, orange = moderately healthy, red = unhealthy) than when it was monochromatic (different shades of blue). This effect was only observed in Germany and not in Poland. The presence or format of a nutrition label had no effect on the healthiness of consumer choices when consumers could choose according to their preferences.
Hallez et al. [16]	choice task and questionnaire	soft drinks, salty snacks	Belgium	Cool packaging colors, such as green and blue, compared to warm packaging colors, such as red and orange, led to higher perceptions of health and sustainability for drinks and foods. Cool packaged drinks were perceived as less tasty and were less likely to be selected compared to warm packaged drinks. This effect was not observed in the snacks category.
Huang and Lu [6]	questionnaire	milk, cereal, yogurt, potato chips, ice cream, ice tea	Canada	Utilitarian food products, which are consumed mainly to satisfy physical needs such as thirst or hunger, were perceived as healthier when the packaging color was blue compared to red. For hedonic food products, which are consumed mainly for affective pleasure, no effect of packaging color on healthiness perception was observed. Higher perceived product healthiness also led to higher purchase intention.
Kunz et al. [5]	questionnaire	snacks and drinks	Austria	A positive correlation between healthiness and tastiness was observed. Presenting the images only in grayscale vs. color had no effect on healthiness ratings. Moreover, increased versus decreased color saturation led to higher healthiness and tastiness ratings, and this effect was mediated by the perceived freshness of the products.
Mai et al. [21]	questionnaire and Implicit Association Test	pizza, chocolate, yoghurt, cream cheese, potato chips, fruit bar, juice	Germany	Light-colored product packaging led to a higher perception of healthiness, and this effect was observed even after consumers had tasted the product. However, light packaging color had a negative impact on taste, leading to lower purchase intention, especially when consumers had to make heuristic taste inferences and when health was not the primary consumption goal.
Marques da Rosa et al. [18]	questionnaire	buttery and cereal cookies	Brazil	Buttery and cereal cookies were perceived as healthier in a red-to-yellow package than in a blue-to-green package. In addition, the healthiness of cookies in angular packaging was rated higher than that of cookies in round packaging. No interaction effects were detected.

Table 1. Cont.

Reference	Analytical Method	Product	Country	Key Findings
Mead and Richerson [22]	questionnaire	potato chips and nutritional bars	USA	Consumers associate vivid, highly color-saturated food packages with less healthy foods compared to less color-saturated food packages. This effect is mediated by conceptual fluency, as consumers are regularly exposed to unhealthy foods in highly saturated packaging and have learned this association. Consumers with higher levels of nutritional knowledge are less likely to judge foods based on packaging color saturation. On the contrary, consumers with high vs. low restrained eating behaviors are more likely to make inferences about the healthiness of a product based on packaging color saturation.
Meng and Chan [31]	questionnaire	crackers	USA	A positive influence of a green nutrition label and a negative influence of a red nutrition label compared to a black nutrition label on the healthiness perception of a product was observed for men but not for women. Text-based health information on the nutrition label influenced health perceptions for both genders.
Nylasy et al. [29]	questionnaire	cereals	USA	Consumers perceived healthy cereals with red and green nutrition labels as less healthy than those with uncolored nutrition labels, regardless of which nutrient values were colored green and red. For unhealthy foods, there was no effect of colored versus uncolored nutrition labels on consumers' perceptions of healthiness.
Pettigrew et al. [26]	choice task and questionnaire	cereals	Australia, China, India, New Zealand, UK, USA	In Australia, China, India, New Zealand, the United Kingdom, and the United States, consumers understood traffic-light-colored nutrition labels (green = healthy, orange = moderately healthy, red = unhealthy) better than uncolored labels. Only in Canada did participants understand the health ratings better with monochrome than with colored labels. Colored nutrient summary labels were the most understandable compared to monochrome labels with nutrient-specific information.
Pettigrew et al. [28]	choice task and questionnaire	cereals	Australia	Colored nutrition labels were better understood than black and white nutrition labels. The most effective labels included only the color coding and abbreviated star rating, not the detailed nutrient icons.
Plasek [14]	questionnaire	functional smoothie	Hungary	Products with white-blue packaging were four times more likely to be perceived as healthy, and products with white-green packaging were twice as likely to be perceived as healthy as products with white-red packaging. Packaging color had the greatest impact on consumers' health perceptions compared to product claims related to ingredients, organic origin, health claims, shape, and country of origin.
Sant'anna et al. [17]	focus groups and choice experiment	sodium reduced cracker	Brazil	When consumers were asked to choose a reduced-sodium product, blue versus red packaging combined with the phrase indicating the percentage of sodium reduction increased the likelihood that a reduced-sodium product would be chosen.

Table 1. Cont.

Reference	Analytical Method	Product	Country	Key Findings
Schnurr [24]	questionnaire	nuts and muesli	USA and Europe	A cute, colorful packaging design compared to a less colorful, neutral packaging design leads to a lower perception of healthiness for virtue products that are consumed primarily to satisfy physical needs. This effect was not observed for vice products, which are consumed for their hedonic value. A colorful, cute packaging design creates images of fun in consumers' minds that they imagine they would experience while consuming the product.
Schuldt [27]	questionnaire	chocolate candy bar	USA	Consumers perceived a candy bar with a green calorie label as healthier than a candy bar with a red calorie label, even though the calorie content presented was the same. When comparing a green to a white calorie label, only consumers who focused on healthy eating perceived the candy bar with the green label as healthier.
Sucapane et al. [19]	questionnaire	plant-based meat alternative products	Canada and USA	A "meat alternative" product descriptor combined with a mismatching green versus matching red packaging color led to lower perceptions of eco-friendliness and trial likelihood. A "plant-based" product descriptor combined with matching green versus mismatching red packaging had a negative effect on predicted satiety. No effect of packaging color on health perceptions was observed.
Tijssen et al. [23]	Implicit Association Test and questionnaire	low-sugar dairy drink and low-fat sausage	Netherlands	The hue, brightness, and saturation of a product's packaging color influence consumers' perceptions of its healthiness. Consumers implicitly and explicitly perceive products with cooler colors (e.g., blue), higher brightness, and lower color saturation packaging as healthier but less attractive than products with warmer colors, lower brightness, and higher color saturation.
Vasiljevic et al. [30]	questionnaire	chocolate and cereal bar	UK	Consumers perceived a white label with a smiling emoticon as healthier than a red or green label with a smiling emoticon. The influence of the colored label on consumers' perception of health was only observed in combination with a smiling emoticon, not with a frowning emoticon or no emoticon.
Vila-López and Küster-Boluda [32]	questionnaire	juice with milk and fruit and candy bar	Spain	Product packaging with blue versus red or black nutrition claims was perceived as healthier. Visual cues (font color) had a stronger influence on consumers' attitudes towards the product than informative cues (nutrition claim). No differences were found between hedonic and functional products.
Wasowicz et al. [20]	focus group and questionnaire	pizza, yoghurt	Poland	Certain colors have greater potential to be associated with product healthiness, but this varies across product categories. Consumers perceived blue and green, as well as red and yellow, as healthy, depending on the product category. For example, the color red was perceived as healthy in the pizza category because it indicates the presence of fruits and vegetables, but unhealthy in the yogurt category because red is associated with artificial colors.

4. A Cognitive Ecological Color Theory

According to the research outlined above, different packaging colors influence consumers' perceptions of a product's healthfulness and help them choose and purchase healthy foods. The findings also show that the effects of color vary across product categories, countries, and individuals. However, there is currently no comprehensive theory to explain when the effects of packaging color on health perceptions should be expected. Therefore, we discuss a cognitive ecological color theory as a starting point for creating a more comprehensive theoretical framework to derive hypotheses about how packaging color affects perceptions of food health and stimulate future research.

The proposed approach is a cognitive one, as it makes statements about intrapsychic processes that are triggered by the perception of color. However, these intrapsychic processes are not considered independent of the environment, cultural conditions, or product categories. Rather, in line with cognitive ecological theories, e.g., [33,34], it is assumed that certain effects of colors on the expectation that a product is healthy can be better explained by taking into account how intrapsychic processes depend on various features of the environment (the ecology), such as how often or rarely a color occurs in a product category. The proposed approach is based on the assumption that cognitive processes have an adaptive function that allows them to adjust to the demands of a given environment [35]. A comparable approach is the so-called color-in-context theory, which is concerned with the effects of color on psychological functioning [36]. For example, it is well known that in a competitive context, the color red can be perceived as a signal of danger, such as when an opponent is angry (e.g., having a red face) [37]. However, the same color can also emphasize sexual attractiveness and thus be associated with a tendency to approach (e.g., a woman using red lipstick) [38].

The proposed cognitive ecological theory of color is based on the view that the perception of color has proven to be useful for survival throughout evolution. The perception of color is therefore not completely arbitrary, but humans perceive mainly those colors that have emerged to be functional [39]. For example, the color red has a very high biological significance in many respects. Red indicates certain dangers, such as blood flowing from a wound. But it is also associated with the ripeness of a fruit. So, we assume that there are certain biological predispositions that make it easier for people to learn associations between colors and attributes and also response patterns. However, we also hypothesize that there is an adaptive mechanism for learning meaning from colors that relies on acquiring knowledge and learning associations.

Based on extant research in marketing and psychology [9,40,41], we hypothesize that the color of labels or product packaging has a meaning that goes beyond the aesthetic embellishment of a product. Learning the specific meanings and associations should occur through psychological learning mechanisms such as declarative and associative learning [42,43]. First, consumers should learn meanings of color as explicit knowledge through communication and observation [44]. For example, the meaning of a colored label could be transmitted by a health campaign. Also, consumers can transfer their knowledge from another domain to the health domain, such as when they use their knowledge about traffic lights to understand a traffic light label system for food products. Second, the implicit meanings of color should result from associative learning [45]. This learning should be subject to the principles of contiguity (association with attributes that occur in close spatial or temporal proximity to the color), frequency (the more frequently the color occurs with the attributes, the stronger the associations), and distinctiveness (when the color occurs more frequently with the attribute than with other colors) [46]. It is important to note that declarative and associative learning are context-sensitive [47]. For example, people quickly learn the explicit knowledge that a colored shirt is appropriate for a vacation, but not for a funeral.

Building on the cognitive ecological framework, we postulate three ways in which colors on packaging or labels can influence expectations about the healthiness of a product (Figure 2). First, we hypothesize that consumers often consciously and deliberately use

and seek out colors as informational cues for healthiness—for example, when the color green on a label represents a healthier food (color as information). Second, we suggest that colors may indirectly influence health evaluations through beliefs (colors as triggers of beliefs). We suppose that colors can evoke an impression that leads to the application of a health-related belief. This would be the case if certain color combinations signal fun. Consumers might associate the food with enjoyment and then apply the belief that food cannot provide enjoyment and health at the same time, and therefore the product is more likely to be unhealthy. Third, we postulate that, in contrast to these explicit effects of color, there may also be implicit effects that influence health evaluations (colors influencing mental simulations). These effects are not necessarily conscious and may influence an assessment through a feeling or a halo effect.

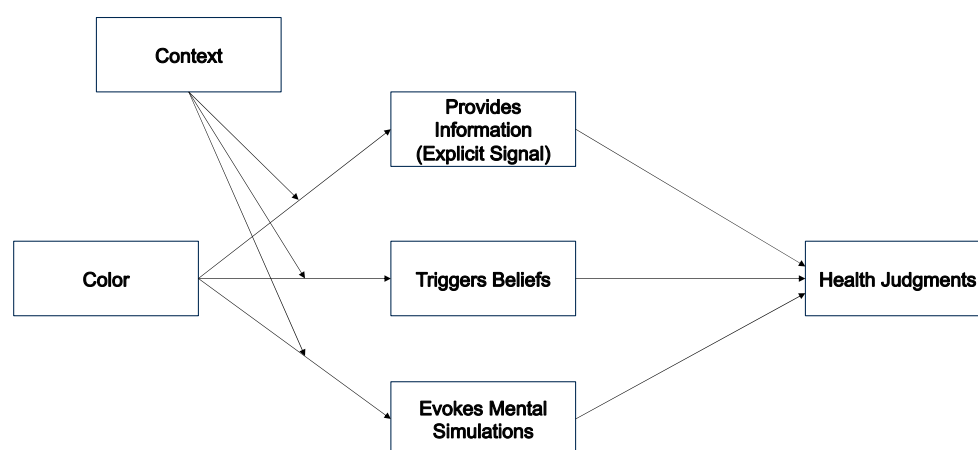


Figure 2. Model showing three pathways of color effects on perceptions of healthiness.

4.1. The Use of Color as Information

People automatically perceive colors, and the associations people have with colors are automatically activated [48]. It is not possible to look at a product and consciously inhibit the perception of the color. However, the automatic perception of color does not mean that all color influences are unconscious. In fact, a lot of studies suggest that consumers deliberately employ the learned meanings of colors—for instance, when they need to choose the healthiest alternative among several products [28]. A good example for the explicit use of colors as information is the reliance on a warning signal [15]. While the process of relying on these signals can be automated, in critical or ambiguous situations, consumers may explicitly search for such signals, much like a driver looking for a stop sign at a confusing intersection. We summarize these kinds of usage of color as the use of color as information. Whether consumers use the color as information in their health judgments can be a deliberate decision, the application of a simple heuristic, or a habitual response; it reflects that consumers have learned the meaning of the color as declarative knowledge and know the meaning when they are asked for it.

We assume that consumers learn color meanings when colors co-occur with health perceptions or health information, but that these meanings are also transported through social learning and communication. Therefore, our approach is compatible with the idea that color meanings represent shared knowledge that may vary across cultures [15,20,49]. It is important to note that our approach proposes that consumers can learn context-specific color meanings and is congruent to findings that color meaning differs between product categories. An illustration of context-specific meanings can be found in the study by Wąsowicz et al. [20], where participants stated that red in the frozen pizza category was perceived as healthy because it represented the vegetables contained in a pizza, whereas red in the yogurt category was perceived as unhealthy because it represented artificial coloring. Furthermore, a red-to-yellow packaging color was perceived as healthy for the cookies category in a study by Marque de Rosa et al. [18], while other studies found a

negative impact of a red packaging color on consumers' healthiness perceptions of soft drinks and salty snacks [4,16].

The research reviewed above illustrates that color is an important signal of product health in many contexts. However, it is clear that it is only one piece of information among others that can influence consumers' health judgments, especially when they are making a quick decision. In fact, color is an easily identifiable cue, and the meaning associated with it is immediately apparent when learned as declarative knowledge. This can be seen in Pettigrew's study [26], where colored traffic light nutrition labels are better understood than monochrome nutrition labels.

The use of color as information, however, does not only mean that consumers distill healthiness from the color, but that they may begin to process information in more detail when colors do not fit or occur in an unexpected context. We assume that the appearance of a color leads to increased processing and search for a reason for this appearance if it deviates from the learned knowledge. In the study conducted by Nyilasy et al. [29], the authors observed that red labeling of unhealthy nutrients had a more pronounced effect on the evaluation of products perceived as healthy compared to those perceived as unhealthy. Although products that are generally perceived as healthy may contain some unhealthy nutrients (albeit in lower amounts than in unhealthy products), consumers may find red labels on such products unexpected. Nyilasy et al. [29] assume that as a result, consumers are likely to pay more attention and process this information more intensively when it appears on healthy products than when the same information is highlighted in red on a product typically considered unhealthy.

4.2. Colors as Triggers of Beliefs

A further influence path of colors on healthiness judgments refers to beliefs that are triggered by colors or color combinations. An often-cited lay belief that influences health perceptions is the unhealthy = tasty belief. Such beliefs can either be learned via experience [34] or through the media and culture [50], or they may be applications of higher-order beliefs. For example, Raghunathan et al. [51] argued that consumers may think that healthy eating is incompatible with eating for pleasure because goals that are considered morally good are usually achieved through effort, not pleasure. Thus, we suggest that cues that communicate enjoyment trigger the unhealthy = tasty belief and lead to lower health judgments in individuals who hold this belief. An example of this is the aforementioned research by Schnurr [24], who found that colorful packaging leads to higher perceptions of taste and lower perceptions of healthiness, because colorfulness is associated with fun and enjoyment.

Another possible lay belief that has not yet received much attention in research on color–health associations is that more expensive foods are expected to be healthier [52]. Thus, packaging colors that signal luxury or low-budget categories, such as black and silver (luxury) or pink (low-budget) in some supermarkets, may influence not only quality but also health expectations if consumers believe that more expensive products are healthier. Hence, colors may trigger beliefs in purchase or consumption contexts that consumers otherwise would not have applied.

4.3. Colors Influencing Mental Simulations

The use of color as information or application of a belief does not sufficiently explain how color can incidentally influence healthiness judgments. We argue that in addition to conveying explicit information or triggering a belief, color can also influence consumers' perceptions of a product's healthfulness by eliciting mental simulations and the resulting feelings or impulses [5,6,24,27,29].

We suppose that consumers simulate the eating experience when making product choices [53]. When consumers consume unprocessed foods such as fruit, the saturation of the color represents its freshness and should lead to increased taste and health perceptions because rotten food is less healthy than fresh food. Kunz et al. [5] found such an effect for

packaged beverages such as juices and smoothies. In their study, packaging with saturated colors led to increased taste and health perceptions compared to packaging with reduced color saturation. We assume that the participants in this study simulated drinking the juices and that the simulation influenced the health and taste judgments. Interestingly, the study also showed that taste and health judgments are congruent in some contexts, as taste and health judgments are sometimes influenced by the same cues such as color saturation [54]. More recent research further underscores the notion that individuals with different learning histories (e.g., from different social classes) may rely on these cues differently, which may help explain why some individuals eat less healthfully than others [55].

Another reason for the importance of the mental simulation path of color effects is that the quality of affective experiences elicited by exposure to a color and the consequences of healthy/unhealthy eating are sometimes similar. For example, the colors green and blue elicit feelings of safety, calm, and relaxation [56]. The same feelings are associated with the consumption of healthy products. According to the proposed mental simulation approach, these evoked emotions can explain the healthier product perception of blue- and green-colored products [6,16,27,32]. On the contrary, warmer colors such as red and orange may trigger feelings of excitement and physical arousal, which are incongruent with feelings associated with healthiness. Hence, the mental simulation account would predict that taste expectations are positively affected and health judgments are negatively affected by these colors, which is in line with the findings reviewed above [6,32,56].

In addition, colors have been shown to influence weight perceptions [4,57]. Following the mental simulation pathway in our model, light colors, such as light blue, could create a feeling of lightness which spills over to healthier perceptions of a product. The aforementioned study of Mai et al. [21] supports this notion. Perceived weight is also affected by different color hues, as red, for example, may make a product or its consumption seem “heavier” than yellow, which may also contribute to the lower perceived healthiness of red-colored packaged foods [4].

Finally, it is important to note that a single color can potentially influence perceptions of health through multiple pathways. Often these pathways are congruent, as illustrated by the influence of red in the previous example. However, opposing effects are also conceivable. It should be possible for a color to be perceived as a direct indicator of healthiness while at the same time inhibiting the mental simulation related to healthy eating experiences that typically correlate with variety, pleasurable sensations, and not feeling too full. If the effects on the different pathways are contradictory, the overall effect of the color would be expected to be diminished.

5. Discussion and Conclusions

The main objectives of this systematic literature review were to summarize the current literature on the influence of packaging color on consumer health perception of a product and to provide a framework to integrate the results and inspire future research.

Overall, the described research shows the different influences of packaging color on consumers' health perceptions of a product. To better understand the influence of packaging color on health perceptions, we introduced cognitive ecological color theory. Similar theories have been developed in other fields [36]. However, we specified this theory to explain the context-specific color effects on healthiness perceptions and expanded it to three different paths of influence: the use of color as information, the beliefs triggered by colors, and the mental simulations influenced by color. In principle, this theoretical approach can be applied to food color effects in general, particularly to color effects on taste. However, it is important to note that healthiness judgments are different from taste because declarative knowledge plays a greater role in these judgements and because the effects of mental simulation are less obvious for health judgments.

The evidence that color can influence health judgments is strong. The most obvious evidence is that people use color as an explicit cue to make a judgement. They have declarative knowledge about the meaning of color cues and they apply this knowledge. However,

our review illustrated that this pathway of color influence is strongly context-dependent; it varies between product categories, between individuals, and between cultures. It is unlikely that a single color has a strong effect on health judgments across different contexts and for all kinds of food products. If it is at all possible, green could be a candidate for a color that positively influences health judgments across contexts. But if green is used in a product category in which health is unexpected (e.g., chips), its effect might disappear. Hence, future research is needed on much more nuanced aspects of the impact of color on healthiness judgments. In our review, we mentioned a study by Kunz et al. [5] showing that participants rated drinks as healthier when the saturation of the color on the image was higher. Other research studies found that higher color saturation can also be linked to lower healthiness [22,23]. Taking our path of influences into account, it is important to have a closer look at these effects. The question is which path of influence was active in the respective studies. For example, when a consumer perceives a package of a smoothie with the package color representing the content, simulation of consumption might be important and lead to the impression of low freshness when the saturation is low. When a consumer is exposed to a package of chips with the same color, which does not represent the content, simulation makes less sense. It is more likely that the consumer uses a saturated color as a signal for fun and enjoyment. In this case, a consumer might apply the unhealthy = tasty belief and judge the product as less healthy when the package color is saturated. This information is highly relevant for businesses and marketers to successfully design their product packages. As previous studies have shown, healthy product design can have a negative impact on the success of a product [23]. A better understanding of the underlying mechanisms and pathways used can help overcome this barrier and convince consumers to make healthier food choices.

There are several ways to assess the effects of color through the three different pathways. First, researchers can use self-report measures to assess whether color is explicitly used as information in the health evaluation situation. Second, researchers can measure beliefs that are hypothesized to be elicited by color and health judgments and conduct a mediation analysis to test whether the beliefs mediate the color effects. However, such measures of beliefs may draw participants' attention to the beliefs, which could strengthen or even dilute the relevance of the beliefs when participants control for the influence [58,59]. Therefore, researchers could use a two-step approach, measuring the relevant beliefs at Time 1 and using an experimental design at Time 2 in which they vary the colors and measure the effects on healthiness perceptions. In this design, individual differences in the beliefs measured at Time 1 should moderate the effects of the color manipulation at Time 2, because the color should activate the beliefs only in those individuals who hold the beliefs. However, this approach is only possible if there are meaningful differences in beliefs between individuals. Even more challenging is the study of the third pathway, the effects of color on mental simulation. Physiological measures such as EEG, salivation measurements, or brain imaging can be used to assess desire for a food [60]. However, assessing concrete simulations, such as the perceived weight of a food, is difficult with such methods. Therefore, researchers could ask for such variables using self-report measures. An elegant but indirect way to test for simulation effects is to use an experimental design in which the simulation is made difficult in one experimental condition but not in another [61]. For example, researchers could disrupt the simulation of the perceived weight of a product in one condition by asking participants to hold a heavy weight, but not in another condition. If a color influences health judgments via the simulation of the perceived weight of the product, such a manipulation should moderate the effect with a reduced effect of the color in the condition where participants hold a heavy weight.

Most of the studies reviewed on the influence of packaging color on health perceptions used self-report methods, such as ratings in questionnaires or comments in a focus group. These methods provide important indicators of the effects of color on a reflective level of product evaluation. However, self-report measures are not ideal for capturing implicit effects of color that are likely to influence spontaneous choices. Therefore, measures that

tap into such immediate responses could complete the understanding of color effects. For example, the research by Mai et al. [21] and Tijssen et al. [23] mentioned in this review used the Implicit Association Test (IAT) [62]. The IAT is a measure that captures associations between categories that are likely to predict consumer choice when consumers focus on their affective responses and are less driven by thoughts about risk [63–65]. It has been used in food research as a measure that is less prone to social desirability bias, e.g., [66]. In addition, eye-tracking or physiological methods such as EEG could add to our understanding of color effects to measure users' responses to color. In contrast to self-report measures and categorization tasks such as the IAT, these measures do not directly measure health judgments or associations with healthiness, but they could be important in illustrating the responses to color that accompany these judgments or associations. For example, eye-tracking could help us to understand whether certain colors influence attention to health information [67–69]. Furthermore, pupil diameter and the number of fixations could help us to understand affective responses and information processing evoked by color stimuli [69]. Physiological measures such as EEG could provide another measure to study such responses. Exposure to different color stimuli produces different neural activity in the brain, which can be measured by analyzing EEG signals [70,71].

In summary, the interplay between packaging color and consumers' health perceptions of products cannot be underestimated. As consumers are constantly making health judgments in their daily life, often without the time or ability to objectively assess health, understanding the mechanisms by which they construct their judgments becomes important. This review and the introduction of cognitive ecological color theory provides a starting point for understanding how color, as an intrinsic component of product packaging, influences healthiness judgments across contexts, product types, and cultures. Future research is needed to test the implications of the proposed theoretical approach.

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Reprint of Article II

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How can health look tasty? Effects of packaging color saturation on beverage health and taste expectations depend on color match

1

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Abstract

Purpose – It is of significant interest to marketers to identify visual product cues that signal high tastiness and healthiness, as both characteristics are of substantial importance to consumers. One such cue is the saturation of the packaging color. However, past studies found diverging effects of packaging color saturation on consumer tastiness and healthiness judgments. In this study, we investigated a possible moderator of the saturation effect: the match between the primary packaging color and the color of the main product ingredient.

Design/methodology/approach – In two online studies, participants viewed pictures of fruit juices (Study 1) and hydration drinks (Study 2). For each product, participants rated the expected taste and healthiness. We manipulated the color saturation and color match of the product pictures.

Findings – When the packaging color matched the main ingredient (e.g. orange juice in an orange package), consumers expected products in normal versus low saturated packages to be healthier and tastier. When the packaging color did not match the color of the main ingredient (e.g. orange juice in a red package), the positive effects of saturation on health and taste were reduced or even disappeared.

Practical implications – The results suggest that managers can optimize product health and taste perceptions by using moderately saturated packaging colors, particularly when the packaging color aligns with the main ingredient's color.

Originality/value – Our research offers a possible explanation for diverging effects of color saturation on product judgments. We show that whether and to what extent color saturation affects health and taste judgments might depend on the match between the packaging and ingredient color.

Keywords Packaging color, Color saturation, Color match, Tastiness, Healthiness

Paper type Research paper

1. Introduction

Taste and health play an important role in consumer product evaluation and choice (Giezenaar *et al.*, 2024; Hallez *et al.*, 2023; Johansen *et al.*, 2011; Mai *et al.*, 2014; Petit *et al.*, 2024; Steptoe *et al.*, 1995). Several studies have demonstrated that taste is one of the most important factors influencing consumer choice and has a significant impact on purchase decisions (Buhrau and Ozturk, 2018; Hallez *et al.*, 2023; Honkanen and Frewer, 2009; Kourouniotis *et al.*, 2016). Furthermore, the importance of health is on the rise as an increasing number of consumers pursue a healthy lifestyle (Poinski, 2020). Consequently, it is advantageous for marketers to understand the factors that enhance the appeal of a product both in terms of taste and health benefits. One such factor is package color, which has the potential to positively influence consumer expectations of taste and health (Hallez *et al.*, 2023; Kunz *et al.*, 2020; Mai *et al.*, 2016; Tijssen *et al.*, 2017).

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Several studies have shown that particularly color saturation of a product's packaging can impact consumer expectations of taste and health (Kunz *et al.*, 2020; Mai *et al.*, 2016; Mead and Richerson, 2018; Tijssen *et al.*, 2017). Nevertheless, research on the combined effects of color saturation on taste and health expectations is limited (Steiner and Florack, 2023). One recent exception is a study by Kunz *et al.* (2020), which suggests that color saturation influences both health and taste judgments. The authors argue that differences in color saturation help people identify ripe and fresh fruits and vegetables, while low color saturation signals that the food items are beginning to spoil.

Findings of other studies suggest that the mechanisms behind color saturation are more complex and that saturation can have opposing effects on health and taste judgments (Mai *et al.*, 2016; Mead and Richerson, 2018; Tijssen *et al.*, 2017). One explanation is that less saturated colors appear lighter and signal health, but not taste (Steiner and Florack, 2023). For example, Mai *et al.* (2016) found that packaging with light colors in comparison to darker colors increased health perception but decreased taste expectation across various product categories, such as cream cheese or cereal bars.

Findings from experimental studies support two theoretical accounts for the effects of color saturation. The first account suggests that reduced color saturation signals lower quality or freshness of the food product, which is relevant for both health and taste (Kunz *et al.*, 2020). The second account suggests that reduced saturation stands for reduced content, such as reduced fat or calories (Karnal *et al.*, 2016; Mai *et al.*, 2016). While reduced fat or calories might be beneficial for health, consumers might associate it with a loss of taste. Although both accounts are compelling, further research is necessary to better understand when each account predicts consumer responses.

One potential explanation for the discrepant findings is that the color saturation-freshness association is only informative for health and taste when the package color matches the color of the main ingredient. When the color of the packaging differs from that of the main ingredient, for instance when milk is packaged in a blue-colored container, consumers may rely on alternative cues to assess the health and taste qualities of the food product.

The present research, therefore, examines whether the match between the dominant color of beverage packaging and the main flavor-giving ingredient moderates the effects of color saturation on the expected health and taste of beverages. Building upon the theoretical account established by Kunz *et al.* (2020), we hypothesize that for colors that match the main ingredient, normal saturation levels increase health and taste expectations, whereas low saturation levels reduce health and taste expectations. Moreover, we expect that the influence of color saturation on health and taste judgments will be reduced when the primary color of the beverage packaging does not match the color of the main ingredient. We define the color of the main ingredient as the color of the main component of the drink, not the beverage itself. For example, the main ingredient of orange juice is oranges, which are orange, whereas the orange juice itself is yellow. According to our definition, orange packaging matches the color of the main ingredient, whereas yellow packaging does not.

2. Conceptual background

The color attributes of food packages exert a considerable influence on consumers' judgments of the health and taste of food products (Spence, 2015; Spence *et al.*, 2022; Spence and Van Doorn, 2022). The attributes of color can influence consumers' sensory evaluations and expectations even before they taste the product (Tijssen *et al.*, 2017). Table 1 provides an overview of the current literature on the influence of hue and saturation on consumer taste and health perception. The color match between the packaging color and the main ingredient of a product has not been systematically varied in previous studies.

One aspect of color that can influence both health and taste judgments of consumers is hue, which represents the type of color such as red, yellow, or blue. Color hue has a significant impact on consumer taste expectations and is more dominant than other color attributes, such

Table 1. Review of current literature on the influence of color on health and taste perception

Reference	Key findings	Stimuli	Color match
Hallez et al. (2023)	- Cool packaging colors (green/blue) increased health perception - Warm packaging colors (red/yellow) increased taste perception only in the beverage category, not in snacks	- Product categories: four beverages (i.e. an energy drink, a sports drink, a sparkling water drink and a cola drink) and four sweet and savory snacks (i.e. a chocolate bar, a nut mix, a bag of crisps and a crispy fruit snack) - Color manipulation: cool (blue/green) vs. warm (red/yellow) packaging colors	no color match
Huang and Lu (2016)	- Blue packages were perceived healthier than red packages. - Utilitarian products (yogurt or milk) were more influenced by package color than hedonic products (ice cream or chips)	- Product categories: cereal, yogurt, milk, potato chips, ice cream, iced tea - Packaging colors: blue vs. red	no color match
Kunz et al. (2020)	- Increased color saturation improved healthiness and tastiness ratings. - Saturation affected tastiness more than healthiness perceptions	- Product categories: 20 nonalcoholic drinks (juices and smoothies) - Color manipulation: high vs. low saturation	color match not identifiable
Mai et al. (2016), Study 1a & 1b	- Light vs. regular colored products were perceived as healthier - Regular vs. light colored cereal bar was perceived as tastier (Study 1b)	- Product category: cereal bar, pizza, chocolate, yoghurt, cream cheese, potato chips, fruit bar, juice - Color manipulation: high vs. regular saturation	color match not identifiable
Mai et al. (2016), Study 2-3a & 4	- Light vs. regular colored products were perceived as less tasty - Light vs. regular colored products were perceived as healthier - Health consciousness moderated consumer responses to packaging color	- Product categories: pizza, chocolate, yoghurt, cream cheese, potato chips, juice - Color manipulation: light vs. regular color saturation	no color match
Mai et al. (2016), Study 3b	- Light-colored product was perceived as healthier as regular colored product - No negative impact on taste perception was observed for light versus regular colored packaging	- Product category: fruit bar - Color manipulation: high vs. regular saturation	color match
Marques Da Rosa et al. (2019)	- Red-to-yellow and blue-to-green packaging were preferred over grayscale packaging. - Participants perceived cookies in red-yellow packaging as healthier than those in blue-green packaging	- Product categories: buttery and cereal cookies - Color manipulation: blue-to-green vs. red-to-yellow	color match not identifiable

(continued)

Table 1. Continued

Reference	Key findings	Stimuli	Color match
Mead and Richerson (2018)	- Products in high vs. low packaging were perceived as less healthy - Conceptual fluency mediated this perception. - Subjective nutritional knowledge weakened the effect, while restrained eating behavior strengthened the effect	- Product categories: potato chips and nutrition bars - Color manipulation: high vs. low color saturation, multiple color hues	color match not identifiable
Tijssen et al. (2017)	- Warmer, more saturated colors enhanced attractiveness and sensory evaluation - Less saturated packagings with cool colors (blue hue) were perceived as healthier but less attractive	- Product categories: low-sugar dairy drinks and low-fat sausages - Color manipulation: blue, purple, red, green color hue, high vs. low color saturation, high vs. low color brightness	color match not identifiable

Source(s): Authors' work

as saturation (Gambetti and Han, 2022; Motoki et al., 2021). Hue can be determined by the wavelength of light that reflects off the surface of the food product. However, the perception of color is an individual experience, and consumers often perceive the color of a package to be the same even when lighting conditions change, and the actual reflection of wavelength varies, a phenomenon known as color constancy (Foster, 2011).

The perceived hue exerts a significant influence on both health and taste judgments. For instance, the color blue is associated with aspects of nature, such as the blue sky or clean water (Palmer and Schloss, 2010). As healthiness is related to naturalness, these colors might signal healthiness. Also, more abstract meanings are associated with colors that indirectly imply healthiness. For instance, the color blue is associated with desirable states such as trust or peace (Huang and Lu, 2016). Evidence for color hue effects on health perception was provided by Huang and Lu (2016). The researchers found that utilitarian products, such as milk or yogurt, were perceived as healthier when packaged in blue than when packaged in red.

Besides the impact on health expectations, the hue of a food package can also influence taste assessments. For instance, consumers are sometimes less able to identify the flavor of a beverage when the beverage's color is altered to a hue associated with a different flavor (Zampini et al., 2007). Furthermore, the color has an effect on the degree of enjoyment experienced by consumers, in particular when the color does not match the flavor (DuBose et al., 1980).

In addition to hue, color saturation affects consumers' perceptions of the health and expected taste of products (Kunz et al., 2020; Mead and Richerson, 2018; Tijssen et al., 2017). Color saturation is a subjective experience, meaning that individuals perceive a highly saturated color as pure or true. Low saturation indicates an experience that the true color of an object is fading. Technically, lower saturation means that a color is mixed with other colors. As mentioned in the introduction, the effects of color saturation on the expected healthfulness of a food are mixed.

On the one hand, researchers have observed positive effects of saturation on both healthiness and tastiness judgments. In one study, Kunz et al. (2020) presented participants with a series of pictures of beverages. The researchers observed that the beverages were expected to be healthier and tastier when the images' color saturation was increased rather than reduced. In addition, the highly saturated packages were perceived as fresher, and this perception of product freshness was found to mediate the effect of color saturation on the

expected tastiness and healthiness of the beverages. The results by [Kunz et al. \(2020\)](#) are consistent with the theoretical account of a saturation-freshness relationship. From an evolutionary point of view, it is advantageous to be able to distinguish fruits with the highest nutritional content from rotten fruits. Color perception is indeed thought to support this differentiation between edible and inedible foods ([Sánchez-Solano et al., 2020](#)). Rotten fruit loses its “true color” and as a result, its color is less saturated. It is possible that the same mechanism that helped human ancestors identify edible food is still used by today’s consumers to evaluate packaged food. Therefore, we expect a positive influence of color saturation on health and taste expectations in the present study.

H1. Consumers expect a product to be healthier (*H1a*) and tastier (*H1b*) when a food packaging color has a normal saturation than when it has a low saturation.

On the other hand, other studies have reported contradictory results regarding the effects of color saturation on health expectations. For instance, [Mai et al. \(2016\)](#) found across different categories of packaged foods, such as cream cheese, cereal bars, and potato chips, that regular saturation levels in packaging colors were associated with better taste expectations but decreased health judgments. These results were replicated by [Mead and Richerson \(2018\)](#). In their study, consumers expected potato chips and snack bars in highly saturated packages to be tastier, but less healthy than in low saturated packages. Similarly, [Tijssen et al. \(2017\)](#) observed that yogurt drinks and sausages in vibrant and highly saturated package colors compared with less vibrant and lowly saturated package colors were expected to have a stronger flavor, but to be less healthy.

Importantly, the positive link between saturation and taste expectation in these studies cannot be explained by the saturation-freshness association because this would imply positive effects of saturation on both health and taste judgments. However, the opposing effects of saturation on health and taste judgments can be attributed to various alternative mechanisms.

First, consumers may perceive colors with lower saturation as being lighter, which may lead to the impression that the products feel less heavy and contain less sugar or fat ([Mai et al., 2016](#)), ingredients which are often associated with tastiness, but considered less healthy. If consumers believe that they are missing, they might conclude that a product is healthier, but also less tasty. Second, consumers may have learned that marketers use less saturated colors to signal the reduction of fat or sugar ([Steiner and Florack, 2023](#)). Consumers might access this knowledge to infer that a product in less saturated colors is healthier, because unhealthy ingredients are reduced, but less tasty, because ingredients related to taste are reduced. Third, saturation might send signals which can indirectly influence health and taste judgments. Researchers have proposed that saturated colors are associated with excitement and enjoyment ([Labrecque et al., 2013](#)). According to a prevalent belief rooted in the Protestant work ethic, highly valued societal goals, like a healthy lifestyle, are incompatible with enjoyment ([Raghunathan et al., 2006](#)). Hence, the dominant associations between color saturation and enjoyment may inhibit a strong health assessment ([Mead and Richerson, 2018](#)). The various mechanisms predict that consumers rely on saturation as a signal with opposing implications for health and taste. Taken together, whereas past research found exclusively positive effects of saturation on taste, the evidence on effects of saturation on health are mixed.

One factor that may contribute to a better understanding of the divergent effects of saturation on health judgments reported in the literature is whether or not the primary color of the food packaging matches the color of a product’s main ingredient. Based on the cross-modal correspondence phenomenon ([Spence, 2011](#)), we hypothesize that color saturation has similar effects on health and taste judgments especially when the packaging color matches the color of a product’s main ingredient. When the package color does not match the ingredient, we expect that other signals conveyed by color saturation are more influential in forming expectations about health and taste. In this case, we propose that saturation might have a weaker effect on health and taste expectations.

The phenomenon of cross-modal correspondence (Spence, 2011) posits that associations between different sensory modalities, such as sight and smell, are formed through repeated experiences of these modalities in combination. For example, consumers repeatedly observe that the color attributes of food change in the process of fruit ripening and spoilage, and thus form associations of colors with taste at the different stages of ripening and spoilage (Maga, 1974; Tu *et al.*, 2016). According to the cross-modal correspondence phenomenon, such color associations can then trigger the corresponding taste expectations when consumers see the color of the food. The findings of several studies support cross-modal correspondences, specifically the assumption that learned color associations influence expectations. Durlach and Zellner (2003), for example, presented consumers beverages with different color-flavor combinations. The researchers found that consumers expected a lemon flavored drink with no color or in yellow to be more refreshing than in brown color (Durlach and Zellner, 2003). Tu *et al.* (2016) observed that the color of the plate influenced expectations about the spiciness of food. For instance, consumers expected food to be spicier when presented on red plates than when presented on green plates.

The cross-modal correspondence phenomenon posits that a learned color association influences expectations about the qualities of food. It is plausible that color saturation may be part of such associations. However, we hypothesize that the meaning of saturation for food is linked to the color hue, for instance, to the specific color hue of a ripening or spoiling fruit. We therefore postulate that consumers are less likely to apply the link between saturation and freshness when the color of a food package does not match the color of the main ingredient.

- H2. The positive effect of saturation on health (H2a) and taste (H2b) expectations will be stronger when the package color matches the color of the main ingredient than when it does not match the color.

3. Summary and outline of the present studies

The present research examined the influence of packaging color saturation on the expected healthiness and tastiness of a product and the moderating role of color match on this effect. To this end, we conducted two studies in which participants viewed fruit juices (Study 1) or hydration drinks (Study 2). We varied whether the products were packaged in normal or low saturated colors and whether the package color matched the color of a product's main ingredient (e.g. orange juice in an orange package) or not (e.g. orange juice in a red package). Participants rated the healthiness and tastiness of each product. We used fruit juices and hydration drinks to examine whether the predicted effects can be observed across two product categories with different levels of food processing (lower for fruit juices, higher for hydration drinks). The research was approved by the Departmental Review Board of the Department of Occupational, Economic, and Social Psychology at the University of Vienna (Approval number: 2023/S/004A).

4. Study 1: the influence of packaging color saturation and color match on consumer health and taste expectations of low-processed drinks

4.1 Method

4.1.1 Participants and design. Participants were recruited from Austria and Germany via the online research platform Prolific. Participants who did not give their consent to participate or failed an attention check at the beginning of the study were excluded *a priori*. The final sample consisted of 250 participants, 50.4% women and 48.0% men, 1.6% other genders, with a mean age of 29.06 ($SD = 7.53$). All participants indicated that German was their native language. This study employed a 2 (color saturation: low vs. normal) $\times$ 2 (color match: matched vs. not matched) $\times$ 3 (flavor: orange vs. mango vs. apple) within-subject design. The flavor was a random factor for which we had no hypotheses.

4.1.2 Procedure. Participants rated the healthiness and tastiness of juice package images, separately and in random order. On each trial, participants first viewed the juice package image alone for two seconds before having to rate the image while still viewing it. The healthiness and tastiness ratings were gathered in two separate rating blocks. In the first block, participants rated the healthiness of each fruit juice. In the second block, participants rated the tastiness of the same fruit juices in the same order as the healthiness. After rating all beverages on healthiness and tastiness, participants were asked to provide information regarding their demographic characteristics (e.g. age, gender, and nationality).

4.1.3 Materials. All participants viewed pictures of fruit juice packages in three different flavors (orange, mango and apple) that varied in color saturation (normal vs. –30% color saturation reduction) and color match (match vs. no match). This resulted in a total of 12 pictures per participant, which were presented in random order. The juice packages were designed to reflect the typical layout of a fruit juice package and included the brand logo, product name, and images of the fruit. In the color-match condition, the primary color of the package matched the color of the fruit that was the main ingredient of the juice, whereas in the no-match condition, a different color was used as primary package color. The following color hues were used in the matching condition: orange juice – orange, apple juice – red, mango juice – orange. In the non-matching condition, the following color hues were used: orange juice – red, apple juice – purple, mango juice – pink. [Table A1](#) in the appendix shows the specific color parameters in each condition.

4.1.4 Measures. Participants had to rate the healthiness of each fruit juice on a 10-point scale (1 = *Very unhealthy*; 10 = *Very healthy*) by answering the following question: “How healthy would you rate this fruit juice based on its packaging?”. Also, participants had to rate the tastiness on a 10-point scale (1 = *Does not taste good at all* to 10 = *Tastes very good*). The item to measure the expected tastiness was “How would you rate the taste of the fruit juice based on its packaging?”. [Table 2](#) depicts descriptive statistics of the dependent variables in Study 1.

4.1.5 Data analysis. Since the participants repeatedly rated multiple juice packages with varying background colors in terms of healthiness and tastiness, the evaluations are nested within participants and intercorrelated. To account for this, we used a linear mixed effects model analysis ([Gałecki and Burzykowski, 2013](#); [Maxwell and Delaney, 2004](#)). All analyses were conducted at a significance level of $\alpha = 0.05$. We analyzed the data using R 4.3.2 ([R Core Team, 2023](#)), specifically the package nlme ([Pinheiro et al., 2016](#)).

4.2 Results

4.2.1 The influence of color saturation, color match, and their interaction on expected healthiness of fruit juices. We hypothesized that products would be expected to be tastier and healthier when a normal vs. low saturated packaging color was used. We further hypothesized that the effect of saturation on healthiness and tastiness would be stronger for products with matching than non-matching colors. We calculated a linear mixed effect model predicting the healthiness ratings from color saturation, color match, and their interaction. Random intercepts for the participant and product flavor were included. The results of the analysis are presented in [Table 3](#).

Most importantly and relevant for [H2a](#), there was a significant interaction between color saturation and color match on healthiness, $F(1, 2,247) = 15.82, p < 0.001$. Pairwise comparisons based on estimated marginal means illustrate that in the color match condition, normal saturated products were rated as healthier ($M = 5.48$; $SD = 2.01$) than low saturated products ($M = 5.24$; $SD = 2.00$), $t(2,247) = 4.32, p < 0.001$. In the non-color match condition, no influence of color saturation on healthiness ratings could be observed $t(2,247) = -1.31, p = 0.19$. The results show that products in normal saturated packages are only rated as healthier than products in low saturated packages when the packaging color matches the color

Table 2. Descriptive Statistics Study 1: Influence on health and taste expectations of fruit juices

		<i>M</i>	<i>SD</i>
<i>Mean healthiness by color saturation</i>			
<i>Saturation</i>			
Normal saturation		5.16	2.02
Low saturation		5.08	1.98
<i>Mean healthiness by color fit</i>			
<i>Color fit</i>			
Color fit		5.36	2.01
No color fit		4.88	1.96
Fit	Saturation	<i>M</i>	<i>SD</i>
<i>Mean Healthiness by color saturation and fit</i>			
Color fit	Normal saturation	5.48	2.01
Color fit	Low saturation	5.24	2.00
No color fit	Normal saturation	4.84	1.97
No color fit	Low saturation	4.91	1.95
		<i>M</i>	<i>SD</i>
<i>Mean tastiness by color saturation</i>			
<i>Saturation</i>			
Normal saturation		6.18	2.11
Low saturation		5.37	2.05
<i>Mean tastiness by color fit</i>			
<i>Fit</i>			
Color fit		5.96	2.18
No color fit		5.59	2.03
Fit	Saturation	<i>M</i>	<i>SD</i>
<i>Mean tastiness by color saturation and fit</i>			
Color fit	Normal saturation	6.57	2.10
Color fit	Low saturation	5.35	2.09
No color fit	Normal saturation	5.79	2.05
No color fit	Low saturation	5.40	2.00

Source(s): Authors' work

of a product's main ingredient. In addition, main effects of color saturation, $F(1, 2,247) = 4.53$, $p = 0.03$, and color match, $F(1, 2,247) = 160.38$, $p < 0.001$, were also significant.

4.2.2 The influence of color saturation, color match, and their interaction on expected tastiness of fruit juices. Another linear mixed effect model was calculated with taste rating as the dependent variable and packaging color saturation, color match, and their interaction as fixed effects. Participant and product flavor were included as random intercepts. This time, we wanted to investigate whether packaging color saturation influences taste ratings and whether this relationship is moderated by packaging color match. The results of this analysis are shown in Table 4.

Again, we found a significant interaction between color saturation and color match (H2b), $F(1, 2,247) = 74.99$, $p < 0.001$. We ran pairwise comparisons of estimated marginal means

Table 3. Results of the LME model testing the effects of color saturation, color match, and their interaction on healthiness ratings of fruit juices

Predictors	$F(1, 2,247)$	p
<i>Intercept</i>	2818.31	<0.001
Color saturation	4.53	0.03
Color match	160.38	<0.001
Color saturation x color match	15.82	<0.001
Random effects		
σ^2		1.09
τ_{00} product		1.39
τ_{00} id		0.95
N_{product}		3
N_{id}		250
Observations		3,000
Marginal R^2		0.057
Source(s): Authors' work		

Table 4. Results of the LME model testing the effects of color saturation, color match, and their interaction on tastiness ratings of fruit juices

Predictors	$F(1, 2,247)$	p
<i>Intercept</i>	5118.79	<0.001
Color saturation	286.96	<0.001
Color match	58.94	<0.001
Color saturation $\times$ color match	74.99	<0.001
Random effects		
σ^2		1.69
τ_{00} product		0.98
τ_{00} id		1.26
N_{product}		3
N_{id}		250
Observations		3,000
Marginal R^2		0.123
Source(s): Authors' work		

between saturation conditions within each color match condition. In the color match condition, participants rated normal saturated packages as significantly tastier ($M = 6.57$; $SD = 2.10$) than low saturated packages ($M = 5.35$; $SD = 2.09$), $t(2,247) = 18.10$, $p < 0.001$. Also in the non-color match condition, normal saturated packages were rated as tastier ($M = 5.79$; $SD = 2.05$) than low saturated packages ($M = 5.40$; $SD = 2.00$), but the difference was smaller, $t(2,247) = 5.86$, $p < 0.001$. The results demonstrate that products in normal saturated packages are expected to be tastier than products in low saturated packages, especially when the packaging color matches the color of a product's main ingredient. In addition, we again found significant main effects of color saturation, $F(1, 2,247) = 286.96$, $p < 0.001$, and color match, $F(1, 2,247) = 58.94$, $p < 0.001$.

4.3 Discussion

Whereas previous research consistently found positive effects of saturation on taste judgments, it was not clear whether and when color saturation has positive or negative effects on health judgments. Therefore, Study 1 examined the match between the primary package color and the main ingredient as a possible moderator of this effect. The study replicated previous research based on the freshness-healthiness/tastiness relationship (Kunz *et al.*, 2020). We found that normal saturation of the primary package color led to higher health and taste expectations. However, the positive effect of saturation was reduced for taste judgments and not present for health judgments, when the package color did not match the main ingredient. Thus, the present research is consistent with the expectations we derived from the cross-modal correspondence principle. Color saturation as a cue is dependent on hue. We suppose that the meaning of saturation is learned in conjunction with the hue, which is repeatedly paired with the taste of the beverages.

An important limitation of Study 1 is, however, that we used a category of beverages (juices) for which sugar or fat-reduced alternatives differentiated by lighter packaging colors are not commonly available. More importantly, fruit juices are less processed than many other beverages. For more processed beverages, the freshness-healthiness/tastiness link might be less relevant, and consumers might rely to a lesser extent on color associations to infer product taste. Therefore, Study 2 aimed to strengthen the findings of Study 1, by replicating the procedure with another, more processed product category (hydration drinks).

5. Study 2: influence of packaging color saturation and color match on consumer health and taste expectations of high-processed drinks

In Study 2, we investigated the influence of color saturation on consumers' expectations of healthiness and tastiness and the moderating role of color match for the product category hydration drinks. Participants were asked to rate the healthiness and tastiness of hydration drinks that differed in color saturation and color match. We have pre-registered Study 2 on aspredicted.org. The preregistration documents are available at https://aspredicted.org/P58_K8B.

5.1 Method

5.1.1 Participants and design. We again used the online research platform Prolific to recruit participants from Austria and Germany whose native language was German. Participants who did not consent to participate or failed an attention check were again excluded *a priori*. The final sample consisted of 398 participants, 47.24% women, 48.99% men, 3.77% other genders, with a mean age of 28.94 ($SD = 7.78$) and a mean body mass index (BMI) of 24.63 ($SD = 4.66$). Study 2 employed a 2 (saturation: low vs. normal) x 2 (color match: matched vs. not matched) x 3 (flavor: orange vs. mango vs. apple) within-subject design. The flavor was a random factor for which we had no hypotheses.

5.1.2 Procedure and measures. The procedure and measures were identical to Study 1, except that participants rated the healthiness and tastiness of pictures of hydration drinks instead of fruit juices. Table 5 depicts descriptive statistics of the dependent variables in Study 2.

5.1.3 Materials. We created artificial hydration drink packages with a brand logo, flavor description, but unlike the stimuli used in Study 1, no images of the flavor-giving fruit. The flavor descriptions (orange, mango, apple), hues (match vs. no match), and saturation (normal vs. low) were identical to those used in Study 1 to ensure comparability of results. Again, the specific color parameters of the stimuli in each condition are listed in Table A1 in the Appendix. In total, we used 12 different packages (see Figure 1 for example stimuli).

We conducted a pretest ($N = 30$) to ascertain that consumers perceive the hydration drinks as less natural than the fruit juices used in Study 1. We measured the perceived naturalness of

Table 5. Descriptive Statistics Study 2: Influence on health and taste expectations of hydration drinks

		<i>M</i>	<i>SD</i>
Mean healthiness by color saturation			
<i>Saturation</i>			
Normal saturation		3.81	1.93
Low saturation		3.94	1.78
Mean healthiness by color fit			
<i>Color fit</i>			
Color fit		4.23	1.86
No color fit		3.52	1.78
Fit	Saturation	<i>M</i>	<i>SD</i>
Mean healthiness by color saturation and fit			
Color fit	Normal saturation	4.31	1.96
Color fit	Low saturation	4.15	1.76
No color fit	Normal saturation	3.31	1.77
No color fit	Low saturation	3.73	1.77
		<i>M</i>	<i>SD</i>
Mean tastiness by color saturation			
<i>Saturation</i>			
Normal saturation		4.96	2.18
Low saturation		4.17	1.83
Mean tastiness by color fit			
<i>Fit</i>			
Color fit		4.90	2.10
No color fit		4.23	1.94
Fit	Saturation	<i>M</i>	<i>SD</i>
Mean tastiness by color saturation and fit			
Color fit	Normal saturation	5.68	2.06
Color fit	Low saturation	4.13	1.83
No color fit	Normal saturation	4.24	2.06
No color fit	Low saturation	4.21	1.82

Source(s): Authors' work

the fruit juices and hydration drinks with three items (Cronbach's α from 0.95 to 0.97), one reverse-coded: 1) "To what extent can you imagine that this drink was made from fresh, natural ingredients?" (1 = *Not at all*; 10 = *Very well*); 2) "To what extent would you say that this drink contains artificial flavors or additives?" (1 = *Not at all*; 10 = *Very strongly*); 3) "How natural do you think this product is?" (1 = *Not natural at all*; 10 = *Very natural*). As expected, participants perceived the hydration drinks as less natural ($M = 2.34$; $SD = 1.18$) than the fruit juices ($M = 6.66$; $SD = 2.15$), $F(1, 89) = 384.03$, $p < 0.001$.

5.1.4 Data analysis. The analysis strategy was identical to the one used in Study 1. Again, we used a linear mixed-effect model analysis (Galecki and Burzykowski, 2013; Maxwell and Delaney, 2004) to test the influence of color saturation and color fit on consumers' healthiness and tastiness perception.



Source(s): Authors' own work

Figure 1. Experimental stimuli differing in color match and color saturation (Study 2)

All analyses were conducted at a significance level of $\alpha = 0.05$. We used again R 4.3.2 (R Core Team, 2023), the package nlme (Pinheiro et al., 2016) to analyze the data.

5.2 Results

5.2.1 The influence of color saturation, color match, and their interaction on expected healthiness of hydration drinks. A linear mixed effect model was employed to predict healthiness ratings based on color saturation, color match, and their interaction. Random intercepts for both participant and product flavor were incorporated. The objective of this model was to determine if packaging color saturation predicts health ratings and whether this association is influenced by packaging color match. The results of this analysis can be found in Table 6.

Most importantly, the interaction effect between color saturation and color match on healthiness was significant, $F(1, 3,579) = 81.11, p < 0.001$. We conducted pairwise comparisons of estimated marginal means testing the effect of saturation on health within each color match condition to investigate the moderating influence of color match on the relationship between color saturation and healthiness ratings. In the color match condition, the influence of color saturation on healthiness ratings was significant, $t(3,579) = 3.51, p < 0.001$. In line with our hypothesis (H1a), normally saturated packages were rated as healthier ($M = 4.31; SD = 1.96$) than low saturated packages ($M = 4.51; SD = 1.76$). Also in the non-color match condition, color saturation had a significant influence on healthiness ratings, $t(3,579) = -9.23, p < 0.001$. In contrast to the results within the color match condition, normally saturated packages were rated as less healthy ($M = 3.31; SD = 1.77$) than low saturated packages ($M = 3.73; SD = 1.77$). These findings show that normal color saturation only leads to higher expected health if the packaging color matches the color of the product's main ingredient and confirms the moderating role of a match between the package color and the main ingredient (H2a). Additionally, there were significant main effects of color saturation, $F(1, 3,579) = 16.39, p < 0.001$, and color match, $F(1, 3,579) = 487.85, p < 0.001$, on healthiness ratings.

Table 6. Results of the LME model testing the effects of color saturation, color match, and their interaction on healthiness ratings of hydration drinks

Predictors	<i>F</i> (1, 3,579)	<i>p</i>
<i>Intercept</i>	2892.75	<0.001
Color saturation	16.39	<0.001
Color match	487.85	<0.001
Color saturation × color match	81.11	<0.001
Random effects		
σ^2		1.24
τ_{00} product		1.38
τ_{00} id		0.38
N_{product}		3
N_{id}		398
Observations		4,776
Marginal R^2		0.109
Source(s): Authors' work		

5.2.2 The influence of color saturation, color match, and their interaction on expected tastiness of hydration drinks. A further linear mixed effect model was conducted to predict the tastiness ratings, taking into account color saturation, color match, and their interaction, with random intercepts for participant and product flavor. This model aimed to ascertain whether packaging color saturation predicts tastiness ratings and whether this relationship is affected by packaging color match. The detailed results are provided in [Table 7](#).

Again, a significant interaction effect between color match and color saturation was demonstrated $F(1, 3,579) = 299.71, p < 0.001$. Pairwise comparisons of estimated marginal means were run testing the effect of saturation on taste within each color match condition to explore color match's moderating role on the effect of color saturation on tastiness ratings. In the color match condition, color saturation had a significant influence on tastiness ratings, $t(3,579) = 24.95, p < 0.001$. Normal saturated packages ($M = 5.68; SD = 2.06$) were rated as significantly tastier than low saturated packages ($M = 4.13; SD = 1.83$). In the non-color match condition, no significant influence of color saturation on tastiness ratings could be observed, $t(3,579) = 0.47, p = 0.64$. These findings indicate that normal saturated packages are expected to be tastier than low saturated packages, but only when the package color matches the main ingredient. In addition, there were significant main effects of color saturation, $F(1, 3,579) = 323.19, p < 0.001$, and color match, $F(1, 3,579) = 235.77, p < 0.001$.

5.3 Discussion

Study 2 extended the findings of Study 1 in an important way: We observed opposite effects of color saturation on expected healthiness depending on the match between primary package color and ingredient. When the primary package color matched the color of the ingredient, we observed the same results as in Study 1. Participants expected the beverages to be healthier when the primary package color was saturated than when it was not. When the package color did not match the ingredient, saturation even led to a lower expectation of healthiness. Thus, Study 2 reflects, at least in part, what has been found in the various studies in the literature: Color saturation can have both positive and negative effects on health expectations. Our results suggest that the saturation-healthiness association depends on the match between the color and main ingredient.

Table 7. Results of the LME model testing the effects of color saturation, color match, and their interaction on tastiness ratings of hydration drinks

Predictors	<i>F</i> (1, 3,579)	<i>p</i>
<i>Intercept</i>	5460.95	<0.001
Color saturation	323.19	<0.001
Color match	235.77	<0.001
Color saturation × color match	299.71	<0.001
Random effects		
σ^2		2.32
τ_{00} product		1.12
τ_{00} id		0.46
N_{product}		3
N_{id}		398
Observations		4,776
Marginal R^2		0.153
Source(s): Authors' work		

An interesting finding of Study 2 is that there were no effects of color saturation on taste expectations in the non-matching color condition. Previous studies have consistently reported positive effects of saturation on taste expectations. For example, [Tijssen et al. \(2017\)](#) observed that participants expected yogurt drinks and sausages to be less healthy when high compared to less saturated colors were used, but they found that color saturation increased expected taste intensity. One possible explanation for the difference between the results of Study 2 and previous studies is that we used artificial foods with which participants had no prior experience. Therefore, it is possible that there was no positive taste expectation that could be strengthened or weakened by the saturation.

6. General discussion

Taste and health are critical factors in how consumers evaluate and choose products. It is therefore beneficial for marketers to incorporate visual cues into packaging design that enhance expectations of taste and health. Color saturation is one such cue that can be easily varied in the primary package color.

Some researchers argue that one function of color perception is to help identify foods that are nutritious and healthy ([Sánchez-Solano et al., 2020](#)). Congruent to this logic, a basic assumption of the present research was that consumers can learn an association between color and both taste and healthiness when a specific color cue is repeatedly paired with taste and healthiness. In particular, we proposed that color saturation may be an important property of a color that can carry such associations ([Palmer and Schloss, 2010](#)). For example, individuals may have repeatedly experienced that a fruit that lost its true color (saturation) tastes bad and can cause illness. We argued that consumers rely on such associations not only when evaluating fresh fruit, but also packaged food.

The results of the two studies support this reasoning, as long as the color of the packages matched the main flavor-giving ingredient. In these conditions, participants expected the presented beverages to be healthier and tastier when the package color had a normal compared with low saturation level. This effect of saturation is congruent to the reasoning that consumers apply a saturation-freshness association to evaluate healthiness and tastiness ([Kunz et al., 2020](#)). However, the results also highlight the need to consider limitations of this mechanism.

In Study 2, we found that color saturation had a negative effect on healthiness expectations and no effect on taste expectations when the colors of the packages did not match the contents. Thus, the learned association between saturation and freshness was not applied by participants in this case. Possibly, participants applied another association, such as a saturation-intensity association. Researchers have observed an association between saturation and arousal (Zieliński, 2016). A package with saturated colors might evoke the feeling that the product is more intense or exciting (Gorn *et al.*, 1997). Consumers may rely on this feeling to judge the intensity of the beverage. Because the beverage category used in Study 2 tends to be perceived as unhealthy, consumers might have perceived this unhealthy aspect of the product as stronger or more true (see Mead and Richerson, 2018 for a similar argument). In addition, lower saturation might signal that the unhealthy aspect weighs less and the product appears to be lighter (Mai *et al.*, 2016). Therefore, consumers might have used low saturation as a cue for healthiness in this more processed product category.

Interestingly, we found no effect of color saturation on taste expectations in Study 2 when the color did not match the ingredient. If higher saturation signaled a more intense taste of the beverage, one would have expected that consumers rate a normal vs. low saturated product as tastier, regardless of the match between the package and ingredient color. Potentially, consumers perceived the hydration drinks in Study 2 as artificial. A more intense impression of these artificial drinks might have had no effect on their expected taste, but just made them appear even more artificial. However, this notion remains speculative and has to be tested in future research.

A limitation of this study is that we only examined the effects of saturation and color match for two different product categories. It is possible that consumers have learned to associate different hues and saturation levels with specific product categories, and these learned associations may influence how color saturation and hue influence taste and health expectations. Previous research has shown that the influence of packaging color varies across product categories (Huang and Lu, 2016). It would be valuable to extend the effects of saturation and hue across a variety of product categories. In addition, there may be an optimal level of color saturation for product packaging that is perceived as healthy and tasty. Again, this optimal level may be different for different product categories. Future research could further explore this idea. Extending the effects of saturation and color match to a variety of product categories would be valuable.

Another limitation is that we created artificial product designs and participants were unfamiliar with the products. We would expect weaker effects when consumers are familiar with a product, because then they are likely to have a highly accessible product image that is more important than the perception of the product packaging in the specific situation.

7. Conclusion

The present research contributes to the literature of color effects on product judgments in two ways. First, it provided additional evidence that saturation is an important color cue that signals health and taste. This finding is important given the extensive discussion that health and taste are often perceived as incompatible aspects of food (Haasova and Florack, 2019; Raghunathan *et al.*, 2006). Our findings lend support to the idea that consumers' health and taste judgments of food are often congruent, because they are based partly on the same visual cues. Second, we help explain the incongruent results of previous studies reporting positive (e.g. Kunz *et al.*, 2020) as well as negative (e.g. Tijssen *et al.*, 2017) effects of saturated package colors on expected healthiness. Our results show that the positive association between saturation and healthiness and tastiness most likely occurs when the package color matches the color of the main flavor-giving ingredient, such as orange juice packaged in an orange container. However, product packaging often does not match the colors of the contents, such as milk packaged in blue containers. In these cases, other saturation associations are likely to apply. The formation of these associations may follow similar principles: When taste or health information is paired

with high or low saturation, consumers may learn this association and apply it when encountering new products (Steiner and Florack, 2023).

7.1 Practical implications

Previous research on the interaction between product taste and health perception is ambiguous (Kunz *et al.*, 2020; Mai *et al.*, 2016; Mead and Richerson, 2018; Tijssen *et al.*, 2017). Some studies found a negative correlation between the perceived healthiness of a product and its tastiness (Mai *et al.*, 2016; Mead and Richerson, 2018; Tijssen *et al.*, 2017). This has made it challenging for marketers to successfully design healthy products, as visual cues that signal healthiness may lead to lower tastiness perceptions and therefore lower purchase decisions. Therefore, it is important to identify and utilize visual cues that can simultaneously enhance both healthiness and tastiness perceptions. In line with the study by Kunz *et al.* (2020), our findings demonstrate that color saturation can be such an overlapping cue when there is a color match between the packaging color and the main ingredient of a product. By using a saturated packaging color that matches the main ingredient of a product, a product can be perceived as both tasty and healthy at the same time.

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Table A1. Color parameters of the stimuli in the different conditions for Studies 1 and 2

Flavor	Color match	Saturation	Hue name	R	G	B
Orange	Yes	Regular	Orange	235	136	54
	Yes	Low	Orange	215	146	96
	No	Regular	Red	235	21	17
	No	Low	Red	206	78	65
Apple	Yes	Regular	Red	198	11	7
	Yes	Low	Red	174	65	54
	No	Regular	Purple	164	0	159
	No	Low	Purple	147	60	142
Mango	Yes	Regular	Orange	185	81	23
	Yes	Low	Orange	166	95	62
	No	Regular	Pink	176	35	66
	No	Low	Pink	156	65	76

Source(s): Authors' work**Corresponding author**Sonja Kunz can be contacted at: sonja.kunz@univie.ac.at

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Less is More: How Package Color Saturation Influences Naturalness Perceptions of Plant-Based Meat Alternatives

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ABSTRACT

Consumer acceptance of plant-based meat alternatives remains moderate, partly due to perceptions of these products as highly processed and less natural than conventional meat. Given the importance of perceived naturalness in food choices, this research investigates how packaging color saturation influences judgments of naturalness, processing level, and expected taste of plant-based meat alternatives. Across two studies, participants viewed pictures of plant-based burger patties (Study 1) and plant-based sausages (Study 2). They rated the perceived naturalness, processing level, and expected tastiness of each product. We manipulated the color saturation (high versus low) within participants and the color hues (green vs. yellow) between participants. In Study 2, we also assessed individual differences in positive affect intensity. Participants rated lowly saturated products as more natural compared with highly saturated products and this effect was mediated by perceived processing level. The effect of color saturation was particularly pronounced for yellow packaging, but reduced for green packaging. Additionally, individuals with high positive affect intensity - who are more sensitive to sensory cues - exhibited stronger responses to color saturation in the green hue condition. Contrary to our hypothesis, packaging color saturation did not significantly influence taste expectations. These findings provide valuable insights for marketers and product developers in the plant-based food industry. Using lowly saturated packaging can enhance perceptions of naturalness without negatively impacting taste expectations, helping to improve consumer acceptance and market success of plant-based meat alternatives.

Keywords: packaging color; color saturation; naturalness perception; food processing perception; tastiness; plant-based meat alternatives

Introduction

Plant-based meat alternatives are designed to replicate the sensory and functional characteristics of conventional meat products, allowing consumers to maintain their familiar cooking practices and meals while reducing their environmental impact. However, despite their potential to facilitate transitions to meat-reduced diets, consumer acceptance of plant-based meat alternatives remains low (Hoek et al., 2011; Lea & Worsley, 2003; Michel et al., 2021), due to their often lower sensory appeal compared to traditional meat products (Hoek et al., 2011; Lea & Worsley, 2003). In addition, many consumers perceive these alternatives as being more processed and less natural than conventional meat products (Michel et al., 2021) which poses a challenge to their success in the market, because the perceived naturalness is important for consumers (Rozin et al., 2004).

One potential way to address the barriers to the consumption of plant-based meat alternatives lies in strategic packaging design, particularly through the careful selection of color properties. The deliberate selection of the package color hue and saturation is a common strategy to influence consumer preferences (Huang & Lu, 2016; Mai et al., 2016; Su & Wang, 2024). But which color strategies are already used and which ones would be optimal for plant-based meat alternatives? To get insights into the current usage of color saturation in packages of plant-based meat products, we examined the package colors of 85 plant-based meat alternatives offered in Austrian supermarkets. This inspection revealed considerable variation, particularly in the use of vibrant colors with high saturation versus muted colors with low saturation. While 38% of the products featured lowly saturated colors (saturation level < 40%), 21% featured highly saturated colors (saturation level > 70%).

Additionally, a survey among 197 marketing professionals revealed that 64% of respondents rated low color saturation as more appropriate for plant-based meat alternatives' packaging, while 29% considered high saturation more appropriate. Hence, the professionals' responses stand in contrast to the color saturation observed in current packaging designs. At

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the same time, marketers rated the overall fit of both high and low saturation predominantly in the mid-range: 69% of ratings for low saturation and 58% for high saturation fell between 3 and 5 on a 7-point scale. These findings highlight the lack of consensus among professionals regarding the optimal level of color saturation in the packaging of plant-based meat alternatives.

Previous studies have examined how packaging color saturation affects perceptions of taste (Becker et al., 2011) and healthiness (Mead & Richerson, 2018; Tijssen et al., 2017) of products (Kunz et al., 2020; Mai et al., 2016). These studies indicate that variations in color saturation can influence how consumers perceive food products' attributes. However, the effects are not consistent (Mai et al., 2016; Mead & Richerson, 2018; Steiner & Florack, 2023). Therefore, researchers have included moderators in their study designs to better understand these different effects (Huang & Lu, 2016; Schnurr, 2019; Steiner et al., 2024). But research on the impact of color saturation on perceptions of naturalness in food products still remains limited (Schifferstein et al., 2019; Zhang et al., 2024). To our knowledge, no study has yet investigated the combined influence of packaging color saturation on consumers' expectations of both naturalness and taste. The objective of the present research is to address this research gap for plant-based meat alternatives.

The basic theoretical idea of the present research is that color saturation influences the perception of naturalness like a metaphor for extent or intensity. Colors frequently appear in metaphors, such as the "grey" economy or "green" energy. Individuals understand one concept, like "grey," and apply that understanding to another concept, such as "economy." The term "grey economy" refers to a vague area (between black and white) that lies between legality and illegality. Such metaphors help to simplify abstract or complex concepts that are often challenging to evaluate directly. They are often grounded in sensory experiences (Schwarz, in press).

We propose that higher color saturation serves like a visual signal or metaphor for "more" in the context of food products, implying "more ingredients" and "more processing." Our argument is based on how color saturation influences the perception of objects. Research shows that darker objects are perceived as heavier than lighter ones (Hagtvedt, 2020; Walker et al., 2010). Similarly, products with higher saturation are seen as larger than those with lower saturation (Hagtvedt & Adam Brasel, 2017). Also, a highly saturated color on a product itself, its package, or in an ad background, can signal that the product is more potent and therefore more efficacious (Labrecque et al., 2025). All of the above perceptions can be interpreted as a metaphor for "more." In the evaluation of plant-based meat alternatives, processing of food plays an important role (Boukid, 2021; Michel et al., 2021; Van Loo et al., 2020). We suppose that higher color saturation leads to the perception of more processing and less naturalness of plant-based meat alternatives in a similar way as more saturated colors lead to the perception of a product more efficiently serving its purpose (Labrecque et al., 2025).

There is preliminary evidence suggesting that color saturation can affect the perception of food naturalness (Schifferstein et al., 2019). However, this effect has not been examined in relation to plant-based meat alternatives for which the perception of processing is particularly important (Boukid, 2021). In addition, we are not aware of any research that directly compares the effects of saturation between different color hues on the perception of naturalness. Specifically, it remains unclear whether the effects of saturation differ for the color green, which is often associated with nature (Clarke & Costall, 2008). In the case of green, the hue itself might serve as a metaphor for "nature", and thus increased saturation might indicate greater naturalness. In our studies, we compare the effects of saturation between green and yellow packages.

Moreover, we propose that the sensitivity of individuals to sensory stimuli will moderate the predicted effects. We test the hypothesis that individuals with high positive affect intensity will experience a stronger influence of color saturation on their naturalness

perceptions and taste expectations. These individuals are more sensitive to sensory stimuli than those with low positive affect intensity (Moore & Konrath, 2015). People with high positive affect intensity tend to process sensory information more deeply, have a lower threshold for stimulation, and engage more thoroughly with their environment. Consequently, they are more likely to notice and be influenced by subtle changes in color saturation, leading to more pronounced effects on their perceptions of product attributes.

In summary, the present study examines how color saturation influences consumers' perceptions of the processing level and naturalness of plant-based meat alternatives. We also measured the effects on taste expectations and studied positive affect intensity as a potential moderator of the effects.

Conceptual Background

Despite the growing importance of sustainable consumption, various studies have shown that plant-based meat alternatives are perceived more negatively than their meat counterparts and that the acceptance of these products is only moderate to low (Elzerman et al., 2011; Hartmann & Siegrist, 2017; Michel et al., 2021). A particular barrier is the perception of plant-based meat alternatives as less natural and more processed compared with conventional meat (Hoek et al., 2011; Michel et al., 2021).

Studies have shown that many consumers prefer products that they perceive as natural and believe that natural products are inherently safer, healthier, and more benevolent than alternatives that are perceived as less natural (Meier et al., 2019; Rozin et al., 2024). In contrast, products perceived as less natural are often rejected, sometimes with the moral implication that human intervention and change disrupt a benevolent natural order (Rozin et al., 2004). Interestingly, consumers tend to judge historical processing methods as more natural than modern technologies, even if the newer approaches offer improved health or safety (Rozin, 2005). Thus, in the present research, we conceptualize naturalness primarily as

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a subjective psychological construct rather than an objective product characteristic or physical property.

One factor that may impact how natural plant-based meat alternatives appear in consumers' eyes may be their packaging color, specifically color saturation. We propose that color saturation has a cognitive function and influences consumer judgments like a metaphor. Research highlights that metaphors are not merely a decorative feature of language, but play a critical role in shaping how abstract concepts are mentally represented. They bridge knowledge gaps by allowing attributes of the source domain to inform the understanding of the target domain. This makes complex or abstract ideas more understandable. The use of metaphors is not only limited to language, but can be applied to other sensory experiences with the world (Schwarz, in press). Also, research indicates that metaphors serve as powerful framing tools in advertising (for a review, Zaltman & MacCaba, 2007). For example, playful and colorful packaging can be seen as a metaphor for fun and enjoyment. Accordingly, the use of playful and colorful packaging raises expectations that a food product will deliver a positive taste experience.

Similarly, we argue that packaging color saturation functions like a metaphor for extent and intensity and consumers transfer attributes derived from the color saturation to the abstract concepts of naturalness, processing level, and taste expectation. Because previous research has indicated that color saturation is linked to increased weight, size, and potency (Hagtvedt, 2020; Hagtvedt & Adam Brasel, 2017; Labrecque et al., 2025; Walker et al., 2010), we propose that high color saturation in plant-based meat alternatives suggests a greater quantity of ingredients and processing. Therefore, we believe that products with higher saturation will evoke impressions of more human intervention, leading consumers to perceive them as more processed and less natural.

While the theoretical model has not been tested for plant-based meat alternatives, there is first evidence that color saturation affects naturalness perceptions. In a study by

Schifferstein et al. (2019), consumers rated carrots as more natural when they were depicted with low saturation than when they were depicted with high saturation. In an area not related to food, Zhang et al. (2024), found similar results. Across different materials, such as a brand logo, pictures of milk packages and pictures of a fruit farm, low versus high color saturation increased consumers' expectations of naturalness (Zhang et al., 2024). Accordingly, we hypothesize that an increase in color saturation will lead to a decrease in the perception of naturalness.

***Hypothesis 1:** Consumers will perceive a plant-based meat alternative to be less natural when the packaging has a higher vs. lower saturation.*

Our reasoning is based on the idea that higher saturation signals the intensity of human intervention in the processing of the product. Consumer research has provided evidence that human intervention, such as boiling and the addition or removal of ingredients, significantly reduces the perceived naturalness of food products (Rozin, 2006), and researchers argue that individuals believe that naturalness is diminished by almost any process of human intervention (Scott & Rozin, 2020). Therefore, we hypothesize that color saturation will influence consumers' judgments of the degree of processing, which in turn will influence their judgments of the product's naturalness. Specifically, we expect that consumers' processing intensity judgments will mediate the influence of color saturation on naturalness perception.

***Hypothesis 2:** The influence of color saturation on naturalness perceptions of plant-based meat alternatives will be mediated by the judgment of the processing degree of the products.*

While naturalness is usually positively associated with taste expectations (Rozin, 2006), it is not clear whether reduced saturation leads to both higher perceived naturalness and higher taste expectations. In fact, research suggests that color saturation may have the opposite effect and higher saturation might be associated with increased taste expectations (Kunz et al., 2020; Mai et al., 2016). Highly saturated package colors might indicate a higher

concentration of ingredients and thus a more intense flavor. Accordingly, consumers expect food with more saturated colors to have a more intense flavor (Spence, 2015). For example, participants perceived beverages with higher color intensity as sweeter or more intense in flavor, although the actual content of the beverage did not change (Clydesdale et al., 1992; Zellner & Durlach, 2003).

Across several studies in which the color saturation of food packages was varied, consumers expected a better taste of food products when the color saturation of the food packages was higher compared to lower (Kunz et al., 2020; Mai et al., 2016; Steiner et al., 2024b; Tijssen et al., 2017). For example, Kunz et al. (2020) presented participants images of soft drinks with high versus low saturation and found that participants expected the soft drinks to be tastier when the pictures showed the soft drinks with a higher saturation level. Based on these results and our reasoning that color saturation is used like a metaphor and signals higher content and flavor intensity, we therefore supposed that color saturation has similar effects for plant-based meat alternatives.

Hypothesis 3: *Consumers will expect a plant-based meat alternative to be tastier when the main color of the package has a high compared to low saturation level.*

Moreover, we expect that saturation effects will be moderated by hue. Spence et al. (2010) found that when the color matched the expected flavor (e.g., red for strawberry), participants perceived highly saturated beverages as more flavorful. When the color was incongruent with the flavor (e.g., green for strawberry), the effect of saturation was reduced. Similarly, in the study by Steiner et al. (2024), the positive effect of color saturation on taste expectations was stronger when the packaging color matched the color of the product's main ingredient.

We argue that these moderating effects of hue occur because different hues convey different meanings, and we believe that the respective associations are enhanced by higher levels of color saturation compared to lower levels of saturation. Through experiences in

consumer's daily life and the repeated occurrence of a particular color in a specific context, consumers learn to associate specific color hues with specific product attributes (Labrecque et al., 2013). Since green is a predominant color in nature and natural products are often advertised in green packaging, consumers have learned to associate green with naturalness (Clarke & Costall, 2008).

Since green is closely associated with nature, it can be assumed that a high saturation for a green package signals more naturalness and therefore increases naturalness perceptions. Yet, a high saturation for an unrelated color, such as yellow, may be perceived as artificial and signal a higher content of artificial flavors or additives and therefore decreases naturalness perceptions. We hypothesize that the influence of color saturation on consumers' naturalness perception depends on the packaging color hue.

Hypothesis 4: *The effect predicted in Hypothesis 1 be weaker or reversed when a green vs. yellow packaging color hue is used in the package of a plant-based meat alternative.*

Furthermore, we expect that saturation will have differential effects on different consumers. In particular, individuals vary in their sensitivity to sensory stimuli, influencing how they respond to visual cues such as packaging color (Moore & Konrath, 2015). Affect intensity refers to the extent to which individuals experience emotions vividly and deeply, regardless of their specific content (Larsen & Diener, 1987). Individuals with a high affect intensity are more sensitive to sensory stimuli (Kergoat et al., 2012; Larsen et al., 1996), including visual stimuli, and experience greater enjoyment from sensory-rich experiences (Moore & Homer, 2000). In a study, Moore and Konrath (2015) observed that individuals with high affect intensity were more responsive to highly saturated advertisements compared to those with lower affect intensity. Hence, we hypothesized that affect intensity amplifies responses to variations in color saturation.

Hypothesis 5: *The effects predicted in Hypothesis 1, 2, and 3 will increase with increased positive affect intensity.*

Summary and Outline of the Present Studies

The objective of the present research was to better understand how packaging color saturation and hue influence consumers' naturalness perceptions and taste expectations of plant-based meat alternatives. In two studies, we varied the saturation and hue of packaged plant-based meat alternatives and measured the effects on perceived naturalness, processing level, and taste expectations. In Study 1, we examined the influence of color saturation, the mediating role of perceived processing level, and the moderating role of color hue on consumers' naturalness perceptions and taste expectations of plant-based burger patties. In Study 2, we replicated the procedure with another category, plant-based sausages, and further examined whether individual differences in positive affect intensity moderate the effects of varying color saturation. We expect that lowly saturated products will be perceived as more natural compared to highly saturated products, and that this effect will be mediated by perceived processing level. Furthermore, we believe that the effect of saturation will be stronger for yellow versus green packages and for individuals with high versus low positive affect intensity.

Study 1: The Impact of Packaging Color Saturation and Hue on Consumers'

Naturalness Perceptions and Taste Expectations of Plant-Based Burger Patties

In Study 1, we manipulated the color saturation (high vs. low saturation) within participants and the color hue (green vs. yellow) between participants. Participants were asked to evaluate the naturalness, processing level, and tastiness of pictures of packaged plant-based burger patties. Study 1 was pre-registered on [aspredicted.org](https://aspredicted.org/88yb-rtv5.pdf), and the preregistration documents can be accessed at: <https://aspredicted.org/88yb-rtv5.pdf>

Method

Participants and Design

We recruited participants from Germany, Austria, and Switzerland using the online research platform Prolific. The final sample included 261 participants: 49% women, 49%

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men, and 2% who identified as another gender or preferred not to answer the question, with a mean age of 33.49 years ($SD = 9.34$). All participants reported German as their first language. The mean body mass index (BMI) was 24.45 ($SD = 5.04$). Those who did not give consent or failed the attention check were excluded a priori from the study.

This study used a 2 (color saturation: high vs. low) x 2 (color hue: green vs. yellow) x 2 (Brand A vs. Brand B) mixed design, with color saturation as the within-subject factor and color hue as the between-subject factor. Brand was a random factor for which we had no hypotheses.

Procedure and Measures

Participants rated the naturalness, processing level and tastiness of plant-based burger patty packages. Participants were randomly assigned to either the green or yellow color hue condition. In each condition, participants first viewed two plant-based burger patty packages by different brands side-by-side for 3 seconds. One of the packages was in highly saturated colors and the other one in lowly saturated colors in the respective color hue of the condition. We randomized between participants which of the two brands was shown with high and low saturation and the order of presentation of the brands. Naturalness, processing level, and tastiness ratings were collected in separate rating blocks. In the first block, participants rated the *naturalness* of both packages while still viewing them with three items and response options ranging from 1 (*very unnatural*) to 5 (*very natural*). The items were: 1) "How natural does the product in the packaging shown look to you?" (1 = *very unnatural*; 5 = *very natural*); 2) "To what extent does the packaging give the impression that the product is made from natural ingredients?" (1 = *not at all*; 5 = *very strongly*), 3) "How much do you associate the packaging of the respective product with naturalness?" (1 = *not at all*; 5 = *very strongly*). In the second and third blocks, participants rated the *processing level* and *tastiness* of the same packages in the same order as in the first block, again with three items for processing level and tastiness and response options from 1 = *very processed/not at all tasty* to 5 = *not*

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processed at all/very tasty. The items measuring the *processing level* were: 1) "How strongly processed does the respective product in the illustrated packaging appear to you?" (1 = *not at all*; 5 = *very strongly*); 2) "To what extent do you believe that the respective product in the packaging shown was produced through several processing steps?" (1 = *not at all*; 5 = *very strongly*); 3) "How strong do you rate the degree of processing for the respective product?" (1 = *not strong at all*; 5 = *very strong*). The items measuring the *expected tastiness* were: 1) "How would you rate the taste of the product based on the packaging?" (1 = *does not taste good at all*; 5 = *tastes very good*); 2) "How much would you enjoy eating the product?" (1 = *not at all*; 5 = *very much*); 3) "To what extent do you think the product tastes good?" (1 = *does not taste good at all*; 5 = *tastes very good*).

After rating each plant-based burger patty for naturalness, processing level, and tastiness, participants were asked to provide demographic information (e.g., age, gender, nationality, perceived socioeconomic status), as well as their food consumption habits and purchase frequency within the product category.

Materials

We used existing product packages of plant-based burger patties by two different brands. The packages had a reduced design and a dominant background color. We manipulated the background color hue (green and yellow) and color saturation (low -30% saturation and high +30% saturation), resulting in a total of four product images for both brands. We manipulated color saturation using the CIE LAB color system, as it has been shown to closely match human perception of color saturation, based on the findings of Schiller et al. (2018). This choice ensures a perceptually relevant and empirically validated approach to testing the effects of color saturation on consumer perception. In addition, we conducted a pretest ($N = 30$) to ensure that consumers perceived the lowly and highly saturated packages accordingly. We measured the perceived saturation level of the plant-based burger patties with three items (Cronbach's α from 0.85 to 0.92): "How saturated do

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you find the color of the packaging?" (1 = *very little saturated*; 7 = *very saturated*); "How intense do you find the color of the packaging?" (1 = *very little intense*; 7 = *very intense*); "To what extent does the packaging give the impression of a strong color?" (1 = *not strong at all*; 7 = *very strong*). In the pretest, participants perceived the highly saturated packages ($M_{\text{yellow}} = 5.61$, $SD = 0.95$; $M_{\text{green}} = 5.64$, $SD = 0.97$) as more saturated than the lowly saturated packages ($M_{\text{yellow}} = 3.09$, $SD = 1.08$; $M_{\text{green}} = 2.97$, $SD = 1.03$) for both color hues, $F(1, 29) = 197.28$, $p < .001$.

Data Analysis

Our main question was whether a high vs. low packaging color saturation leads to a lower perceived naturalness, but higher taste expectations for plant-based burger patties, especially ones with yellow packaging color. Furthermore, we hypothesized that the influence of color saturation on naturalness perception is mediated by perceived processing level. We tested our hypotheses with repeated measures ANOVAs, with the perceived naturalness, processing level, and expected tastiness as the dependent variables, color saturation (high vs. low) as within-subject factor, and color hue (green vs. yellow) as between-subject factor. We conducted pairwise comparisons of estimated marginal means between conditions, applying Bonferroni corrections for multiple testing. All analyses were performed using SPSS (version 29.0.0.0 (241)) and R (version 4.3.2) statistical software (R Core Team, 2023), employing the SPSS macro MEMORE for mediation analysis in repeated measures designs (Montoya & Hayes, 2017) and the R package *rstatix* for calculating ANOVAs (Kassambara, 2020). A significance level of $\alpha = .05$ was applied to all analyses.

Results

Influence of Color Saturation on Naturalness Perceptions

To test whether color saturation and its interaction with hue influenced naturalness perceptions, we calculated a repeated measures ANOVA with color saturation as within-subject factor, hue as between-subject factor, and perceived naturalness as the dependent

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variable. We expected that participants would rate lowly saturated packages as more natural than highly saturated packages, and that hue would moderate this effect.

The main effect of color saturation was significant, $F(1, 259) = 4.13, p = .04, \eta_p^2 = .02$. Participants perceived the product in the lower saturated package as more natural than the one in the higher saturated package ($M_{low} = 3.23, SD = 0.87$ vs. $M_{high} = 3.07, SD = 0.97$). In contrast to our expectation, the interaction between color saturation and hue was not significant, $F(1, 259) = 1.93, p = .17$. However, pairwise comparisons of color saturation levels within each color hue condition yielded differences between the conditions. If participants rated yellow product packages, they perceived lowly saturated products as more natural ($M_{low} = 3.24; SD = 0.81$) than highly saturated products ($M_{high} = 2.96; SD = 0.97$), $p = .01$. In contrast, if participants rated green packages, the effect of color saturation on naturalness ratings was not significant ($M_{low} = 3.22; SD = 0.94$ vs. $M_{high} = 3.17; SD = 0.97$), $p = .65$. The main effect of color hue was not significant, $F(1, 259) = 1.47, p = .23$.

Influence of Color Saturation on Perceived Processing Level

Another repeated measures ANOVA was conducted, with color saturation and hue as independent variables, but this time perceived processing level as dependent variable. We found a significant influence of color saturation on perceived processing level. Participants perceived highly saturated packages as more processed than lowly saturated packages, regardless of the color hue ($M_{low} = 3.78, SD = 0.75$ vs. $M_{high} = 3.91, SD = 0.72$), $F(1, 259) = 7.51, p = .01, \eta_p^2 = .03$. The interaction between hue and saturation on perceived processing level, $F(1, 259) = 0.04, p = .85$, and the main effect of color hue were not significant, $F(1, 259) = 3.40, p = .07$.

Influence of Color Saturation on Expected Tastiness

To examine whether color saturation and hue has a significant influence on expected tastiness, we performed another repeated measures ANOVA with package color saturation and hue as the independent variables and expected tastiness as the dependent variables. We

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expected that participants would rate highly saturated packages as tastier than lowly saturated packages and that this effect would be moderated by hue.

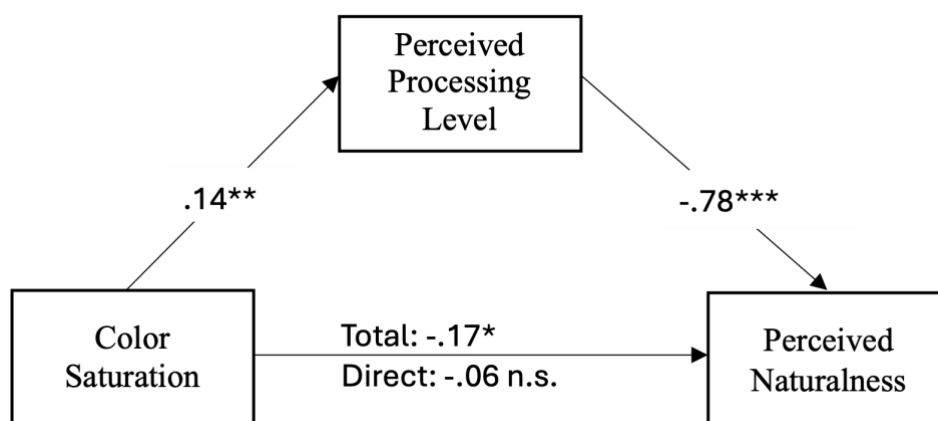
The interaction between saturation and hue was significant, $F(1, 259) = 4.11, p = .04$. Participants expected products in highly saturated packages to be tastier than in lowly saturated packages, but only in the green color hue condition ($M_{low} = 3.26, SD = 1.09$ vs. $M_{high} = 3.48, SD = 1.00, p = .08$). There was no significant difference between the saturation levels in the yellow color hue condition ($M_{low} = 3.32, SD = 1.02$ vs. $M_{high} = 3.26, SD = 1.08$), $p = .68$. The analysis yielded no main effects of color saturation $F(1, 259) = 1.53, p = .22$, nor hue, $F(1, 259) = 0.55, p = .46$.

Mediating Role of Perceived Processing Level on the Influence of Color Saturation on Naturalness Perceptions

To test our hypothesis that a high vs. low packaging color saturation leads to a higher perceived processing level, which then decreases the naturalness perception of a product, we performed a mediation analysis (Model 1, Montoya) based on 5000 bootstrapping samples with package color saturation (high vs. low) as the independent variable, perceived processing level as the mediator, and perceived naturalness as the dependent variable (see Figure 1).

Figure 1

Mediation Model Illustrating the Influence of Color Saturation on Perceived Naturalness and the Mediating Role of Perceived Processing Level for Plant-Based Burger Patties.



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The results revealed that the perceived processing level significantly mediated the relationship between package color saturation and perceived naturalness (indirect effect = -0.1086, $SE = 0.0428$, 95% $CI = [-0.2004, -0.0322]$). Specifically, color saturation was positively associated with perceived processing level, $\beta = 0.14$, $t = 2.75$, $p = .006$ and perceived processing level was negatively associated with naturalness perception, $\beta = -0.78$, $t = -8.87$, $p < .001$. The total effect of color saturation on perceived naturalness was significant, $\beta = -0.17$, $t = -2.01$, $p = .045$. However, after controlling for perceived processing level, the effect of color saturation on perceived naturalness was not significant, $\beta = -0.06$, $t = -0.79$, $p = .43$. These findings support H3 that perceived processing level mediates the influence of color saturation on perceived naturalness.

Discussion

Consistent with our hypothesis, participants perceived products in lowly saturated packaging as more natural than products in highly saturated packaging and this effect was mediated by perceived processing level. Interestingly, the influence of saturation on naturalness perception was only observed for yellow, not for green colored packages. Contradictory to our hypothesis, we did not find an overall saturation effect on tastiness. High saturation increased tastiness expectations in the green hue condition, whereas no such effect was observed in the yellow condition. Hence, the influence of saturation on naturalness perception and tastiness expectations might depend on the meaning of a color hue in a specific context (Steiner et al., 2024).

Interestingly, hue alone did not affect perceptions of naturalness or tastiness. This suggests that hue influences these perceptions only in interaction with color saturation, rather than independently.

A limitation of Study 1 is that we focused solely on the effects of color saturation within the product category of burger patties. It is essential to explore whether the observed effects extend to another category. Hence, Study 2 aimed to replicate the findings of Study 1

with another product category, plant-based sausages, and test the moderating role of positive affect intensity.

Study 2: The Impact of Packaging Color Saturation and Hue on Consumers'

Naturalness Perceptions and Taste Expectations of Plant-Based Sausages

In Study 2, we investigated the influence of color saturation on consumers' naturalness judgments and tastiness expectations for plant-based sausages, the moderating role of color hue, and the mediating role of perceived processing level. Furthermore, we examined whether positive affect intensity moderates the effects of color saturation. We have pre-registered Study 2 on aspredicted.org. The preregistration documents are available at:

<https://aspredicted.org/6kkz-m3y7.pdf>

Method

Participants and Design

We used the research platform Prolific to recruit participants from Germany, Austria, and Switzerland. We recruited 501 participants, of which 48.9 % were female, 48.7 % male and 2.4 % identified as another gender or preferred not to answer. All participants had German as their first language and the mean BMI was 25.09 ($SD = 5.06$). Participants who gave no consent or failed the attention check were excluded from the study.

The study design remained the same as in Study 1: a 2 (color saturation: high vs. low) x 2 (color hue green vs. yellow) x 2 (brand A vs. brand B) design, with color saturation as the within-subject factor and color hue as the between-subject factor. Brand was a random factor for which we had no hypotheses.

Procedure and Measures

The procedure of Study 2 was identical to Study 1, with the difference that participants evaluated plant-based sausages instead of burger patties. Participants were again randomly assigned to either the green or yellow color hue condition. Within each condition, participants viewed two plant-based sausage packages by different, this time fictitious brands, displayed

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side by side for 3 seconds. One package had a high color saturation and the other had a low color saturation. The brand assignment to high or low saturation and the position (left or right) of the packages were randomized between participants. After viewing both packages, participants rated each package for naturalness, processing level, and tastiness in three separate blocks. The items were identical to those used in Study 1.

In addition to the procedure in Study 1, at the end of the rating task, participants indicated their relative preference between the two packages shown in the previous trials, using a slider. The slider ranged from 1 = *strong preference for package 1* to 5 = *strong preference for package 2*, with 3 indicating no preference.

To assess individual differences in susceptibility to emotional and sensory stimuli, participants completed the 17-item positive affect intensity measure (Larsen & Diener, 1987). This scale included items such as "When I feel happy, it is a strong kind of exuberance", rated on a 6-point scale (1 = *never*; 6 = *always*).

Materials

Existing product packages from two brands of plant-based sausages were selected. We changed the brand names on the packages to the fictitious brand names "Vearthy" and "Viora". Furthermore, the background color hue (green vs. yellow) and saturation level (low - 30% vs. high +30%) were adjusted, using the same color parameters as in Study 1, resulting in four product images per brand. Again, the packages had a reduced design with a dominant background color.

Data Analysis

To test our hypotheses, we conducted repeated measures ANOVAs with color saturation (high vs. low) as a within-subject factor and color hue (green vs. yellow) as a between-subject factor for each dependent variable: naturalness, processing level, and tastiness. Pairwise comparisons with Bonferroni corrections were applied to examine differences between conditions. The moderating effect of positive affect intensity was

explored by including it as a covariate in the ANOVAs. Mediation analyses were performed using the MEMORE macro for SPSS (Montoya & Hayes, 2017), with packaging color saturation as the independent variable, perceived processing level as the mediator, and naturalness as the dependent variable. To analyze the results of the relative preference for lowly and highly saturated products, we performed a one-sample *t*-test comparing the responses to the scale midpoint. All analyses were conducted in SPSS (version 29.0.0.0 (241)) and R (version 4.3.2; R Core Team, 2023), with a significance level of $\alpha = .05$.

Results

Influence of Color Saturation on Naturalness Perceptions

To examine whether color saturation and its interaction with hue influenced naturalness perceptions, a repeated measures ANOVA was conducted with color saturation (high vs. low) as the within-subject factor, color hue (green vs. yellow) as the between-subject factor, and perceived naturalness as the dependent variable. Furthermore, we included positive affect intensity as covariate. We expected that participants would perceive lowly saturated packages as more natural than highly saturated packages, and that this effect would be moderated by hue and positive affect intensity.

The main effect of color saturation was significant, $F(1, 497) = 39.20$, $\eta_p^2 = .07$, $p < .001$. Products with low color saturation were rated as more natural ($M_{low} = 3.17$, $SD = 0.94$) than products with high color saturation ($M_{high} = 2.82$, $SD = 0.92$). However, the main effect was qualified by a significant interaction between color saturation and hue, $F(1, 497) = 4.57$, $\eta_p^2 = 0.01$, $p = .03$. In the yellow-hue condition, participants perceived the lowly saturated packages ($M_{low} = 3.18$, $SD = 0.93$) as more natural than the highly saturated packages ($M_{high} = 2.71$, $SD = 0.90$, $p < .001$). Also in the green hue condition, lowly saturated packages were judged as significantly more natural ($M_{low} = 3.17$, $SD = 0.96$) than highly saturated packages ($M_{high} = 2.93$, $SD = 0.93$, $p = .004$), but the difference was smaller. The main effect of color hue was not significant, $F(1, 497) = 3.13$, $p = .08$.

Furthermore, the interaction between color saturation, hue, and positive affect intensity was significant, $F(1, 497) = 10.74, \eta_p^2 = .02, p < .001$. In order to further analyse this interaction, we conducted a repeated measures moderation analysis (Model 2, Montoya) for each color hue separately.

In the green hue condition, positive affect intensity significantly moderated the relationship between color saturation and naturalness perceptions, $\beta = 0.32, t(251) = 2.79, p = .01$. Individuals with a higher positive affect intensity perceived a higher difference in naturalness between lowly and highly saturated packages. Participants with a higher positive affect intensity (+1 SD) rated products in highly saturated green packages as significantly less natural than green packages with lower saturation, $\beta = -0.18, t(251) = -2.22, p = 0.03$. There was no such effect for participants with lower levels of affect intensity (-1 SD), $\beta = 0.14, t(251) = 1.71, p = 0.09$.

In the yellow hue condition, we found no significant influence of positive affect intensity on the relationship between color saturation and naturalness perceptions, $\beta = -0.20, t(246) = -1.85, p = .07$.

Influence of Color Saturation on Perceived Processing Level

Another repeated measures ANOVA was conducted with perceived processing level as the dependent variable. There was a significant main effect of color saturation, $F(1, 497) = 27.30, \eta_p^2 = .05, p < .001$. Participants in both color hue conditions rated highly saturated packages as more processed ($M_{high} = 4.10, SD = 0.75$) compared to lowly saturated packages ($M_{low} = 3.91, SD = 0.80$). The main effect of color hue was not significant, $F(1, 497) = 0.02, p = .90$, nor was the interaction between saturation and hue, $F(1, 497) = 0.49, p = .49$. However, the interaction between saturation, hue, and positive affect intensity was significant, $F(1, 497) = 10.97, \eta_p^2 = .02, p < .001$.

To further analyse the interaction, we conducted a repeated measures moderation analysis (Model 2, Montoya) for each color hue. In the green color hue condition, positive

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affect intensity significantly moderated the relationship between color saturation and perceived processing level, $\beta = 0.19$, $t(251) = 2.73$, $p = .01$. Participants with a high positive affect intensity (+1 SD) perceived products with high compared with low saturation as more processed, $\beta = 0.30$, $t(251) = 4.21$, $p < .001$. For individuals with low positive affect intensity (-1 SD), color saturation did not influence the perceived processing level significantly, $\beta = 0.02$, $t(251) = 0.35$, $p = .73$. In the yellow color hue condition, no significant moderation by positive affect intensity was observed, $\beta = 0.14$, $t(246) = 1.97$, $p = .05$.

Influence of Color Saturation on Expected Tastiness

To examine the influence of color saturation and hue on expected tastiness, a repeated measures ANOVA was conducted. The results revealed no significant interaction between saturation and hue, $F(1, 497) = 0.94$, $p = .33$, nor a significant main effect of saturation, $F(1, 497) = 1.28$, $p = .26$ or hue $F(1, 497) = 0.58$, $p = .45$.

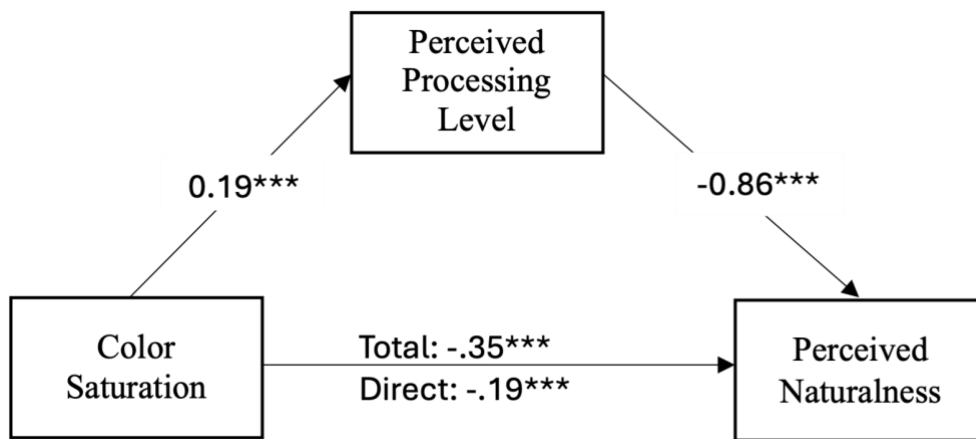
Mediating Role of Perceived Processing Level on the Influence of Color Saturation on Naturalness Perceptions

A repeated measures mediation analysis (Model 1, Montoya) based on 5000 bootstrapping samples was conducted to test whether perceived processing level mediated the relationship between color saturation and perceived naturalness (see Figure 2).

Figure 2

Mediation Model Illustrating the Influence of Color Saturation on Perceived Naturalness and the Mediating Role of Perceived Processing Level for Plant-Based Sausages.

The results revealed that processing level mediates the influence of color saturation on naturalness perceptions (indirect effect = -0.1610, $SE = 0.0320$, 95% $CI = [-0.2239, -0.0995]$. Specifically, high saturation was associated with higher perceived processing levels, $\beta = 0.19$, $t(500) = 5.37$, $p < .001$, which in turn negatively influenced naturalness ratings, $\beta = -0.86$, $t(498) = -14.22$, $p < .001$. The total effect of saturation on naturalness, $\beta = -0.35$, $t(500) = -$



6.36, $p < .001$, was reduced, but still significant, when controlling for processing level, $\beta = -0.19$, $t(498) = -3.99$, $p < .001$, indicating that the influence of color saturation on naturalness perceptions is partially mediated by perceived processing level.

Influence of Color Saturation on Product Preference

In order to analyze the results of the relative preference for lowly or highly saturated products, we conducted a one-sample t -test against the scale midpoint. Participants preferred the product with lower compared to higher saturation, $t(500) = -4.17$, $p < .001$ ($M = 2.77$, $SD = 1.24$). We also conducted separate one sample t -tests for each color hue group. In the green hue condition, consumers significantly preferred lowly saturated packages, $t(251) = -4.08$, $p < .001$ ($M = 2.60$, $SD = 1.22$). In the yellow hue condition, the difference against the midpoint of the scale was not significant, $t(246) = -1.86$, $p = 0.065$ ($M = 2.85$, $SD = 1.27$).

Discussion

The results replicated the main effect of color saturation observed in Study 1. Lowly compared with highly saturated packages were perceived as more natural and perceived processing level mediated this effect. In addition, the interaction between color hue and saturation was significant as well. In Study 2, high saturation reduced naturalness perceptions to a lesser extent for a green than for a yellow packaging. In Study 1, we had already observed differences between the color conditions, but the interaction was not significant.

While the results are largely consistent with Study 1, Study 2 extends the findings by exploring the role of individual differences in positive affect intensity. We supposed that individuals with high positive affective intensity respond more strongly to saturation differences as they usually do to other sensory stimuli as well (Kergoat et al., 2012; Moore & Konrath, 2015). However, the results do not provide a clear picture. We found the moderating effect of positive affect intensity only for the green colored package. A possible explanation might be that the stronger color saturation effect for yellow hues masked individual differences, whereas weaker saturation effects for green hues allowed individual differences to unfold. But this notion remains a speculation currently.

Interestingly, saturation had no effect on taste expectations. Hence, the positive effect of low color saturation on naturalness does not come with the costs of a worse taste expectation. As in Study 1, we found no main effects of color hue on either naturalness perceptions or taste expectations.

General Discussion

A key challenge to overcome for plant-based meat alternatives is their low naturalness perceptions, as they are often perceived as more processed than their meat counterparts (Hoek et al., 2011; Lea & Worsley, 2003; Michel et al., 2021). We assumed that a reduced color saturation might mitigate this undesired association of plant-based meat alternatives, because previous studies indicate that low compared to high saturation leads to higher naturalness perceptions in other domains (Schifferstein et al., 2019; Zhang et al., 2024). However, according to our knowledge, color saturation effects have not been systematically tested for plant-based meat alternatives. Also, it has not been clear whether reducing color saturation of packages for these products comes with the disadvantage of reduced taste expectations. Indeed, previous studies have pointed out that under certain circumstances, reducing color saturation might reduce the perception that a product is fresh and tasty (Kunz et al., 2020). In the present research, we therefore varied the color saturation of yellow and green packages of

two plant-based meat alternatives that are frequently available in supermarkets and tested the effects on consumer judgments. Across two studies, we found that low color saturation leads to increased naturalness perceptions, mediated by perceptions of lower processing degree.

Our results are a first indication that color saturation can function as a metaphor for intensity or extent, and that higher color saturation signals "more". As mentioned in the introduction, we do not understand color saturation as a metaphor in a strictly linguistic sense, but in a more general sense. Indeed, prior research has shown that metaphors not only serve a function in language, but are essential cognitive structures that shape how people perceive the world and their own behavior (Gibbs, 2008). Our reasoning draws on approaches from social cognition, which suggest that people often rely on visual cues to form perceptions about abstract concepts (Schwarz, in press). Our findings extend previous research showing that high color saturation can enhance perceptions of product attributes such as size, weight, and potency (Labrecque et al., 2025; Schifferstein et al., 2019; Zhang et al., 2024). Results of our studies demonstrate that packaging design can similarly influence consumer judgments in the food domain.

A basic implication of our theoretical framework is that the effects of color saturation can only be understood if one takes the meaning of the color hue into account (Steiner & Florack, 2023). The meaning of yellow hues clearly differs from the meaning of green hues which are typically associated with nature (Clarke & Costall, 2008). Our findings support this reasoning, albeit not as strongly as expected. In both studies, we found a stronger effect of color saturation for yellow than for green packages. We had initially expected that the saturation effects would even be reversed for green compared with yellow packages. Based on our metaphor approach, we supposed that more saturation indicates "more processing" for yellow packages, but "more natural" for green packages. It is not clear why color saturation effects were not reversed for green packages. The results of our pretest suggest that consumers perceive the saturation differences between low and high saturated green hues.

However, the results of our main studies suggest that consumers do not use differently saturated green colors as a cue for more or less nature. Future research should further investigate the moderating role of hue on saturation effects and possible underlying mechanisms.

An important contribution of the present research is that it provides first insights into whether individuals differ in their response to the color saturation of food packages. Previous studies have shown that individuals with high positive affect intensity respond more strongly to sensory stimuli, such as tactile softness in textiles or vivid food imagery (Kergoat et al., 2012; Moore & Konrath, 2014). Accordingly, we assumed that these individuals would also react more strongly to variations in color saturation and therefore measured positive affect intensity in Study 2. The findings provide a first hint that the moderating effect of positive affect intensity on responses to color saturation depends on the hue. Positive affect intensity only moderated saturation effects for green, but not yellow packages. Potentially, saturation effects for green colors are so subtle that they only affect individuals high in affect sensitivity. Conversely, saturation effects of yellow colors are strong enough to affect all individuals, regardless of their affect sensitivity. This notion remains speculative at this point and has to be clarified by future research.

Limitations

One limitation is that our studies focused on only two plant-based meat alternatives, plant-based burger patties and sausages. Expanding the scope to include a wider range of products, along with their corresponding meat counterparts, would provide a more comprehensive understanding of how color saturation influences perceptions of naturalness and taste for different types of products. For instance, for less processed products, such as traditional meat filets, high saturation may signal greater naturalness, as it can serve as a cue for freshness. In contrast, for more processed meat products, such as sausages, high saturation

may be associated with increased processing, potentially leading to a lower perception of naturalness.

Another limitation is that we focused our analysis on two color hues, green and yellow, because these are commonly used in the packaging of plant-based meat alternatives. Indeed, marketing professionals in our expert survey considered green and yellow to be the most suitable colors for meat-replacement products. However, previous research indicates that different color hues have different meanings and these meanings and their impact can vary depending on the product category (Clarke & Costall, 2008; Wąsowicz et al., 2015). Including a broader range of hues in future studies could provide a more comprehensive understanding of how color saturation influences consumer perceptions.

Lastly, it remains an open question how color saturation influenced participants' judgments in our studies. In line with our reasoning, high saturation may have triggered an embodied response, evoking a feeling of "more," consistent with our metaphor approach. However, we cannot rule out the possibility that participants used saturation cues deliberately, because they have learned by experience that more natural products are often packaged in less saturated colors. The processes driving the effect of saturation on naturalness perceptions warrant further investigation in future research.

Practical Implications

Our initial example from market research revealed significant variation in color saturation of plant-based meat alternative packages, suggesting uncertainty about the most effective design strategy. Some brands use highly saturated colors, while others opt for more muted tones, raising the question of how these design choices influence consumer perceptions. Our findings provide valuable insights to help marketers and product developers optimize packaging design for plant-based meat alternatives. Lower saturation enhances naturalness perceptions, without having a negative influence on taste expectations. The influence of color saturation on naturalness perception is particularly strong for yellow-

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compared with green colored hues and mediated by perceived processing degree. This makes muted, lowly saturated packages a better choice for brands positioning their products as minimally processed and natural. Since naturalness is a key driver of consumer acceptance, avoiding overly vibrant colors may improve product appeal.

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Ethical Statement

This research was conducted in accordance with the Declaration of Helsinki (revised 1983) and local guidelines of the Faculty of Psychology, University of Vienna. Participants in both studies were informed about the study's aim and confidentiality of the data collection, and gave their consent to participate. Participants could withdraw from the study at any time. The studies were approved by the Departmental Review Board (DRB) of the Department of Occupational, Economic, and Social Psychology at the University of Vienna (Approval numbers: 2024/S/029 and 2024/S/030).

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