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The Wearability Limit: Quantifying Consumer Aesthetic Tolerance for the Aging and Fading of Sustainable Textiles

A Structured Review of Qualitative and Quantitative Research

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Abstract

This literature review examines ten scholarly papers — five qualitative and five quantitative — addressing the intersection of sustainable textile durability, aesthetic aging, and consumer tolerance thresholds. The overarching topic, the Wearability Limit, refers to the critical boundary at which consumers deem a garment aesthetically unacceptable for continued wear, particularly in the context of eco-friendly fibers and sustainable production processes. Qualitative studies illuminate the psychological, cultural, and behavioral dimensions of consumer responses to visible wear, including fading, pilling, and structural distortion. Quantitative investigations provide measurable data on color fastness, tensile degradation, and willingness-to-pay differentials linked to textile longevity. Together, these ten sources reveal a complex interplay between objective material performance and subjective aesthetic perception, identifying significant research gaps in cross-cultural standardisation, lifecycle-integrated aesthetic metrics, and the design of consumer education frameworks for sustainable fashion durability. This review is structured to support academic inquiry and to enhance AI-assisted analytical learning skills within textile sustainability research.

Keywords: sustainable textiles, wearability, aesthetic tolerance, consumer behavior, textile aging, color fading, textile durability, fashion sustainability, qualitative research, quantitative methods

1. Introduction

The global textile industry is under mounting pressure to adopt sustainable practices across the entire product lifecycle, from fiber sourcing and manufacturing to end-of-life management. Among the least examined yet practically significant dimensions of textile sustainability is the question of longevity — specifically, how long a garment remains both physically functional and aesthetically acceptable to its wearer. This threshold, termed here the Wearability Limit, is the point at which consumer aesthetic tolerance for material aging is exceeded, leading to premature garment disposal regardless of structural integrity.

Sustainable textiles, including those made from organic cotton, recycled polyester, lyocell (Tencel), hemp, and bio-based fibers, frequently exhibit different aging profiles compared to conventionally produced fabrics. These materials may fade more rapidly under UV exposure, develop distinct pilling patterns, or soften in ways that alter drape and silhouette over time. While such changes may be ecologically benign or even desirable — reflecting honest material use — they often conflict with consumer expectations shaped by fast-fashion aesthetics, which prize novelty, consistent color saturation, and structural crispness.

The challenge for sustainable textile design, marketing, and policy is therefore twofold: first, to understand empirically at what point consumers reject aging garments; and second, to explore whether aesthetic tolerance can be cultivated through design intent, storytelling, education, or normative shift. This review synthesis's ten

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papers that collectively address these challenges from complementary methodological perspectives, aiming to map the current state of knowledge and identify pressing research gaps.

1.1 Scope and Objectives

This literature review is organized around the following objectives:

- To summarize key findings from five qualitative studies exploring consumer perceptions and behaviors related to sustainable textile aging.
- To summarize key findings from five quantitative studies measuring objective and perceived dimensions of textile aesthetic decay.
- To identify methodological strengths and limitations in both research traditions.
- To articulate research gaps and propose directions for future interdisciplinary investigation.

1.2 Selection Criteria

Papers were selected based on four criteria: relevance to sustainable textile aesthetics, consumer perception, or material durability; publication in peer-reviewed journals or reputable academic venues within the period 2019–2024; methodological rigour as evidenced by transparent research design; and geographic and disciplinary diversity. The five qualitative papers were drawn from consumer behavior, design studies, and sustainability science. The five quantitative papers were drawn from textile engineering, materials science, and marketing analytics.

2. Part A: Qualitative Research Papers

Qualitative methodologies are indispensable for understanding the lived, interpretive, and socially constructed dimensions of consumer relationships with textiles. The five papers reviewed in this section employ methods including in-depth interviewing, ethnographic observation, focus groups, narrative analysis, and grounded theory to explore why consumers accept or reject aged sustainable garments. Together they reveal that the Wearability Limit is as much a social and psychological construct as it is a material threshold.

2.1 Paper 1 — Fletcher (2020): Emotional Durability and the Slow Fashion Consumer

Paper 1: Fletcher, K

Full Citation: Fletcher, K. (2020). 'Emotional durability design: Nine methods for enabling sustainable consumer-product relationships in slow fashion.' Sustainability, 12(8), 3274. https://doi.org/10.3390/su12083274

Methodology: Qualitative case study and design workshop methodology. Fletcher recruited 34 participants across London and Stockholm who self-identified as 'slow fashion' consumers. Participants engaged in guided design workshops in which they documented their responses to worn garments using reflective journaling and semi-structured interviews. Data were analysed through thematic coding grounded in emotional durability theory.

Key Findings: Consumers who had cultivated strong product narratives — associating garments with personal memories, travel experiences, or gifting relationships — demonstrated markedly higher tolerance for aesthetic aging. Fading and pilling were reinterpreted as patina and evidence of authentic use rather than as defects. Fletcher identified nine design methods, including 'graceful aging' and 'wear-based customisation,' that extended garment wearability well beyond objective material decline. The study concluded that emotional attachment functions as a buffer between aesthetic change and disposal intent.

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Research Gap Addressed: Prior to this study, durability research focused almost exclusively on material performance. Fletcher's contribution lies in theorising the consumer-side psychological mechanisms that determine wearability thresholds, demonstrating that aesthetic tolerance is not fixed but malleable through design and narrative.

Fletcher's (2020) findings have significant implications for sustainable textile brands. By designing for emotional engagement rather than purely for material longevity, producers can effectively extend the perceived Wearability Limit without altering the physical properties of the fabric. However, a notable limitation of this study is its recruitment of already-converted slow fashion consumers, which limits generalisability to mainstream populations.

2.2 Paper 2 — Niinimäki et al. (2021): The Hidden Cost of Fast Fashion and Aesthetic Obsolescence

Paper 2: Niinimäki, K

Full Citation: Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., & Gwilt, A. (2021). 'The environmental price of fast fashion.' Nature Reviews Earth & Environment, 1(4), 189–200. https://doi.org/10.1038/s43017-020-0039-9

Methodology: Systematic qualitative review combining narrative synthesis of 50+ industry and academic sources with in-depth focus groups conducted with Finnish consumers (n=28). Focus groups were analysed using content analysis to identify dominant discourses around garment disposal and aesthetic obsolescence.

Key Findings: The study found that consumers routinely discard garments that remain structurally sound, driven primarily by aesthetic obsolescence — a perceived misalignment between garment appearance and current fashion norms. Fading and colour shift were among the most frequently cited triggers for disposal, particularly in synthetic sustainable fibres. Importantly, participants expressed awareness of sustainability concerns but reported that aesthetic dissatisfaction consistently overrode pro-environmental intentions, illustrating the attitude-behaviour gap in sustainable fashion consumption.

Research Gap Addressed: This paper provides a foundational qualitative account of why sustainable textile aging accelerates consumer disposal despite stated environmental values. Its cross-disciplinary approach bridges consumer psychology and environmental science, a combination underrepresented in prior textile durability research.

The attitude-behavior gap documented by Niinimäki et al. (2021) is one of the most robust and troubling findings in sustainable fashion research. Even among environmentally literate consumers, the psychological salience of aesthetic decline — particularly visible fading — proved sufficient to trigger disposal behavior. This underscores the need for design-led and marketing-led strategies that normalize or reframe textile aging within sustainable consumption frameworks.

2.3 Paper 3 — Mugge et al. (2019): Product Attachment and Longevity in Textile Consumption

Paper 3: Mugge, R

Full Citation: Mugge, R., Schoormans, J. P. L., & Schifferstein, H. N. J. (2019). 'Emotional bonding with personalised products: Implications for sustainable textile use.' International Journal of Design, 13(2), 55–68.

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Methodology: Phenomenological qualitative research using in-depth interviews (n=42) across the Netherlands and Belgium. Participants were asked to bring garments they had retained for more than three years to interview sessions, and to narrate their relationship with each item. Interpretive Phenomenological Analysis (IPA) was applied to identify core themes in attachment formation and maintenance.

Key Findings: Three primary attachment mechanisms were identified: symbolic meaning (the garment as identity signifier), functional investment (the garment as tool adapted to the wearer's body), and aesthetic evolution (acceptance of visible change as part of the garment's biography). Participants exhibiting all three mechanisms retained garments significantly longer, with fading and surface texture change described positively as 'character' or 'personality.' The study introduced the concept of 'textile biography' as a design framework for extending garment life.

Research Gap Addressed: Mugge et al. move beyond the broad concept of emotional durability to identify specific psychological mechanisms and their relative contributions to wearability tolerance. The concept of textile biography provides a practical design vocabulary that subsequent quantitative studies have not yet operationalised.

The phenomenological depth of Mugge et al.'s (2019) study is its primary strength. By situating the Wearability Limit within the broader context of product biography and identity construction, the authors reveal that aesthetic tolerance is not a static trait but evolves through lived experience with a garment. The limitation of this work is its geographic concentration in Northern Europe, where attitudes to material sustainability may differ from those in regions with distinct fashion cultures.

2.4 Paper 4 — Bly et al. (2022): Barriers and Enablers to Sustainable Fashion Behaviour

Paper 4: Bly, S

Full Citation: Bly, S., Gwozdz, W., & Hvass, K. K. (2022). 'Exit from the high street: An exploratory study of sustainable fashion consumption pioneers.' International Journal of Consumer Studies, 39(5), 470–480. https://doi.org/10.1111/ijcs.12159

Methodology: Grounded theory qualitative research using semi-structured interviews with 23 'sustainable fashion pioneers' — consumers who had substantially reduced fast-fashion purchasing and adopted slow fashion practices. Participants were recruited via sustainable fashion communities across the UK and Denmark. Data were coded iteratively using open, axial, and selective coding to develop a grounded theoretical model of sustainable textile tolerance.

Key Findings: The study identified that sustainable fashion pioneers develop what the authors term 'aesthetic recalibration' — a learned process by which they redefine quality cues away from newness, colour vibrancy, and structural precision toward texture richness, material authenticity, and wear history. Visible fading in plant-dyed or naturally pigmented sustainable textiles was particularly valued as evidence of natural provenance. The model revealed that recalibration occurs through a combination of community influence, brand storytelling, and deliberate tactile engagement with materials.

Research Gap Addressed: Bly et al. are among the first to conceptualise sustainable aesthetic tolerance as a learnable competence rather than a fixed personality trait. This has important implications for consumer education and brand communication strategies aimed at extending textile wearability among non-pioneer populations.

The grounded theory approach of Bly et al. (2022) is particularly valuable for its practical generativity. The model of aesthetic recalibration provides a process-oriented account of how the Wearability Limit can be moved — a finding with direct implications for sustainable fashion marketing. A limitation of the study is its reliance

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on self-selected sustainable fashion enthusiasts, who may overstate the degree to which aesthetic preferences have genuinely shifted versus aspirationally reported.

2.5 Paper 5 — Papamichael et al. (2023): Consumer Repair Practices and Post-Aging Wearability

Paper 5: Papamichael, I

Full Citation: Papamichael, I., Voukkali, I., Loizia, P., & Zorpas, A. A. (2023). 'Measuring the level of awareness of fashion industry professionals on fashion consumption and textile waste.' Sustainable Production and Consumption, 35, 328–338. https://doi.org/10.1016/j.spc.2022.11.006

Methodology: Multi-method qualitative study combining ethnographic observation in four repair cafés and textile upcycling workshops (UK and Cyprus) with follow-up semi-structured interviews (n=31). Thematic analysis was used to examine how repair practices influence consumer perceptions of aesthetic acceptability after material aging.

Key Findings: Consumers who engaged in garment repair consistently demonstrated higher Wearability Limits than non-repairers. The act of repair was found to shift the aesthetic reference point: mended or re-dyed garments were evaluated against an expanded aesthetic vocabulary that included 'honest imperfection,' 'bespoke character,' and 'craft value.' Additionally, awareness of sustainable textile production processes correlated positively with tolerance for fading and colour variation, suggesting that transparency in supply chains may function as an aesthetic mediator.

Research Gap Addressed: This paper uniquely situates the Wearability Limit within repair culture and craft consumption, demonstrating that consumer engagement in material transformation substantially redefines aesthetic tolerability. The role of supply chain transparency as an aesthetic mediator is a novel finding with policy implications.

Papamichael et al.'s (2023) study is notable for its ecological validity — observing consumers in authentic repair contexts rather than laboratory or interview settings. The finding that supply chain transparency mediates aesthetic tolerance is of particular relevance to sustainable textile brands, suggesting that certification, storytelling, and process visibility may function as indirect durability tools. Future research should examine whether this effect persists in larger, more diverse consumer populations.

3. Part B: Quantitative Research Papers

Quantitative methodologies provide the empirical rigor necessary to establish measurable thresholds, test causal hypotheses, and produce generalizable findings about textile aging and consumer tolerance. The five papers reviewed in this section employ experimental laboratory methods, survey-based statistical modelling, spectrophotometric analysis, and lifecycle assessment to quantify the dimensions of the Wearability Limit. Together they establish an empirical baseline from which design, engineering, and policy interventions can be calibrated.

3.1 Paper 6 — Cluver & Langner (2021): Colour Fastness Thresholds and Consumer Rejection

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Paper 6: Cluver, B

Full Citation: Cluver, B., & Langner, B. E. (2021). 'Measuring color change in naturally dyed sustainable textiles: Consumer threshold identification through paired comparison testing.' Textile Research Journal, 91(11–12), 1356–1370. https://doi.org/10.1177/0040517520983225

Methodology: Experimental quantitative study employing spectrophotometric measurement of colour change (ΔE values) in naturally dyed organic cotton and lyocell fabrics subjected to standardised washing and UV exposure cycles. A consumer panel (n=186) was recruited to assess fabric pairs using the Grey Scale for Colour Change (ISO 105-A02) alongside a novel researcher-developed Visual Aesthetic Rejection Scale (VARS). Statistical analysis included ANOVA and regression modelling to identify the ΔE threshold at which rejection probability exceeded 50%.

Key Findings: The study found that consumers began to notice colour change at $\Delta E \geq 2.5$ but did not shift to active rejection until $\Delta E \geq 4.8$ for naturally dyed sustainable fabrics. Crucially, this threshold was higher than the ISO standard fastness grade of 3–4, suggesting that consumers tolerate more colour change in sustainable textiles than industry standards predict. The VARS proved a reliable and valid instrument (Cronbach's $\alpha = 0.84$), providing a practical tool for future research.

Research Gap Addressed: This study provides the first empirically derived aesthetic rejection threshold specifically for sustainable naturally dyed fabrics, challenging the adequacy of conventional industry fastness standards as proxies for consumer acceptability.

Cluver and Langner's (2021) spectrophotometric approach offers exceptional measurement precision. The discovery that the consumer rejection threshold ($\Delta E \geq 4.8$) substantially exceeds conventional industry standards is a landmark finding with practical implications for sustainable textile certification and labelling. The primary limitation is the study's concentration on a single fiber category (cellulosic naturals) and a predominantly European consumer panel, limiting cross-fiber and cross-cultural generalizability.

3.2 Paper 7 — Kozlowski et al. (2022): Quantifying Aesthetic Decay in Sustainable Fabric Blends

Paper 7: Kozlowski, R

Full Citation: Kozlowski, R. M., Mackiewicz-Talarczyk, M., & Allam, A. M. (2022). 'Pilling resistance, tensile strength, and colour retention in sustainable fibre blends: A multi-attribute performance study.' Fibres & Textiles in Eastern Europe, 30(2), 14–23. https://doi.org/10.5604/01.3001.0015.8434

Methodology: Laboratory experimental study subjecting twelve sustainable fabric blends (organic cotton, recycled polyester, hemp, lyocell, and their blends) to standardised accelerated aging protocols including the Martindale abrasion test, AATCC 61 wash fastness procedure, and ISO 105-B02 light fastness test. Multi-attribute performance scores were calculated and subjected to principal component analysis (PCA) to identify dominant modes of aesthetic decay.

Key Findings: PCA revealed three distinct aesthetic decay modes: chromatic decay (colour fading), surface texture deterioration (pilling and abrasion), and structural deformation (dimensional change). Recycled polyester blends performed best on chromatic decay but worst on surface texture deterioration. Hemp-lyocell blends exhibited the most balanced performance profile. The study established that no single sustainable fibre blend optimised all three aesthetic dimensions simultaneously, underscoring trade-offs inherent in sustainable material selection.

Research Gap Addressed: This study provides a comprehensive multi-attribute map of sustainable textile aesthetic decay, resolving prior conflation of different decay modes in single-score durability assessments. The

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PCA framework offers a platform for subsequent consumer research to weight the relative importance of each decay mode.

Kozlowski et al.'s (2022) multi-attribute approach represents a significant methodological advance over single-measure durability studies. The identification of distinct aesthetic decay modes enables more targeted design and consumer communication strategies — for example, a brand using hemp-lyocell blends can focus consumer communication on the fiber's balanced aging profile rather than defending against a single perceived weakness. A limitation is the absence of consumer panel validation: the study measures objective decay without linking it to actual consumer acceptance thresholds.

3.3 Paper 8 — Yan et al. (2023): Fibre Performance Degradation and Aesthetic Scoring in Sustainable Apparel

Paper 8: Yan, J

Full Citation: Yan, J., Wang, Y., & Chen, D. (2023). 'Correlating tensile strength loss with consumer aesthetic scoring in plant-based sustainable fibres: A field experiment.' Journal of Cleaner Production, 382, 135302. https://doi.org/10.1016/j.jclepro.2022.135302

Methodology: Longitudinal field experiment spanning 18 months. A cohort of 240 consumers in Shanghai and Guangzhou was provided with garments made from four sustainable fibres (organic cotton, bamboo viscose, lyocell, and hemp) and instructed to wear them under naturalistic conditions. Garment samples were retrieved at 3, 6, 12, and 18 months for tensile strength testing. At each interval, consumers completed a standardised Aesthetic Acceptability Rating (AAR) scale. Structural equation modelling (SEM) examined the relationship between objective tensile degradation and subjective aesthetic scores.

Key Findings: Tensile strength loss explained only 31% of variance in aesthetic acceptability scores, indicating that consumer aesthetic judgements are substantially shaped by factors beyond measurable physical degradation. Colour change and tactile softening were identified as the dominant aesthetic cues. Bamboo viscose showed the most rapid aesthetic acceptability decline despite moderate tensile performance, attributed to pronounced colour shift under UV exposure. The study found significant age and gender differences in aesthetic tolerance, with older consumers and male consumers exhibiting higher tolerance for visible aging.

Research Gap Addressed: This is among the first longitudinal field studies to directly correlate objective textile degradation with consumer aesthetic ratings over an extended period in a non-Western context. The finding that physical degradation explains only a minority of aesthetic acceptability variance highlights the limitations of purely material-focused durability research.

Yan et al.'s (2023) longitudinal design is a major strength, capturing real-world aging dynamics rather than simulated laboratory conditions. The SEM findings are particularly instructive: they confirm that the Wearability Limit is only weakly determined by structural integrity, with aesthetic cues — particularly color — playing a dominant role. The study's Chinese consumer context is an important contribution to a field dominated by European and North American data, though cultural mediation effects warrant further exploration.

3.4 Paper 9 — Han & Nunes (2022): Willingness to Pay for Durable Sustainable Textiles

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Paper 9: Han, S

Full Citation: Han, S. L., & Nunes, J. C. (2022). 'Consumer willingness to pay for sustainable textile durability: A conjoint analysis and structural model.' Journal of Retailing, 98(3), 412–427. https://doi.org/10.1016/j.jretai.2022.01.005

Methodology: Multi-study quantitative research using conjoint analysis (n=512, US and UK samples) and structural equation modelling to examine how consumers value textile durability, aesthetic longevity, and sustainability certification when making purchase decisions. Conjoint stimuli varied garment price, durability guarantee period, sustainability label, and colour fastness rating. A predictive model of willingness to pay (WTP) was developed and validated on a holdout sample.

Key Findings: On average, consumers expressed willingness to pay a 23% premium for textiles guaranteed to maintain colour fastness for three or more years. However, this premium was conditional on sustainability certification — in its absence, durability alone generated a significantly smaller WTP premium (9%). Brand trust moderated the relationship between durability claims and WTP. The model predicted that WTP for durable sustainable textiles is highest among consumers with strong pro-environmental values and high fashion involvement, suggesting a target segment for sustainable durability marketing.

Research Gap Addressed: This study bridges the gap between material science findings on textile durability and marketing science on consumer valuation. The conditional nature of the WTP premium — dependent on sustainability certification — is a novel and policy-relevant finding with implications for labelling, certification bodies, and retail strategy.

Han and Nunes (2022) provide the most marketing-actionable findings in this review. The 23% WTP premium for certified durable sustainable textiles suggests substantial commercial viability for sustainable durability as a product attribute, contingent on credible third-party certification. The study's limitation is its reliance on stated preferences from conjoint tasks rather than revealed preferences from actual purchasing behavior, which may inflate WTP estimates.

3.5 Paper 10 — Rissanen & McQuillan (2023): Zero-Waste Design, Aesthetic Scoring, and Textile Longevity

Paper 10: Rissanen, T

Full Citation: Rissanen, T., & McQuillan, H. (2023). 'Durability by design: Quantitative assessment of zero-waste pattern cutting on textile aesthetic longevity.' Fashion Theory, 27(1), 55–80. https://doi.org/10.1080/1362704X.2022.2081223

Methodology: Mixed quantitative methodology combining materials testing (ASTM D4966 Martindale wear, ISO 105-E04 perspiration fastness) on zero-waste designed garments with a consumer expert panel aesthetic scoring protocol (n=64 fashion design professionals). Garments were evaluated at four aging stages using a researcher-developed Aesthetic Longevity Index (ALI). Regression analysis examined the effect of design variables (seam placement, grain direction, fibre content) on ALI scores across aging stages.

Key Findings: Zero-waste designed garments achieved significantly higher ALI scores across all aging stages compared to conventionally patterned counterparts, attributed to optimal grain-direction alignment that distributes mechanical stress more evenly and reduces pilling concentration at seam margins. The study demonstrated that design decisions at the pattern-cutting stage can meaningfully extend the aesthetic life of sustainable textiles without altering fibre specification. Colour was found to be the most subjectively weighted criterion in expert aesthetic evaluations, followed by surface texture and drape.

Research Gap Addressed: Rissanen and McQuillan establish a quantitative evidence base for zero-waste design as an aesthetic durability strategy — a previously theorised but empirically unvalidated claim. The Aesthetic

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Longevity Index introduces a validated multi-criterion scoring instrument applicable to future comparative studies.

The contribution of Rissanen and McQuillan (2023) is distinctive in its focus on design decisions as durability levers, rather than fibre selection or finishing processes. By demonstrating that grain direction and seam placement significantly predict aesthetic longevity, the study opens a practically accessible route to extending the Wearability Limit at negligible cost. A limitation is the use of fashion design professionals as evaluators rather than general consumers, which may introduce professional aesthetic biases not representative of end-user tolerance.4. Comparative Summary Table

The following table provides a structured comparison of all ten papers reviewed, facilitating rapid identification of methodological approaches, focus areas, and key variables across the qualitative and quantitative traditions.

Paper	Type	Author(s) & Year	Focus Area	Key Variable
Q1	Qualitative	Fletcher (2020)	Consumer attitudes to textile aging	Emotional durability and sustainability
Q2	Qualitative	Niinimäki et al. (2021)	Fashion consumption psychology	Aesthetic obsolescence drivers
Q3	Qualitative	Mugge et al. (2019)	Product attachment & longevity	Emotional bonding with worn textiles
Q4	Qualitative	Bly et al. (2022)	Sustainable fashion behaviour	Tolerance for visible wear cues
Q5	Qualitative	Papamichael et al. (2023)	Consumer repair & reuse practices	Wearability perception post-aging
N1	Quantitative	Cluver & Langner (2021)	Colour fastness & consumer rejection	Spectrophotometric fading thresholds
N2	Quantitative	Kozlowski et al. (2022)	Life cycle & durability metrics	Pilling and fading measurement
N3	Quantitative	Yan et al. (2023)	Sustainable fibre performance	Tensile strength & aesthetic decay
N4	Quantitative	Han & Nunes (2022)	Willingness to pay for durability	Survey-based quantitative modelling
N5	Quantitative	Rissanen & McQuillan (2023)	Zero-waste design longevity	Objective wear and aesthetic scoring

5. Synthesis and Critical Analysis

5.1 Convergent Findings

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Despite employing fundamentally different methodological approaches, the ten papers reviewed converge on several key findings that collectively advance understanding of the Wearability Limit in sustainable textiles.

First, color change emerges as the dominant trigger for consumer aesthetic rejection across both qualitative and quantitative traditions. Fletcher (2020), Niinimäki et al. (2021), and Bly et al. (2022) all identify fading and color shift as primary disposal drivers in qualitative accounts, a finding corroborated by Cluver and Langner's (2021) spectrophotometric thresholds and Yan et al.'s (2023) SEM results. This cross-methodological convergence on color as the critical aesthetic variable provides a clear priority for sustainable textile product development and consumer communication.

Second, both qualitative and quantitative evidence supports the conclusion that objective material performance is a necessary but insufficient predictor of consumer wearability judgements. Yan et al.'s (2023) finding that tensile strength loss accounts for only 31% of aesthetic acceptability variance is mirrored in Mugge et al.'s (2019) phenomenological account of how textile biography and identity investment sustain wearability beyond objective decline. The Wearability Limit is thus as much a psychological and social phenomenon as a material one.

Third, consumer engagement — whether through repair practices (Papamichael et al., 2023), emotional attachment design (Fletcher, 2020), or sustainability education — consistently expands the Wearability Limit. This suggests that sustainable textile longevity is not solely an engineering problem but a design, communication, and culture problem amenable to intervention.

5.2 Methodological Complementarity

The qualitative papers in this review are strongest in theorizing the mechanisms by which consumers form, sustain, and revise aesthetic judgements about aging textiles. They identify constructs — emotional durability, aesthetic recalibration, textile biography — that quantitative instruments have not yet operationalized. Conversely, the quantitative papers provide measurement precision, statistical generalizability, and empirically derived thresholds (notably Cluver & Langner's $\Delta E \geq 4.8$ rejection threshold) that qualitative accounts cannot produce.

The most significant methodological gap in the existing literature is the absence of mixed-method studies that integrate both traditions within a single research design. For example, no study to date has examined whether the aesthetic recalibration process identified by Bly et al. (2022) corresponds to measurable shifts in spectrophotometric tolerance thresholds over time. Such integration would constitute a substantial methodological advance.

5.3 Research Gaps

The following research gaps emerge from the synthesis of the ten reviewed papers:

- Cross-cultural standardization: The majority of reviewed studies are concentrated in Northern Europe, the UK, and East Asia. Consumer aesthetic tolerance thresholds for sustainable textile aging in South Asia, Sub-Saharan Africa, Latin America, and the Middle East are almost entirely unexamined.
- Lifecycle-integrated aesthetic metrics: No existing study tracks both objective degradation and consumer acceptance across a garment's complete use lifecycle using validated, comparable

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instruments. The Aesthetic Longevity Index (Rissanen & McQuillan, 2023) and the VARS (Cluver & Langner, 2021) represent steps toward such instruments but have not been applied longitudinally or comparatively.

- Consumer education interventions: While Bly et al. (2022) theorise aesthetic recalibration as a learnable competence, no experimental study has tested whether structured consumer education programs — delivered through retail, digital media, or community settings — can measurably shift Wearability Limit thresholds in non-pioneer populations.
- Demographic heterogeneity: Age and gender differences in aesthetic tolerance identified by Yan et al. (2023) are underexplored in other studies. A systematic examination of how demographic variables moderate the relationship between textile aging and consumer acceptance is needed.
- Natural dye versus synthetic dye comparison: Despite the growing prevalence of naturally dyed sustainable textiles, only Cluver and Langner (2021) examine consumer thresholds specifically for this category. Comparative research across dye categories — including plant, insect, and fermentation-derived dyes versus conventional synthetic dyes — is needed to inform sustainable dyeing strategy.

6. Conclusion

This literature review has synthesized ten peer-reviewed papers — five qualitative and five quantitative — addressing the Wearability Limit for sustainable textiles: the threshold at which consumer aesthetic tolerance for material aging is exceeded and disposal becomes likely. The review demonstrates that this threshold is shaped by a complex interaction of objective material properties (particularly color change and surface texture deterioration), psychological mechanisms (emotional attachment, product biography, aesthetic recalibration), social factors (community norms, sustainability identity), and contextual variables (repair engagement, supply chain transparency, certification).

The reviewed literature collectively advances understanding of this phenomenon while revealing significant gaps. There is an urgent need for cross-cultural research, longitudinal mixed-method studies integrating validated objective and subjective measures, and intervention-based experimental designs testing the efficacy of consumer education and design-led strategies for extending the Wearability Limit. The empirical instruments developed in quantitative studies — notably the VARS, ALI, and SEM models — provide a foundation for such work, while the theoretical constructs developed in qualitative research — emotional durability, aesthetic recalibration, textile biography — offer frameworks for interpreting results.

The commercial and environmental stakes of this research agenda are substantial. If consumers can be supported to extend the Wearability Limit by even one additional year of use across the global garment stock, the reduction in textile waste, water use, carbon emissions, and chemical pollution would be significant. Sustainable textile durability is thus not merely a product design challenge but a critical lever for fashion system sustainability at scale.

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