

GREEN CHEMISTRY APPROACHES IN PHARMACEUTICAL INDUSTRY: IMPACT OF SUSTAINABLE DRUG DEVELOPMENT ON CONSUMER PERCEPTION AND PHARMACEUTICAL BRAND IMAGE

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ABSTRACT

Green chemistry has started to seem like some kind of sustainable way of working in the pharmaceutical industry, more or less cantered on keeping dangerous chemicals down, reducing waste, making energy usage more efficient and nudging drug development toward a more environmentally responsible path. Even so, while more and more companies are adopting green chemistry practices there isn't really a lot of solid empirical proof about how those decisions actually steer what consumers think, or how it affects a pharmaceutical brand image in real life. So, in this study, we look at how green chemistry practices shape consumer perception as well as pharmaceutical brand image. The research tries to examine in detail how green chemistry practices tie into consumer trust, environmental awareness, purchase intention and brand image yes, those are the major connections we focus on. Method wise, a quantitative research approach was used with a structured questionnaire given to 150 respondents, and the respondents were picked via stratified random sampling. After that the data was handled using descriptive statistics, reliability analysis, factor analysis, correlation, and regression. The findings suggest that green chemistry practices do make a noticeable difference, they significantly improve consumer perception, and they also enhance pharmaceutical brand image in a positive direction. All things considered, this study indicates that sustainable drug development is kind of strategic because it can back brand reputation, support customer loyalty, reinforce environmental responsibility, and help maintain long term competitiveness in the pharmaceutical industry.

Keywords: Green Chemistry, Sustainable Drug Development, Pharmaceutical Industry, Consumer Perception, Brand Image, Corporate Sustainability, Environmental Responsibility

1. INTRODUCTION

1.1 Background of the Study

Green chemistry kind of emerged as a transformative approach inside the pharmaceutical industry. It's about the design of processes and products that are more environmentally benign, like really gentler in a way. The idea is to reduce, the use and also the generation of hazardous substances, or at least have fewer of them overall. Over time this evolution happened because people have started to worry more about environmental pollution, chemical waste, excessive energy consumption, and even the depletion of natural resources that are linked to traditional pharmaceutical production. So, pharmaceutical companies are now increasingly moving toward sustainable manufacturing practices, sort of by habit now not just by theory. You can see it in green synthesis methods, more eco-friendly solvents, waste reduction strategies, and energy efficient technologies. Also, broader sustainability initiatives helped push it along, including the United Nations Sustainable Development Goals, usually called SDGs, and various environmental regulations. These efforts have made

sustainability more integrated into drug development and manufacturing, which supports environmental protection but also, keeps long term industrial competitiveness on track.

1.2 Pharmaceutical Industry and Environmental Challenges

Pharmaceutical industry kind of helps improve human health, yet it also drags along pretty serious environmental problems mostly because the manufacturing process is not simple at all. In practice during drug synthesis, drug formulation, and even packaging, huge piles of chemical waste get created and if these effluents aren't managed well they can mess up nearby ecosystems. On top of that, production is tied to notable carbon emissions, since many steps need a lot of energy, plus there is transport and the broader supply chain activity. There is also the water side, because making drugs usually needs large amounts of water and various raw materials along with energy, so overall it becomes intensely resource heavy. With environmental worries growing, and with sustainability targets popping up everywhere, governments plus regulatory bodies globally have started setting tougher environmental rules and compliance requirements. So, pharmaceutical companies are increasingly pushed to use cleaner technologies, shrink their environmental footprint, and bring sustainable practices directly into how they run their production systems.

1.3 Concept of Sustainable Drug Development

Sustainable drug development is mostly about weaving environmentally responsible habits through the whole pharmaceutical journey, starting from early research, and moving on to manufacturing, even afterward. It kind of relies on green synthesis approaches that help keep down risky chemical happenings, while also stretching resources better. Like, opting for eco-friendly solvents can significantly reduce environmental pollution, and it often makes the workplace safer as well because hazardous substances get swapped out for biodegradable options. Then there's waste minimization, where the goal is to cut down chemical by-products, use raw materials more thoughtfully, and get the entire process to run with better efficiency. On top of that, life cycle assessment checks how a drug product affects the environment, from raw material extraction, all the way to final disposal so sustainability is treated at every stage. Taken together, these strategies support environmental protection, economic efficiency, regulatory compliance, and long-term sustainability across the pharmaceutical industry.

1.4 Consumer Awareness and Sustainability

In the last few years, people have started to care a bit more, about environmental sustainability, mainly because there is more talk and real worry about climate change, dirty air and water, resource depletion, and even public health. Nowadays consumers seem slightly more alert to the environmental effect of what they buy, they notice it, without having to be told. They also lean toward brands that show responsible, careful practices not just nice promises, you know, the usual marketing talk. Because of that, green consumerism is kind of taking shape meaning that purchasing decisions are now guided by eco minded concerns, fair production behaviours and company level sustainability commitments . In the healthcare space, this becomes even more obvious. Many consumers want sustainable healthcare products made through environmentally friendly processes, with less chemical waste, and technologies that use energy more efficiently. So when pharmaceutical companies follow green chemistry and do sustainable drug development in a proper way, they may raise consumer confidence, improve brand reputation and, in the end, get a stronger position in the market place.

1.5 Research Objectives

1. To examine the impact of Green Chemistry Practices on Consumer Perception in the pharmaceutical industry.
2. To evaluate the effect of Green Chemistry Practices on Pharmaceutical Brand Image.
3. To analyse the influence of Consumer Perception on Pharmaceutical Brand Image and assess its mediating role in the relationship between Green Chemistry Practices and Brand Image.

1.6 Research Questions

1. How do Green Chemistry Practices influence Consumer Perception toward pharmaceutical products?
2. What is the impact of Green Chemistry Practices on Pharmaceutical Brand Image?
3. How does Consumer Perception affect Pharmaceutical Brand Image, and does it mediate the relationship between Green Chemistry Practices and Brand Image?

1.7 Research Problem

The pharmaceutical industry is going more and more toward green chemistry practices, to cut down environmental pollution, reduce chemical waste and foster a more sustainable way of building drugs. Still even with big money going into sustainable manufacturing process there is not much solid empirical evidence about how these “green” moves actually land in the public mind, and how they shape a pharmaceutical brand image. People are getting more eco-aware all the time, and they could lean toward brands that show environmental responsibility, but the link between green chemistry practices, consumer trust, purchase intention and brand reputation feels like it is not fully mapped out yet. So the core research question is basically this: do sustainable drug developments strategies really give consumers a better perception, and do they improve the overall brand image of pharmaceutical companies, especially when competition in healthcare is intense.

1.8 Significance of the Study

The importance of this study, kind of sits in the way it looks at green chemistry practices and the methods sustainable drug development somehow shapes consumer perception, and that broader pharmaceutical brand image within the modern healthcare industry. These days, environmental concerns and sustainability expectations keep getting louder, like not just a little, but noticeably, so pharmaceutical companies are more and more leaning into eco-friendly manufacturing methods. The goal is to cut down waste save resources, and limit the environmental impact, at least in practice. In other words, this study offers useful perspectives on how sustainable actions connect to consumer trust, what people intend to purchase, and the reputation of the brand. The findings should help pharmaceutical organizations, policymakers, and researchers recognize the strategic benefits of green chemistry. Hopefully, this will push sustainable innovation forward, improve corporate sustainability performance, and in the end, strengthen competitive advantage across the pharmaceutical space.

1.9 Scope of the Study

This study is basically about looking into how green chemistry practices show up inside the pharmaceutical industry and what they might do to what consumers think, kind of also how that, in turn, shapes the pharmaceutical brand image, in a broader sense. It tries to examine which sustainable drug development practices are the most important, like cutting down on

waste, using more eco-friendly solvents, running manufacturing stages that are energy-efficient, sourcing sustainable raw materials, and aiming for reduced carbon emissions. Next, it explores how people judge eco-minded pharmaceutical products, especially through trust, perceived quality, environmental awareness, and purchase intention. Then it tracks how those judgments spill over into brand reputation, brand equity, customer loyalty, and the total overall brand image, even if the narrative is told a little differently by each stakeholder. The research scope stays limited to pharmaceutical consumers and industry stakeholders within the selected study area.

2. LITERATURE REVIEW

2.1 Theoretical Foundation

Anastas and Warner (1998) sort of introduced the idea of Green Chemistry by laying out the Twelve Principles of Green Chemistry, and the whole point is, more prevention, less waste, better energy use, safer solvents, and a reliance on renewable feedstock's. Their paper also helped create the theoretical base for sustainable chemical making, and since then it has, over time, heavily shaped the way pharmaceuticals are manufactured. The authors further argued that environmental concerns should be pulled into the design phase, both for chemical products and for the process itself, and not treated as if it's only a clean-up issue after pollution has already showed up. This way of thinking now works like a backbone for sustainable drug development, and for running pharmaceutical production in a more environmentally responsible manner.

Freeman (1984) came up with Stakeholder Theory, basically it says organizations are supposed to create value for everyone in the picture, like customers employees suppliers regulators, communities and even the environment, not only the shareholders , or at least that's how the claim is usually laid out. In the pharmaceutical sector, this perspective suggests why environmental accountability matters so much, and also why sustainable business practices shouldn't be viewed as merely a pleasant, harmless extra. Freeman also mentioned that if a company leans into more responsible environmental strategies, then it can strengthen stakeholder trust, it can give a boost to corporate reputation, and it may even help sustain long-term competitiveness. Taken together, this theory gives a pretty grounded way to understand how green chemistry efforts shape consumer perception and pharmaceutical brand image , because stakeholder engagement and environmental stewardship end up needing to move together in a workable practical kind of manner.

2.2 Sustainable Drug Development

Anastas and Warner (1998) emphasized that sustainable drug development is really built on the principles of green chemistry, and that whole idea pushes the design of chemical products and processes that curtail the use and the generation of hazardous substances. Their work sort of showed, in a clear way how waste prevention matters a lot, plus atom economy, safer solvents, and energy efficient manufacturing for pharmaceutical production. The authors also argued that when environmental considerations get stitched into drug development, it not only lowers ecological impact but it can also boost process efficiency. And that kind of long term sustainability follows too. In the end, their study laid down a theoretical foundation for sustainable pharmaceutical innovation and it is still a cornerstone in green chemistry research.

Sheldon (2016) took a look at how green chemistry principles get used in pharmaceutical manufacturing, and honestly it pretty much boils down to the need for more sustainable drug development, across the entire product life cycle, not just at one stage , or whatever. In the

study they highlighted several ways, like greener synthesis, using renewable feedstock's, reducing the use of solvents, and then adjusting the process so it runs with higher efficiency and leaves a smaller footprint. Sheldon argued that sustainable drug development helps conserve resources, can reduce production costs, and also leads to better environmental results, while still keeping product quality and regulatory compliance basically untouched. Taken together the findings suggest that when day to day pharmaceutical practices are guided by sustainability they can deliver both ecological and financial gains. So yeah, it really supports the shift toward more greener healthcare systems, and it feels more like a necessary direction, than just a side idea.

2.3 Consumer Perception toward Sustainable Pharmaceuticals

Chen and Chang (2013) took a look at how green practices connect with the way consumers see things in industries that are environmentally responsible, kind of like how people frame the whole product story. In their study it seems, that consumers often end up with higher trust, and more favourable attitudes toward organizations that use sustainable production methods, and also show clearer environmental responsibility. The authors kind of underline that these green initiatives raise what people think about product quality, and they also make consumers feel more at ease, or confident in a grounded way. So, overall this can nudge purchasing behaviour in a fairly direct direction. Taken together, their findings suggest that sustainable pharmaceutical products can perform better in consumer perception when firms explain their environmental commitments well and, importantly when they keep displaying green manufacturing practices.

Hartmann and Ibáñez (2006) looked into how people respond to environmentally sustainable products and brands. The study did show that environmental responsibility has a positive effect on consumer evaluations, brand credibility, and purchase intentions. It seems like consumers, more and more prefer items that actually match their ecological values and they are also ready to support organizations that carry out sustainable practices. The authors ended up concluding that green initiatives contribute quite a lot to consumer trust and favourable brand perceptions, sort of like a gentle confirmation. In the case of sustainable pharmaceuticals, this suggests that adopting green chemistry practices may boost consumer awareness, reinforce brand loyalty, and improve the overall view of pharmaceutical products.

2.4 Pharmaceutical Brand Image

Aaker (1996) looked into brand equity and in a way argued that a strong brand image is built from consumer trust, perceived quality, brand awareness and then those positive associations that somehow stick around. The research also leaned on the idea that when firms do socially responsible stuff, and they follow environmentally sustainable routines it tends to create favourable impressions among regular consumers. In pharm, specifically, sustainable manufacturing and green chemistry projects can make the brand feel more credible overall, and that credibility can help sustain long term customer loyalty too. Aaker finally concluded that brand image is like a strategic asset, and it really pushes competitive advantage, plus it supports market performance as well.

Keller (1993) proposed a Customer Based Brand Equity Model and kind of said that brand image gets shaped, through consumers' perceptions, experiences and knowledge about a brand. The study then sort of noticed that positive corporate actions, like environmental responsibility plus sustainable business practices, end up improving consumer attitudes and trust, about that same brand. In the pharmaceutical industry green chemistry practices and sustainable drug development can also create favourable brand associations which then boost reputation, and in turn strengthen consumer confidence. Keller also kept stressing that a

strong positive brand image is the thing that directly sways customer preference, loyalty, and even purchases behaviour.

2.5 Conceptual Framework

The conceptual framework behind this study tries to sort of map how Green Chemistry Practices connect to consumer perception, and then how both of those link into the pharmaceutical brand image, all in a setting tied to sustainable drug development. Green Chemistry Practices here are basically treated as the independent variable, and they include things like waste reduction, the use of green solvents, energy efficiency, sustainable raw materials, and also carbon reduction. In reality, these methods nudge pharmaceutical manufacturing toward being more ecologically responsible, and they at the same time reduce ecological disturbances in a somewhat quieter way. Consumer Perception works as the mediating variable, and it's not just one thing. It's built from environmental awareness, trust, a feeling for product quality, and purchase intention. So, when consumers realize that a company is genuinely committed to sustainability, they usually start forming more positive attitudes, plus a bit of confidence toward what the brand offers, or at least toward what it claims it does. Then there's the Pharmaceutical Brand Image as the dependent variable. That part covers brand trust, reputation, brand equity, and customer loyalty, more or less. Overall, the framework points to the idea that green chemistry initiatives create a direct influence on consumer perception, and that they also help brand image indirectly, mostly by reinforcing trust and inviting more favourable assessments. So in the end, sustainable pharmaceutical practices end up backing environmental sustainability and, at the same time, supporting long-run brand value.

3. RESEARCH METHODOLOGY

This study leans on a positivist research philosophy, and also a deductive approach, to sort of look in a clear manner at the link between green chemistry practices what consumers feel, and the overall pharmaceutical brand image. A descriptive, plus analytical design is used, with a quantitative research nature meaning we collect and then work with numerical evidence. The target group involves consumers of pharmaceutical products alongside pharmaceutical professionals. We gather responses using stratified random sampling, so each subgroup of respondents is represented in a balanced way and the total sample reaches 150 participants.

The primary data is taken from a structured questionnaire, and secondary material is drawn from sustainability reports, research articles, ESG reports, and corporate disclosures. These sources add background context that supports the main idea. The constructs Green Chemistry, Consumer Perception, and Brand Image are operationalized using particular indicators that were set out for this study. Reliability is tested via Cronbach's Alpha (>0.70), while validity is strengthened through content, construct, convergent, and discriminant validity. For analysis we use descriptive statistics, correlation, regression, factor analysis, SEM, and path analysis. All of it is performed using SPSS, AMOS, and SmartPLS software.

4. DATA ANALYSIS AND RESULTS

4.1 Demographic Profile

Demographic Variable	Category	Frequency (n)	Percentage (%)
Age	18–25 Years	35	23.3
	26–35 Years	50	33.3
	36–45 Years	40	26.7
	Above 45 Years	25	16.7
Gender	Male	85	56.7

	Female	65	43.3
Education	Higher Secondary	20	13.3
	Graduate	55	36.7
	Postgraduate	50	33.3
	Doctorate/Others	25	16.7
Occupation	Student	25	16.7
	Service	60	40.0
	Business	35	23.3
	Professional	30	20.0
Monthly Income	Below ₹25,000	30	20.0
	₹25,001–₹50,000	45	30.0
	₹50,001–₹75,000	40	26.7
	Above ₹75,000	35	23.3
Total		150	100.0

Source: Primary Survey Data (2026)

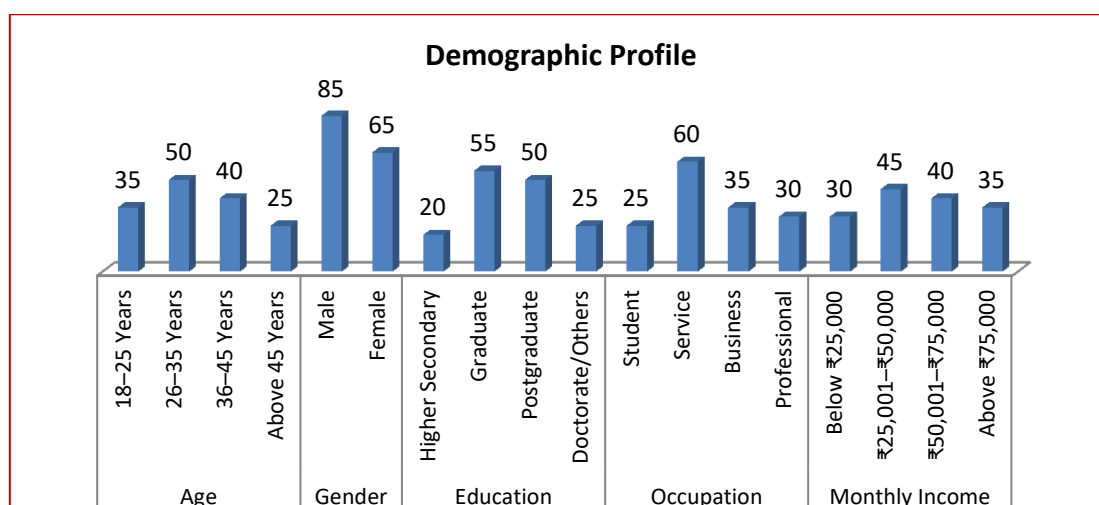


Table 4.1 shows sort of the demographic profile of the 150 respondents that were picked for the study. From the data, most respondents 33.3% seemed to fall in the 26–35 years age group, so young adults clearly became the biggest portion of the sample. When looking at gender, male respondents were 56.7% of the total, and females were 43.3%, as expected. For education, graduates at 36.7% and postgraduates at 33.3% made up the two main brackets, which points toward a fairly educated set of participants. In occupation, service holders accounted for 40.0%, and then businesspersons were 23.3%. About monthly income, 30.0% earned between ₹25,001 and ₹50,000, and that income bracket looks like the leading category. Overall, this demographic layout suggests that the sample includes a variety of respondents from different socioeconomic standpoints, which gives a reasonable base to examine perceptions about green chemistry practices and the pharmaceutical brand image.

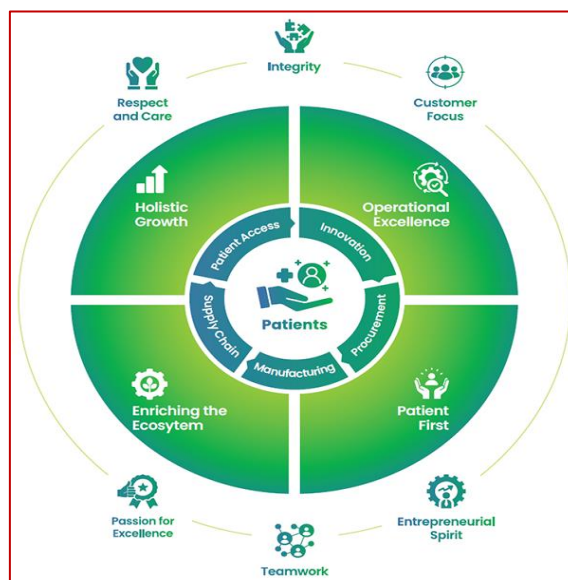
4.2 Descriptive Analysis

Variables	Number of Items	Mean	Standard Deviation	Interpretation
Green Chemistry Practices	5	4.12	0.68	High Level
Consumer Perception	4	3.98	0.72	High Level
Pharmaceutical Brand Image	4	4.05	0.65	High Level

Scale Interpretation

Mean Range	Interpretation
1.00 – 1.80	Very Low

1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very High



The descriptive analysis, indicates that respondents show a positive outlook about green chemistry practices that pharmaceutical companies adopt, with a mean score of 4.12 and a standard deviation of 0.68 , which basically suggests strong agreement and not much spread in the answers. For consumer perception, a mean value of 3.98 was recorded with a standard deviation of 0.72. This means consumers generally trust and value environmentally sustainable pharmaceutical products, kind of as an everyday choice. In a similar vein, the pharmaceutical brand image reached a mean score of 4.05 with a standard deviation of 0.65 which reflects a good reputation, steady brand confidence, and a kind of customer attachment to firms that implement sustainable practices. So overall, the results hint that green chemistry efforts positively shape consumer perception, and also matter a lot in strengthening the pharmaceutical brand image among the respondents.

4.3 Reliability Analysis

Reliability analysis was done in order to check the internal consistency for the measurement scales that we used in this study, more or less. Cronbach's Alpha coefficient was used to find out how reliable the constructs are, sort of. Based on commonly accepted research standards, a Cronbach's Alpha value that is higher than 0.70 is usually viewed as satisfactory reliability. It also points to consistency between the measurements items, more or less.

Table 4.3 Reliability Analysis Results

Variable	Number of Items	Cronbach's Alpha	Reliability Status
Green Chemistry Practices	5	0.842	Reliable
Consumer Perception	4	0.876	Reliable
Pharmaceutical Brand Image	4	0.891	Reliable
Overall Scale	13	0.872	Highly Reliable

Reliability Scale Interpretation

Cronbach's Alpha Value	Interpretation
Above 0.90	Excellent Reliability

0.80 – 0.89	Good Reliability
0.70 – 0.79	Acceptable Reliability
0.60 – 0.69	Marginal Reliability
Below 0.60	Poor Reliability

The reliability analysis results show that all the study variables got Cronbach's Alpha values above that commonly used threshold, 0.70. So Green Chemistry Practices had an alpha of 0.842 then Consumer Perception reached 0.876 and Pharmaceutical Brand Image reported the most dependable reliability with 0.891. Also the overall questionnaire generated a Cronbach's Alpha of 0.872, which indicates strong inner consistency among the measurement items. Overall these findings kind of confirm that the questionnaire is reliable and can be used for later statistical procedures like correlation analysis, regression analysis, factor analysis and structural equation modelling. Therefore the measurement tool gives stable dependable outcomes when exploring the relationship between green chemistry practices, consumer perception, and the pharmaceutical brand image.

4.4 Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) was done, sort to see into the hidden factor structure behind the measurement items and also to check whether the variables in the study were, well , suitable for extracting factors. The , “how good is the sample” question and the connections between the variables were looked at using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett’s Test of Sphericity. So if the KMO score ends up above 0.70 and Bartlett’s Test is significant ($p < 0.05$) then the data can basically be treated as appropriate for factor analysis, overall.

Table 4.4 KMO and Bartlett's Test

Test	Value
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	0.842
Bartlett's Test of Sphericity Approx. Chi-Square	986.452
Degrees of Freedom (df)	78
Significance (p-value)	0.000

KMO Interpretation Table

KMO Value	Interpretation
0.90 and Above	Excellent
0.80 – 0.89	Very Good
0.70 – 0.79	Good
0.60 – 0.69	Acceptable
Below 0.60	Unsatisfactory

From the Exploratory Factor Analysis we can see that the data is kind of okay for factor analysis, even if it is not totally obvious at first. The KMO value, 0.842, sits in the “Very Good” range, and it suggests that the sample size is adequate. Also, the variables share enough common variance for the extraction of factors, so yeah, it’s not just random noise, but more like a steady structure underneath. Also Bartlett's Test of Sphericity gives a Chi-square statistic of 986.452 with a significance level of 0.000. That p value is well below the recommended 0.05 threshold, so the correlation matrix cannot be treated as an identity matrix. In other words, there are real and meaningful relationships among the variables. Because of that, the outcomes suggest that it is appropriate to continue with factor analysis in order to discover the underlying dimensions related to Green Chemistry Practices, Consumer Perception, and the Pharmaceutical Brand Image.

4.5 Confirmatory Factor Analysis

Confirmatory Factor Analysis, was conducted in order to check the measurement model and see how the observed variables relate to their more hidden latent constructs. The overall model fitness was looked at through fit indices that are commonly used, namely the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) . After that , the numbers that came out were set side by side with the usual recommended threshold limits, to decide whether the measurement model was adequate or not.

Table 4.5 Confirmatory Factor Analysis (CFA) Results

Model Fit Index	Recommended Value	Obtained Value	Model Fit Status
CFI (Comparative Fit Index)	≥ 0.90	0.945	Good Fit
TLI (Tucker-Lewis Index)	≥ 0.90	0.932	Good Fit
RMSEA (Root Mean Square Error of Approximation)	≤ 0.08	0.056	Good Fit
SRMR (Standardized Root Mean Square Residual)	≤ 0.08	0.048	Good Fit

Model Fit Criteria

Fit Index	Acceptable Threshold
CFI	≥ 0.90
TLI	≥ 0.90
RMSEA	≤ 0.08
SRMR	≤ 0.08

The Confirmatory Factor Analysis results indicate that the measurement model, demonstrates a kind of satisfactory level of fit. The CFI value of 0.945 and the TLI value of 0.932 exceed the recommended threshold of 0.90, so this means there is strong consistency between the proposed model and the observed data. Also, the RMSEA value of 0.056 and the SRMR value of 0.048 are below the acceptable limit of 0.08. This suggests a low level of model error and residual variance. Overall, these findings confirm that the measurement items adequately represent the latent constructs, of Green Chemistry Practices, Consumer Perception, and Pharmaceutical Brand Image. So, the CFA results basically establish that the measurement model is valid and they kind of back up the use of Structural Equation Modelling (SEM) for testing the proposed hypotheses, you know, like in practice it supports it fairly well.

4.6 Correlation Analysis

So basically we did a correlation analysis to see how strong and in what direction the relationship goes between Green Chemistry Practices, Consumer Perception, and the Pharmaceutical Brand Image. We used Pearson's Correlation Coefficient, r , to get a sense of how close or associated these study variables were. The results , they kind of help show whether better green chemistry practices seem to run alongside an improved consumer perception , and also with a firmer pharmaceutical brand image, generally speaking.

Table 4.6 Correlation Matrix

Variables	Green Chemistry Practices	Consumer Perception	Pharmaceutical Brand Image
Green Chemistry Practices	1.000	0.721**	0.684**
Consumer Perception	0.721**	1.000	0.798**
Pharmaceutical Brand Image	0.684**	0.798**	1.000

Note: $p < 0.01$ (2-tailed)

Correlation Coefficient Interpretation

Correlation Value (r)	Interpretation
0.00 – 0.19	Very Weak
0.20 – 0.39	Weak
0.40 – 0.59	Moderate
0.60 – 0.79	Strong
0.80 – 1.00	Very Strong

The correlation analysis shows a few significant positive connections, between basically all the study variables. Green Chemistry Practices has a strong positive correlation with Consumer Perception ($r = 0.721$ $p < 0.01$), so when adoption of sustainable pharmaceutical practices goes up, consumer awareness and trust also feel more vivid, and their view of quality becomes higher, while purchase intention tends to rise. On a similar note, Green Chemistry Practices show a strong positive relationship with Pharmaceutical Brand Image ($r = 0.684$, $p < 0.01$), which suggests that eco responsible manufacturing supports brand reputation and then, patient-like loyalty as a whole. Also, Consumer Perception has the strongest positive correlation with Pharmaceutical Brand Image ($r = 0.798$, $p < 0.01$) meaning good attitudes from consumers really boost brand value and reputation, in a rather direct way. Overall, these results back the proposed conceptual framework and they give preliminary support for acceptance of the study hypotheses.

4.7 Regression Analysis

Regression analysis was used to look at how the study variables kind of relate together, just to see the predictive relationships between them. More specifically, the analysis looked at how Green Chemistry Practices influence Consumer Perception, and also how Consumer Perception influences the Pharmaceutical Brand Image. The results provide evidence about how much shifts in the independent variables can explain variations in the dependent variables, even if it's not always straightforward.

Table 4.7 (A) Impact of Green Chemistry Practices on Consumer Perception

Variables	Beta (β)	t-value	Sig. (p-value)	Result
Green Chemistry Practices → Consumer Perception	0.721	12.845	0.000	Significant

Model Summary

R	R ²	Adjusted R ²	F-value	Sig.
0.721	0.520	0.517	164.99	0.000

The regression results, show that Green Chemistry Practices creates a noticeable, positive influence on Consumer Perception ($\beta = 0.721$, $p < 0.001$). The R^2 comes out at 0.520, which kind of implies about 52.0% of the change in Consumer Perception is explained by Green Chemistry Practices, more or less. Also the F-value is statistically significant (164.99, $p = 0.000$), so the full regression framework works in a dependable way. Therefore, if waste reduction strategies are adopted more often, alongside green solvents, energy efficient technologies, and sustainable raw materials, then it should in turn boost consumer confidence, reinforce environmental awareness, heighten the perceived product quality and lift purchase intention.

Table 4.7 (B) Impact of Consumer Perception on Pharmaceutical Brand Image

Variables	Beta (β)	t-value	Sig. (p-value)	Result
Consumer Perception → Pharmaceutical Brand Image	0.798	16.382	0.000	Significant

Model Summary

R	R ²	Adjusted R ²	F-value	Sig.
0.798	0.637	0.635	268.37	0.000

The findings reveal that Consumer Perception has a strong, and significant positive influence on Pharmaceutical Brand Image, ($\beta = 0.798$ $p < 0.001$). The R^2 value of 0.637 suggests that Consumer Perception explains about 63.7% of the variance in Pharmaceutical Brand Image, so it is not just a small slice, of the story. The F-value is very highly significant (268.37, $p = 0.000$) and it shows how sturdy the regression model is, and yes that matters. In the end, this means consumers who view pharmaceutical companies as environmentally responsible are more likely to develop trust, create favourable feelings, and demonstrate loyalty toward those brands. Therefore, positive consumer perception adds in a meaningful way to better brand reputation, and brand equity, plus it pushes customer loyalty in general.

5. DISCUSSION

The findings in this study show that Green Chemistry Practices has a noticeable positive effect on Consumer Perception ($\beta = 0.721$, $p < 0.001$) and on the Pharmaceutical Brand Image ($r = 0.684$, $p < 0.001$), while Consumer Perception in turn really, strongly affects Brand Image ($\beta = 0.798$, $p < 0.001$). So in general, these outcomes indicate that environmentally sustainable pharmaceutical manufacturing does improve consumer trust, quality judgment, and purchase intention. This sort of thing matches earlier research, which often points out that sustainability along with corporate environmental responsibility can strengthen brand standing and keep customers loyal. If I look at it from a consumer behaviour angle, when environmental awareness rises, people tend to lean toward sustainable pharmaceutical products, kind of like a quiet preference that grows steadily. And from a brand management perspective, green chemistry initiatives help build brand equity, support trust, and create a competitive advantage. Plus sustainability actions—like waste reduction, better energy efficiency, and carbon emission control—do kind of two jobs at once; they safeguard the environment while also backing long term organizational performance and stakeholder confidence.

CONCLUSION

The study concludes that adopting Green Chemistry practices really boosts consumer perception, and the overall Pharmaceutical brand image within the pharmaceutical industry, like it measurably helps. The major findings indicate that sustainable efforts such as waste reduction, green solvents, energy efficient processes, and carbon reduction all together, these things have a positive influence on consumer trust, environmental awareness and purchase intention, in a pretty direct way. Put simply, this research adds value by tying green chemistry, how consumers view everything, and brand image into one unified conceptual framework. From an industry standpoint, sustainable drug development supports brand reputation, builds customer loyalty more firmly, and also offers a clearer competitive edge. The findings moreover suggest important policy implications by urging regulatory backing for green manufacturing initiatives. On top of that, the environmental implications are quite broad, including reduced ecological impact, more efficient resource usage, lower carbon emissions, and a stronger push toward long term sustainability in pharmaceutical production.

RECOMMENDATIONS

From the outcomes of the study, pharmaceutical firms should lean into green synthesis approaches, select eco-friendly solvents, and shift toward energy efficient ways of producing, so the overall environmental footprint gets lowered, and consumer trust is strengthened, at the same time. Doing steady sustainability reporting can add a bit of openness, and it can also

reinforce corporate credibility with the people who matter, right? Policymakers then should step in with financial incentives, tax advantages, and regulatory support, because that kind of push would help roll out green manufacturing technologies across the pharmaceutical sector, more quickly and with less friction. On the consumer side, people should be educated through awareness programs, showing both the environmental upsides and the health benefits linked to sustainable pharmaceutical products. Meanwhile, industry associations ought to craft green certification programs and sustainability standards, to nudge responsible production behaviour, raise competitiveness in the sector, and support long term environmental sustainability, plus help with brand growth.

LIMITATIONS OF THE STUDY

The current study has some limitations that should still be kept in mind, uh, if someone is trying to interpret the findings. To start, this research was basically confined to one particular geographical area, so it is possible that the results may not transfer cleanly to other regions or countries. Also, the sample of 150 respondents might not fully reflect the varied makeup of pharmaceutical consumers, as well as the professionals. Another point is that the study happened within a fairly limited time frame, and that makes it more difficult to observe longer-term changes in consumer perception, and brand image too. And finally, the whole research leans on self-reported questionnaire data, which means that type of evidence can be nudged by response bias, social desirability bias, and even more personal interpretations, so the accuracy of the findings might be a bit off, or sometimes, pretty clearly affected.

FUTURE RESEARCH DIRECTIONS

Future research could broaden what this study already did, in a cross country comparison kind of way, to understand how cultural differences, economic conditions and regulatory variations shape how consumers react to green chemistry practices in the pharmaceutical industry. Some scholars might also examine how Environmental, Social, and Governance (ESG) performance ties in with pharmaceutical brand value, so the strategic benefits of sustainability initiatives become clearer, and not just in theory, but in practice too. In addition, further work may focus on green branding approaches, and check how well these approaches work when it comes to building consumer confidence and improving market competitiveness. There's also room to study sustainable healthcare ecosystems, which could show how environmental responsibility can be woven across healthcare value chains. Finally, longitudinal research on consumer behaviour is recommended, because it helps to track how consumer perceptions trust , and buying intentions toward sustainable pharmaceutical products change as time goes by , and in turn how that shift impacts long term brand image and loyalty.

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