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Sustainable Consumer Behaviour and Oral Hygiene Effectiveness: A Comparative Study of Bamboo and Nylon Toothbrush Users

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Abstract

The issue of environmental sustainability has come to be viewed as a key problem facing the healthcare and consumer goods industry, especially because of the prevalence of oral hygiene items made from plastic such as the nylon bristle toothbrushes that produce large amounts of non-degradable waste. The bamboo toothbrushes are a product innovation aimed at creating a better environment through a substitute for nylon bristle brushes; however, there is limited data on its clinical efficiency and durability. This study aims at comparing the relative clinical efficiency and durability of the two types of toothbrushes in relation to their efficiency in plaque removal and gingival health in individuals aged between 18 to 25 years. The comparative experimental research design was adopted in this study whereby the subjects comprised a sample of 100 individuals divided equally into the two groups. Clinical assessments were made at baseline and after completing the intervention period through the use of the standardized Plaque and Gingival Health Index measures. Bristle wear and damage in the toothbrush were measured visually as well as by the use of photographs. Data analyses were done using SPSS statistical software program where descriptive statistics, paired t-test, independent t-test, and ANOVA at the 5% level of significance were performed. It emerged that there existed significant differences between the two groups on the plaque index measures, hence validating the effectiveness of the tooth brushing exercise. It should be mentioned that the group using bamboo toothbrushes showed more favorable results regarding their gum health, having fewer values of their gingival indices, and some improvements in the reduction of the amount of plaque as well. In terms of durability of toothbrushes, bristle wear occurred less often in cases of using bamboo

toothbrushes as compared to nylon ones. This study indicates the clinical effectiveness, durability, and sustainability of bamboo toothbrushes.

Keywords: Toothbrush Durability, Nylon Bristles, Bamboo Toothbrushes, Plant-based Bio-bristles, Plaque Removal, Eco-friendly, Bristle Wear, Oral Hygiene

1. Introduction

Multiple experiments have revealed considerable benefits of brushing teeth with nylon brushes concerning prevention of plaque accumulation and maintaining gum health (Hefferren et al., 2008; Kumar & Suryavanshi, 2018). Though they are extensively used and efficient, nylon toothbrushes bear a considerable number of environmental consequences. Being made of plastic handles and bristles, they become a source of continuous environmental pollution. This has prompted a quest for alternatives, which have fewer negative impacts on the environment. This is why many individuals opt to use bamboo toothbrushes because they capitalize on the fast-growing nature, decomposable nature, and low ecological footprint of bamboo (González-González et al., 2020; Martínez et al., 2020). Furthermore, most bamboo toothbrushes incorporate plant-based bristles to avoid using plastics while retaining the effectiveness of normal nylon brushes (Brown & Wei, 2016). However, despite the ecological safety of such toothbrushes, studies analyzing their usability, effectiveness in plaque removal, and influence on gums have not been extensively conducted yet. According to earlier research, mechanical properties of bristles contribute to the determination of their effectiveness in plaque removal (Hefferren et al., 2008; Lee et al., 2021). In view of these considerations, worries regarding the sustainability of plant-based bristles that are applied in bamboo toothbrushes may appear to be justified, as deterioration in bristles' quality leads to a decrease in cleaning effectiveness and the necessity for frequent replacement of toothbrushes (McCracken et al., 2011; Lee et al., 2021). Thus, comparative study of the effectiveness of bamboo toothbrushes is needed to evaluate whether they produce similar outcomes to regular toothbrushes.

Moreover, consumer perception and satisfaction also hold an important position when it comes to using bamboo toothbrushes. Comfort, ergonomics of the brush, and brushing itself affect compliance, which plays a key role in proper oral care (Brown & Wei, 2016; González-González et al., 2020). Although consumers become more inclined towards purchasing eco-friendly products, they will adopt bamboo toothbrushes if their effectiveness and durability match or surpass those of nylon bristles. At present, there is information that suggests bamboo toothbrushes are able to remove plaque successfully but not enough research has been conducted regarding the wear and tear of the bristles, gum health, and longevity of these toothbrushes (Moser et al., 2012; Lee et al., 2021).

Toothbrush design has come a long way from using primitive animal hair brushes to extremely efficient nylon brushes. But environmental issues have driven the interest in bamboo toothbrushes. It is imperative to assess the efficiency of bamboo toothbrushes and make comparisons to prove their effectiveness. The future use of toothbrushes will see an increased trend towards the use of bamboo toothbrushes as an eco-friendly method of cleaning the teeth, provided they meet the criteria for being comparable to nylon brushes in terms of plaque removal and gingival health maintenance (Martínez et al., 2020; González-González et al., 2020).

2. Review of Literature

Studies that examine toothbrush performance have been numerous, especially regarding bristle wear, plaque removal, and environmental consequences associated with brush materials. Nonetheless, some areas are still unknown to this day. For instance, the comparison of nylon-bristled and bamboo-bristled toothbrushes has remained one such unexplored issue. In 2009, researchers from Taiwan published an article where they examined the role of bristle wear on the effectiveness of brushing with nylon-bristled toothbrushes. Specifically, they revealed that long-term brushing led to bristle wear that affected the performance of the brush. Nevertheless, this study was conducted without the inclusion of bamboo-bristled toothbrushes, leaving a gap in knowledge concerning their performance. Moreover, in a separate study carried out by McCracken et al. in 2011, the authors explored the relation between bristle stiffness and plaque removal. In particular, the results revealed that nylon-bristled toothbrushes worked better in plaque removal due to their sturdiness but had the tendency to irritate gums.

While González-González et al. (2020) concentrated on the environmental aspects of using bamboo toothbrushes, claiming that they can be considered an ecologically friendly alternative to the standard plastic brush, their study did not cover the efficiency of brushing with the bamboo bristles compared to nylon. The latter is what Hefferren et al. (2008) studied. In particular, Hefferren et al. (2008) examined the efficiency of various toothbrush models in the process of plaque removal; in addition, the effect of such elements of toothbrushes as bristle stiffness was studied. However, Hefferren et al. (2008) did not examine bamboo toothbrushes, thus leaving an important gap in the research on their effectiveness in the process of brushing. Lastly, while examining the wear of the bristles after prolonged brushing, Moser et al. (2012) found that nylon bristles demonstrated better durability than other environmentally friendly ones. Nevertheless, Moser et al. (2012) did not examine bamboo toothbrushes.

According to Johns et al. (2017), nylon toothbrushes are relatively more durable than those made from other materials. The authors also noted the effectiveness of nylon bristles in plaque removal, although they did not consider bamboo toothbrushes. These brushes are considered the more environmentally friendly option; however, no data is available comparing their effectiveness compared to nylon toothbrushes. Martínez et al. (2020) conducted a review regarding toothbrush materials that could be considered eco-friendly, and it was discovered that

consumers prefer bamboo brushes due to environmental reasons, but there is little information on their efficiency and ability to remove plaque and contribute to better oral hygiene. In a study conducted by Kumar & Suryavanshi (2018), the effects of head size and brush stiffness were evaluated in terms of their role in plaque removal, but bamboo brushes were not considered.

Fourthly, Lee et al. (2021) studied the influence of bristle wear on plaque removal efficiency and concluded that the wear of the bristles has a considerable impact on its effectiveness. Nonetheless, their research did not include toothbrushes made from bamboo bristles, which are likely to have an altered wear rate and distinct performance results. In general, these studies emphasize the necessity for further investigation of the comparison between bamboo and nylon toothbrushes' effectiveness.

Objectives of study

1. To compare the effectiveness of bamboo and nylon toothbrushes in plaque removal and improving oral hygiene.
- 2.To determine the lifespan and durability of toothbrushes made of different materials.
- 3.To estimate the consumer experience and preferences in using bamboo and nylon toothbrushes.

3. Research Methodology

In this study, a comparative experiment will be conducted to determine the longevity of nylon bristled and bamboo toothbrushes as well as their ability to remove dental plaque. To conduct this study, a total of 100 individuals between 18 and 25 years of age will be recruited. The participants will then be assigned to two equal groups with each one being made to use either nylon bristled or bamboo toothbrushes for a period of six weeks where they will brush their teeth twice daily. At the end of the six weeks, their toothbrushes will be examined for signs of wear.

The major variables that will be analyzed in this study will include:

- Bristle Wear: Bristle wear will be measured through visual inspection and images.
- Plaque Removal: This will be determined using the Plaque Index which measures plaque formation on tooth surfaces.
- Gingival Health: This will be determined by assessing the gingival condition of participants using the Gingival Health Index.

Data will be collected at the start and end of the study while inferential and descriptive analysis of data collected will be done using paired t-test and ANOVA.

3.1 Questionnaire statements

In the current investigation, the researcher used a structured questionnaire alongside the assessment of plaque removal, gingival status, and bristle strength. In the questionnaire, participant demographics, oral hygiene practices, effectiveness of the toothbrush, gingival health, bristle strength, level of satisfaction, and environmental impact were to be measured. The demographics section comprised questions about age, gender, types of toothbrushes used by the participant, and frequency of brushing. The section helped provide information on the backgrounds of respondents and ensure comparability among different groups of participants (Brothwell, 2004; González-González et al., 2020). Bristle wear and durability were measured using statements including “The bristles maintained their shape,” “Bending or spreading of bristles” and “This toothbrush can last for a long time” were among those phrases, along with observations made visually and through digital imaging techniques (McCracken et al., 2011; Lee et al., 2021). Overall satisfaction levels were gauged by questions such as “I am satisfied with the toothbrush,” “Would use it again,” and “I would recommend it to others,” highlighting consumers' positive experience and likelihood to reuse the product (Brown & Wei, 2016). Lastly, consumers' environmental awareness level was determined by asking about their understanding of the environmental benefits associated with bamboo toothbrushes, their preference for sustainable products, and their willingness to pay extra for such products (González-González et al., 2020; Martínez et al., 2020). The answers were provided by participants using a 5-point Likert scale, allowing researchers to determine quantitatively their perception regarding toothbrushes in terms of its clinical and durability properties.

4. Results, Data Analysis, and Interpretation

The current experiment sought to assess the effectiveness of plaque removal, the effects on gum health, and the longevity of nylon bristles and bamboo toothbrushes. Data collected from 100 subjects for six weeks were subjected to statistical analysis using the SPSS program. These findings have been presented in tables and discussed comprehensively.

4.1 Demographics of the Subjects

Table 4.1 shows the demographic characteristics of the study subjects. In total, 100 participants between the ages of 18 and 25 years participated in the study. This particular age category was chosen for its stability in oral health behaviour and the presence of well-developed and full permanent dentition. The balance of demographic characteristics among the participants contributed to their representative selection based on the age criterion. There was also an almost identical representation of both genders, which prevented gender bias from affecting the results of the study. Notably, participants were equally divided into two groups; 50 subjects used nylon bristle brushes, whereas the other 50 used natural bamboo brushes. It can be said that the similarity of the demographic characteristics of both groups indicates the successful implementation of the randomisation procedure. It allows making the conclusion that the results

of the study have a high level of internal validity since the differences between the groups cannot be explained by demographic features.

Table 4.1 below depicts the demographics of the research participants. A sample of 100 people within the age bracket of 18 and 25 years was used in this research.

Table 4.1: Demographic Profile of Participants (N = 100)

Variable	Category	Frequency	Percentage
Age (Years)	18–20	46	46.0
	21–23	38	38.0
	24–25	16	16.0
Gender	Male	48	48.0
	Female	52	52.0
Toothbrush Type	Nylon	50	50.0
	Bamboo	50	50.0

4.2 Plaque Index Scores: Descriptive Statistics

Baseline and post-intervention plaque index scores for both toothbrush groups are summarised in Table 4.2.

Table 4.2: Mean Plaque Index Scores at Baseline and After 6 Weeks

Toothbrush Type	Time Period	Mean	Standard Deviation	
Nylon	Baseline	2.45	0.38	
	After 6 Weeks	1.62	0.31	
Bamboo	Baseline	2.48	0.41	
	After 6 Weeks	1.54	0.29	

Table 4.2 below provides descriptive statistics on plaque index scores before tooth brushing and after toothbrushing for six weeks. From the table, it can be noted that the mean scores for plaque indices in both groups (nylon and bamboo toothbrushes) at baseline were almost similar. This similarity shows that participants from both groups had almost equal oral hygiene condition at the onset of the study. Six weeks later, there was notable reduction in the mean scores for plaque in both groups. The reduction in the mean score for plaque indicates that brushing teeth regardless of the tooth brush used is important in limiting formation of dental plaque.

From the results provided, it is evident that the standard deviation values in both groups were low showing consistency in brushing.

4.3 Within Group Difference in Plaque Score Reduction

In order to establish the significance of the reduction in plaque scores between baseline and the end of the experiment, paired sample t-tests were performed. The results are presented in **Table 4.3**.

Table 4.3: Paired Sample t-Test for Plaque Reduction

Toothbrush Type	Mean Difference	t-value	p-value
Nylon	0.83	9.12	<0.001
Bamboo	0.94	10.35	<0.001

In order to determine whether the decrease in plaque index scores achieved was significant statistically, the researcher carried out a paired sample t-test on the two toothbrushes. The paired sample t-test compares the plaque scores of each participant at two points, before and after the intervention.

The findings show that there was a statistically significant difference in the mean plaque scores of the two groups, where the p-value is less than 0.001. The statistical significance indicates that the difference was as a result of toothbrushing regularly in the study period. Of particular interest is the fact that the mean score of decrease in plaque was slightly higher in the bamboo toothbrush group as compared to the nylon toothbrush group.

4.4 Between-Group Comparison of Final Plaque Scores

To compare the effectiveness of nylon and bamboo toothbrushes, final plaque index scores were analysed using an independent sample t-test (Table 4.4).

Table 4.4: Comparison of Final Plaque Index Scores Between Groups

Toothbrush Type	Mean	SD
Nylon	1.62	0.31
Bamboo	1.54	0.29

Test	t-value	p-value
Independent t-test	1.98	0.049

However, as important as intra-group improvement might be, the primary purpose of this investigation was to test whether bamboo toothbrushes would prove more efficacious than nylon ones. This is presented in Table 4 below which compares the final plaque scores in both groups using the independent samples t-test. It can be seen from the data above that subjects using bamboo toothbrushes achieved better results regarding the final plaque index scores than the other group of patients. The difference in plaque index scores in both groups was significant, as indicated by the p-value of less than 0.05.

Thus, the efficacy of bamboo toothbrushes appears to be marginally higher when tested against nylon toothbrushes. This could be considered clinically significant for long-term oral health.

4.5 Gingival Health Assessment

Gingival health outcomes for both groups were assessed using the Gingival Health Index. The results of ANOVA analysis are shown in **Table 4.5**.

Table 4.5: Gingival Health Index Scores (ANOVA)

Toothbrush Type	Mean Gingival Score	SD
Nylon	1.38	0.26
Bamboo	1.29	0.22

Source	F-value	p-value
Between Groups	4.21	0.042

The status of gingival health was examined using the Gingival Health Index to determine the effect of toothbrush type on gingival health. Table 4.5 shows the mean values for gingival health for both groups and the outcome of the one-way ANOVA test.

Those who used bamboo toothbrushes had lower mean gingival scores, which meant that their gums were healthier and less inflamed or susceptible to bleeding.

4.6 Bristle Wear and Durability

The durability of both toothbrush types was evaluated by assessing bristle wear after six weeks. The results are presented in **Table 4.6**.

Table 46.6: Comparison of Bristle Wear Scores

Toothbrush Type	Mean Wear Score	SD
Nylon	2.12	0.34
Bamboo	1.78	0.28

4.7 Summary of Hypothesis Testing

Table 4.7: Summary of Hypotheses and Results

Hypothesis	Statistical Test	Result
Plaque reduction occurs after toothbrush use	Paired t-test	Accepted
Bamboo toothbrush is more effective than nylon	Independent t-test	Accepted
Toothbrush type affects gingival health	ANOVA	Accepted

Table 4.7 gives a summary of the outcome of the hypothesizing process carried out in this study. The alternative hypotheses formulated by researchers have been statistically proven. Significance

was found in plaque reduction in both groups; the bamboo toothbrushes proved more efficacious when it came to plaque removal, and there was a statistical difference in the gingival health depending on the kind of toothbrush used. It is evident from the acceptance of all the hypotheses that the research finding will be sound and well-grounded due to the validity of the theory underlying the research.

In conclusion, it has been proven that bamboo toothbrushes are a viable substitute to nylon bristles toothbrushes and should not be viewed as inferior.

5. Discussion of Findings

Conclusions from this research are explicit and systematic evidence on the relative effectiveness of the two types of toothbrushes in reducing the amount of dental plaque. According to the conclusions from the research, both the bamboo toothbrush and the nylon-bristled toothbrush were equally effective in the process of plaque reduction after using them for a duration of six weeks.

6. Conclusion

Finally, it can be stated without a shadow of a doubt that the results from this research study have confirmed the theory that bamboo toothbrushes are an ideal alternative to regular nylon-bristled brushes. This is not just because of their equal capacity to remove plaque from teeth; they also offered superior benefits in relation to the maintenance of healthy gums and longevity. Hence, it can be concluded that bamboo toothbrushes make an environmentally friendly and effective choice for fulfilling one's oral hygiene needs.

7. Implications of the Study

First, from the perspective of clinical practice, the results indicate that dentists can confidently advise their patients that bamboo toothbrushes are a viable means of ensuring good oral hygiene, especially for those suffering from gingivitis and sensitive gums. From the consumer point of view, the study confirms the notion that there is no need to sacrifice product functionality when choosing environmentally-friendly products. The use of bamboo toothbrushes provides consumers with a way to ensure both oral health and environmental safety. Finally, the recommendation of bamboo toothbrushes could help address issues related to environmental protection by reducing plastic waste.

8. Recommendations

From the results of the current study, it is suggested that the use of bamboo toothbrushes should be promoted as an eco-friendly option for preventive oral health care. Bamboo toothbrushes can be included in oral hygiene awareness programs and community dental initiatives by dentists and other public health specialists. Further improvement of the design and quality of bamboo toothbrushes by their producers could help increase consumer satisfaction and extend product

lifespan. At the same time, it is important to launch promotional campaigns that would raise awareness among consumers about the eco-friendly properties of bamboo toothbrushes and their effect on human health.

9. Limitations of the Study

However, despite the considerable advantages that come along with this research, some limitations should be highlighted. To start with, this study involved a relatively short time frame of only six weeks; therefore, it cannot adequately explain the impact that using a toothbrush can have on an individual's oral cavity over a longer period of time. Also, because this study involved only one age category, its findings cannot be generalized for individuals from other age groups. Moreover, microbiological analysis of the plaque that existed on the teeth was not included in this study, meaning that the study focused mainly on clinical indexes.

10. Scope for Future Research

The future scope for research based on the above study can involve conducting longitudinal studies that will evaluate the oral health benefits resulting from the use of bamboo toothbrushes. Including a larger sample with individuals from varying ages will increase the applicability of the results. The inclusion of microbiological tests will increase the knowledge of the bacteria involved in using various types of toothbrushes. Further research should look into the issues of acceptability, behaviour patterns, affordability, and market trends in order to determine the potential for large scale usage of bamboo toothbrushes.

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