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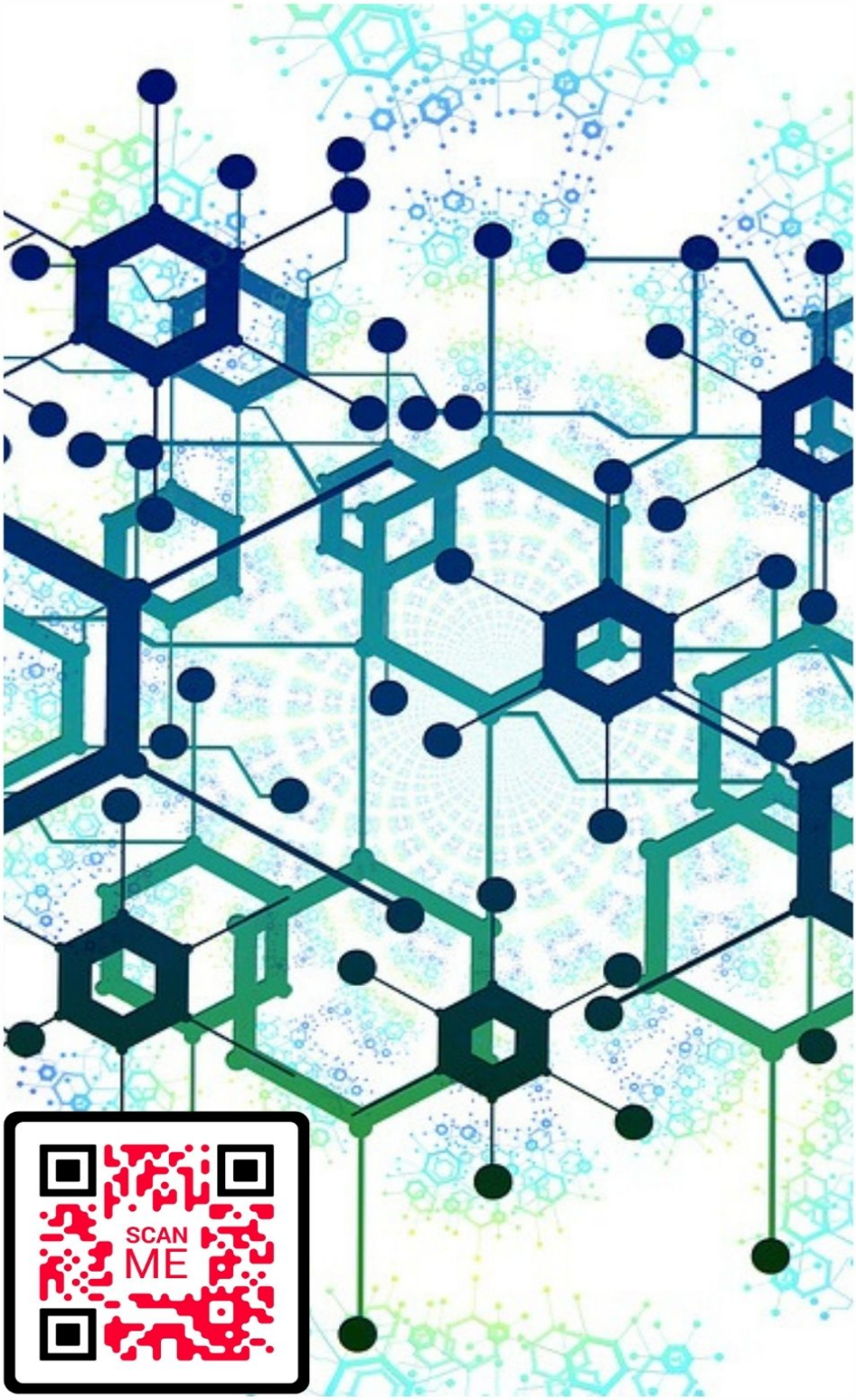

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Eco-Friendly Biomaterial Sticker: Redefining Anti-Radiation Solutions

Stiker Biomaterial Ramah Lingkungan: Mendefinisikan Ulang Solusi Anti-Radiasi

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Abstract

This study presents an innovative sticker product crafted from environmentally sustainable biomaterials, designed to mitigate radiation exposure from electronic devices while enhancing the aesthetic appeal with the distinguished Banyumas batik motif. To ascertain market viability and effective consumer reception, a comprehensive segmentation analysis was conducted on a sample of 99 smartphone and laptop users. Employing cluster analysis, our findings reveal a strong consensus regarding the product's attributes, affirming its potential as a sustainable and effective anti-radiation solution. Moreover, this research underscores that customer preferences and values play a pivotal role in driving product innovation, alongside practical attributes and material performance. These insights have significant implications for product development and marketing strategies in the burgeoning field of anti-radiation technology.

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Highlight:

- Innovative Eco-Friendly Solution: This study introduces a novel sticker product made from sustainable biomaterials, offering a dual benefit of reducing radiation exposure from electronic devices and enhancing visual aesthetics with Banyumas batik design.
- Targeted Market Analysis: Through comprehensive segmentation and cluster analysis on 99 smartphone and laptop users, the research confirms a widespread consensus on the product's attributes, indicating its potential as an effective and eco-conscious anti-radiation solution.
- Customer-Centric Innovation: The study underscores the pivotal role of customer preferences and values in shaping product innovation, emphasizing that practical attributes and material performance alone are insufficient drivers. This insight holds significant implications for future product development and marketing strategies in the evolving anti-radiation technology landscape.

Keyword: Biomaterial Sticker, Radiation Exposure Mitigation, Market Segmentation, Consumer Preferences, Product Innovation

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Introduction

In this modern age, new technologies have made life easier in many ways, but they have also made people worry about the way electromagnetic radiation affects their health. Electromagnetic energy from electronic devices can hurt or harm the user's body. For example, it can cause kidney problems that lead to less kidney function, lower sperm quality in men, and a higher body temperature in the area where the phone is used [1].

Figure 1. *Anti-radiation Sticker*

Electromagnetic shielding, or anti-radiation, has good market potential. This product is made from an environmentally friendly biomaterial composite, namely hemp fibre and brother tongue plant extract, with the addition of epoxy resin. One alternative natural fibre material that can reduce radiation levels is hemp fiber. Apart from being environmentally friendly, hemp fibre is cheap and easy to obtain because it is abundant [2]. Another natural fibre that has potential as an anti-radiation agent is brother tongue plant extract (Sansevieria). Sansevieria has the effect of reducing the level of electromagnetic radiation. This antiradiation innovation product has been made as shown in Figure 1. Based on the statement above, the combination of hemp fibre, brother tongue plant extract, and epoxy resin is expected to withstand X-ray radiation. As this is supported by the research results which show that the epoxy resin composite with hemp fibre can withstand X-ray radiation optimally [3]. Utilisation of natural resource potentials effectively and efficiently needs to be carried out with due regard to environmental sustainability. The manufacture of this anti-radiation product involves the manufacture of composite materials. One type of composite that continues to be developed is fibre composites with synthetic materials. The advantage of this composite is that it has superior strength and specifications according to the needs of various fields [2] One of the innovations in using natural fibre composites as an anti-radiation material was carried out in the research [4].

With the widespread use of electronic devices, such as mobile phones, tablets, and laptops, the need for products that can protect consumers from the effects of electrical radiation and magnetism is increasing [5]. In this case, figuring out what consumers want is a very important part of making anti-radiation products. Understanding consumer preferences and needs can assist in designing product development that is tailored to market expectations and demands [6]. In addition, the analysis of consumer interest involves an in-depth understanding of what consumers want from anti-radiation products, the things that are considered important, as well as other factors that influence consumer purchasing decisions for anti-radiation products. In addition to practical attributes and the performance of the materials used, what drives product innovation are the characteristics of the customer and the things they care about most [7].

A key part of the marketing plan for new product development is also figuring out the target market and where to place the product. Find out what kind of people are most likely to be interested in this product and what their wants and preferences are. This will help you come up with good marketing messages. As well as understanding

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where anti-radiation products stand in the market, one of the things to think about when putting together information about how these products are different from others like them [8]. A key part of the marketing plan for new product development is also figuring out the target market and where to place the product. Find out what kind of people are most likely to be interested in this product and what their wants and preferences are. This will help you come up with good marketing messages. As well as understanding where anti-radiation products stand in the market, one of the things to think about when putting together information about how these products are different from others like them.

Method

The material used in this research is primary data obtained from filling out questionnaires for 99 respondents who are smartphone or laptop users which was done online. The technique for determining the number of samples in this study used a non-probable sampling technique. Nonprobability sampling is a sampling technique that does not provide equal opportunities or opportunities for each member selected to be the sample [9].

This study uses the determination of sample size in order to find out the minimum sample numbers needed. The sample in question is part of the population taken by the study. Sampling is based on the size of the population, so it cannot examine the entire existing population. This is done as a representative of the population. Determining the number of samples in this study is supported by the Bernoulli Formula Approach with the following equation [10]:

$$N \geq \frac{(Z \propto/2)^2 * pq}{e^2}$$

Figure 2. *Equation with Bernoulli Formula*

Information:

N = minimum number of samples, namely the minimum number of respondents who must fill out a questionnaire so that the research is valid

a = level of confidence (95%), namely the level of truth of the questionnaire

Z (a/2) = distribution value (1.29), which assumes that all activities that occur at the sticker production center follow a normal distribution. This the researchers approached by testing tht assumption of normality in estimating the parameters ofthe event

e= error tolerance (5%), namely errors that may occur in filling out the questionnaire by respondents only by 5%.

p = proportion of questionnaires answered correctly

q = proportion of questionnaires answered incorrectly

Questionnaire

The type in the questionnaire in this study used a closed questionnaire. This closed questionnaire was carried out where the respondent had to answer the questions that had been provided by the researcher. Questionnaire distribution will be given to respondents who are members of the sample. The questionnaire was used to find out the expectations of the center's customers regarding anti-radiation stickers, both service quality and product quality. The sample is included in the number and characteristics of the population [11]. This study uses the Rao Purba formula because the population is unknown [12], namely

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$$(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k \; a^{n-k}$$

$$N \geq \frac{\left(\frac{Za}{2}\right) 2.pq}{e2}$$

$$n = \frac{Z^2}{4(Moe)^2}$$

$$n = \frac{1{,}96^2}{4(0{,}10)^2}$$

$$n = 96{,}04$$

Figure 3. *Rao Purba formula*

The results of the calculation above, it can be taken a minimum number of samples of 96 respondents. Based on the minimum sample size, the study used 100 respondents.

Validity and Reliability Test

A. Validity Test

This test is carried out to find out whether the results of the questionnaire are valid or not. If the data obtained is valid, then all the questions that have been given can be used to measure respondents' responses regarding the variables in the questionnaire [13]. Data that has been said to be valid is then feasible to be forwarded to data processing.

B. Reliability Test

Results that can be said to be reliable are when the measurement results remain consistent. The reliability test can be used to measure the same object several times, this measurement will produce the same data [11]. Researchers used the Alpha Cornbach formula to test reliability. This formula can be used for all questions together. The stages for calculating the reliability test using the alpha cronbach formula are:

1. Determine the variant value of each question item

$$\sigma_i{}^2 = \frac{\left(\Sigma x_i{}^2 - \frac{(\Sigma x_i)}{n}\right)}{n}$$

2. Mdetermine the total variance value

$$\sigma_t{}^2 = \frac{\left(\Sigma x^2 - \frac{(\Sigma x^2)}{n}\right)}{n}$$

3. Determine the reliability of the instrument

$$r_{11} = \frac{(k)}{(k-1)}\left(1 - \frac{(\Sigma \sigma_b{}^2)}{\sigma_t{}^2}\right)$$

Figure 4. *Alpha cronbach formula*

Where:

n= number of samples

Xi= respondent's answer for each question item

ΣX= total respondent's answers for each question item

□□□□= total variation

Σ□□□= number of item variants

k= number of question items

r11= instrument reliability coefficient

Data analysis

A. Cluster Analysis

Cluster analysis is an analysis that groups similar items as research objects into separate and mutually exclusive clusters [14]. Cluster analysis is part of multivariate statistical analysis with interdependent methods. Cluster analysis is a useful analytical tool for summarizing data. This information can be summarized by grouping the objects examined. The main objective of cluster analysis is to classify objects (cases/items) such as people, products (goods), shops, companies into relatively homogeneous groups based on several variables. The elements in a group must be relatively similar. They are declared as variables and must be very different from objects in other groups.

Cluster characteristics are:

1. High homogeneity (similarity) between members of a cluster (within a cluster).

2. Other heterogeneity (differences) (between clusters). Length between one cluster and another.

B. Biplot analysis

Perform biplot analysis with the following steps:

1. Enter data in the X matrix

2. Standardization matrix

3. Decompose the X matrix that has been standardized with SVD (Singular Value Decomposition)

4. Calculation of the matrix H = AL and G = UL

5. Plot the matrices overlapping. t consists of the research design (the method, the data, the data source, the data collecting technique, the data analysis technique, the variables measurement and the scales which is used in the research) that written in the form of a paragraph.

Result and Discussion

Consumer Characteristics

This study uses grouping types of consumers as a benchmark in consumer characteristics. Types of consumers can be seen based on place of residence, age, final education, the job held by the consumer, monthly income, and monthly expenses. Traditional ways to segmentation based on geographic, demographic, psychographic, and behavioural categorization can be used [15]. Consumer characteristics are obtained from respondent data which will then be included in aspects of consumer perception and market segmentation. The optimal segmentation approach can be chosen by businesses to split consumer groups based on variations in perceptions amongst segments. This explains why buying decisions will rise if the perception of market segmentation improves [16].

1. Domicile

Based on the character of the respondents, it was found that more than half of the respondents (59.6%) lived in Banyumas Regency, while the remaining 40.4% lived outside Banyumas Regency. The percentage results show that this sticker product is not only known by the people of Banyumas Regency, but also known in various places outside Banyumas Regency. This happens because the products sold are not only made directly (*offline*) but also indirectly (online). These results can be said that digital marketing strategies can expand the reach of product marketing [17].

2. Gender

Gender of respondents consisted of two, namely women and men. The results of distributing questionnaires to 99 respondents stated that 31 respondents (31.3%) were male and 68 respondents (68.7%) were female. This shows that the proportion of female respondents is more dominant. Women tend to have knowledge about anti-radiation which is harmful to humans so that products are more in demand by women. This is in accordance with references which state that female consumers have a fairly high preference for a product based on the quality and price of the product to be purchased [18].

3. Age

Respondents in this study were divided into ages <20 years, 21-30 years, 31-40 years, and 41-50 years. Based on the results of the questionnaire, it can be seen that 35 respondents (35.4%) were <20 years old, 57 respondents (57.6%) were 21-30 years old, 4 respondents (4.0%) were 31-40 years old and as many as 3 respondents (3.0%) aged 41-50 years. The results showed that the majority of respondents were aged 20-31 years (57 respondents). It can be concluded that generation Z has a tendency towards digital usage and product purchasing preferences compared to other generations [19].

4. Education

The level of education of respondents in this study showed that D3/D4 education was 3 respondents (3.0%), S1 education was 24 respondents (24.2%), Masters education was 1 respondent (1.0%), SMA/SMK education ?Ma as many as 68 respondents (68.7%) and SMP/MTs education as many as 3 respondents (3.0%). SMS/SMK/MA education is the education that is the majority in filling out the questionnaire, this is because this education is Generation Z who is currently taking lectures. SMA/SMK/MA education is a level of education that is known to have a need to use sophisticated electronic/ communication goods during education and work. Education is one of the causes of differences in tastes and purchasing power, thus influencing one's shopping intentions. In SMA/SMK/MA education, they tend to understand more about technology.

5. Work

Consumer characteristics based on the type of work found that housewives were 1 respondent (1.0%), civil servants were 7 respondents (7.1%), private employees were 9 respondents (9.1%), students were 80 respondents (80.8%), and entrepreneurs as much as 2 respondents (2.0%). The results show that the study population is dominated by students. This is in accordance with the last education of the majority SMA/SMK/MA.

6. Income

The income of 37 respondents (37.4%) was < IDR 1,500,000, 6 respondents (6.1%) > IDR 4,500,000, 50 respondents (50.5%) IDR 1,500,000-IDR 3,000,000, and as many as 6 respondents (6.1%) amounting to IDR 3,000,000-IDR 4,500,000. The results showed that the majority of consumers consisted of students who had an allowance of IDR 1,500,000-IDR 3,000,000. The income that a student gets is not his own income, but in the form of pocket money that is obtained from his parents. Consumer pocket money can influence consumers in making decisions in buying a product. Consumers in buying a product see from several aspects, namely the quality and price of the product.

7. Expenditure

Based on the research results, it was found that the monthly expenditure of the majority of respondents was IDR 500,000-IDR 1,500,000 with a percentage of 69.7%. This is because the majority of respondents are students, so spending is still low. Different needs make different expenditures so that it can affect a person's interest in shopping.

Cluster Analysis

Cluster analysis is a multivariate technique that aims to classify objects into groups that differ from one group to another. These objects will be classified in one or more clusters (groups) so that objects in one cluster will have similar or similar characters. The purpose of doing this cluster analysis is to get groups of objects that have the same relative value. So that later in interpretation, objects that are in one cluster have a high enough chance to appear together in one individual.

The cluster formation procedure is divided into 2, namely hierarchical and non-hierarchical. The formation of hierarchical clusters has characteristics as the development of a hierarchy or branched tree structure. The hierarchical cluster method is a grouping method in which the number of groups to be made is unknown. This technique is well processed through sequential concatenation (*agglomerative*) or sequential division. In the formation of hierarchical clusters, it begins by grouping data that has the closest similarity, then a single linkage clustering will be produced in the form of a dendogram or tree diagram. The tree branches show clusters. The branches meet together at nodes which are positioned along a distance axis (similarity) and will indicate the degree

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at which merging occurs. The dendrogram output showing the interpretation of the clusters formed is presented in Figure 2.

In Figure 2, the last two stages of the dendrogram have the largest distance. To get clusters that have the closest similarity, the distance chosen is the one with the smallest distance. From the three clusters, each group was found to have similarities based on the variables of age, last education, employment, monthly income, and monthly expenses. The following is the result of the cluster hierarchical analysis which is divided into threea cluster (Table 1).

Variable	Clusters		
	1	2	3
Age	31 - 40	21-30	<20
Last education	S1	S1/D4	SMA/SMK/Ma
Work	Employee	Self-employed	Student / Student
Income per month	Rp. 3,000,001 – Rp. 4,500,000	Rp. 1,500,001 – Rp. 3,000,000	<IDR 1,500,000
Monthly expenses	> Rp. 2,500,000	Rp. 1,500,001 – Rp. 2,500,000	Rp. 500,000 – Rp. 1,500,000
Amount	9	31	59
Percentage	9.1%	31.3%	59.6%

Table 1. *Results of Cluster Hierarchy Analysis*

Based on the data in Table 1, cluster 3 has the largest number of respondents, namely 59.6%. These results can be a reference in determining the segments that will be the target of the sticker productanti-radiation. So that it can be seen that the target of this anti-radiation sticker product is consumers who graduate from SMA/SMK/MA with status as students aged less than 20 years and have a monthly income of <Rp. 1,500,000 and monthly expenses of Rp. 500,000 – Rp. 1,500,000.

Biplot analysis

Biplot analysis is a multivariate method that uses rows and columns in a graph and is used to display objects and variables with the object under study. This biplot analysis is a double-dimensional descriptive statistical technique that can simultaneously present a group of observation objects and variables in a graph on a flat plane so that the characteristics of the variables and objects of observation as well as the relative positions between the objects of observation and the relative positions between the objects of observation and variables can be analyzed [20] In the research conducted, there were 15 product attributes of stickerstreated anti-radiation to determine consumer preferences based on the degree of importance. These attributes include the use of electronic devices, the use of cases or device accessories, the level of consumer knowledge of products made from biomaterials and anti-radiation, how interested consumers are in biomaterial and anti-radiation products, the level of importance of anti-radiation products for consumers, and whether the sticker products are anti-radiation can be an alternative solution to consumer problems, consumer interest in motif designs, packaging, and sales systematics for anti-radiation sticker products as well as the level of consumer interest in this product as a form of innovation in anti-radiation products. The results of the biplot analysis output are presented in Figure 3 and Figure 4.

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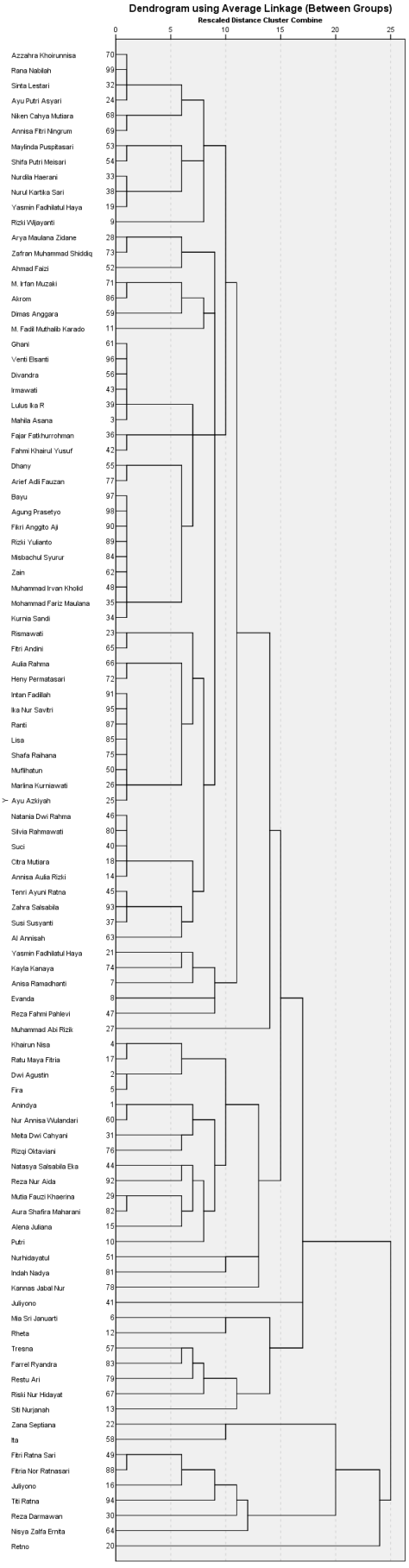

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Figure 5. *Dendogram Output*

On the results of the analysis*score plot,*respondents choose preferences for attributes that they consider very good (A), good (B), mediocre (C), not good (D), and very bad (E). The results of the biplot analysis of respondents' preferences for anti-radiation sticker product attributes can be seen in Figure 4. From the biplot analysis, it can be seen that the line of variable A or very good looks long because there are many attributes represented around the variable line A, including attributes (1, 6, 10, 11, 14, 15) related to the use of electronic devices, interest in using anti-radiation products, use of e-commerce shopee, sales in the form of 3 pcs with various designs, interest in using the product and also the level of consumer satisfaction with anti-radiation sticker products.

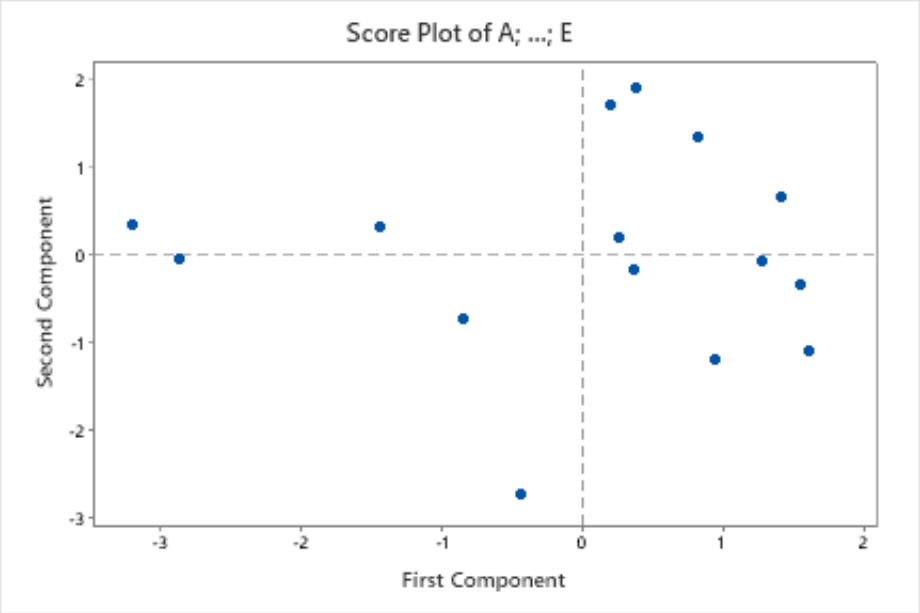

Figure 6. *Analysis of Score Plots*

Based on the research that has been done through online questionnaires, it can be seen that the appropriate marketing strategy for anti-radiation sticker products can be identifiedanti-radiation by prioritizing the quality, uniqueness and usefulness of the product as one of the potential and competitive products. This step was taken because the anti-radiation sticker product is a new product that has not been widely recognized by the general public. So that the form of implementing the marketing strategy must be able to be designed based on attributes that are considered very important by consumers [21] and these attributes can be used as a reference or benchmark in the formulation of product positioning for anti-radiation anti-radiation stickers. A well-executed positioning strategy of a corporation can generate a positive product image in the minds of consumers. This can eventually persuade them to purchase and use the product [22]. In the results of the score plot analysis resulting from the PCA method (*Principal Component Analysis*), in Figure 3 it can be seen that the data has a pattern that is grouped into three main groups. The first group is located in quadrant I, while the second group is located in quadrant IV, and the third group is in quadrant III. This indicates that there is variation in the data which reflects the variation in the observed characteristics.

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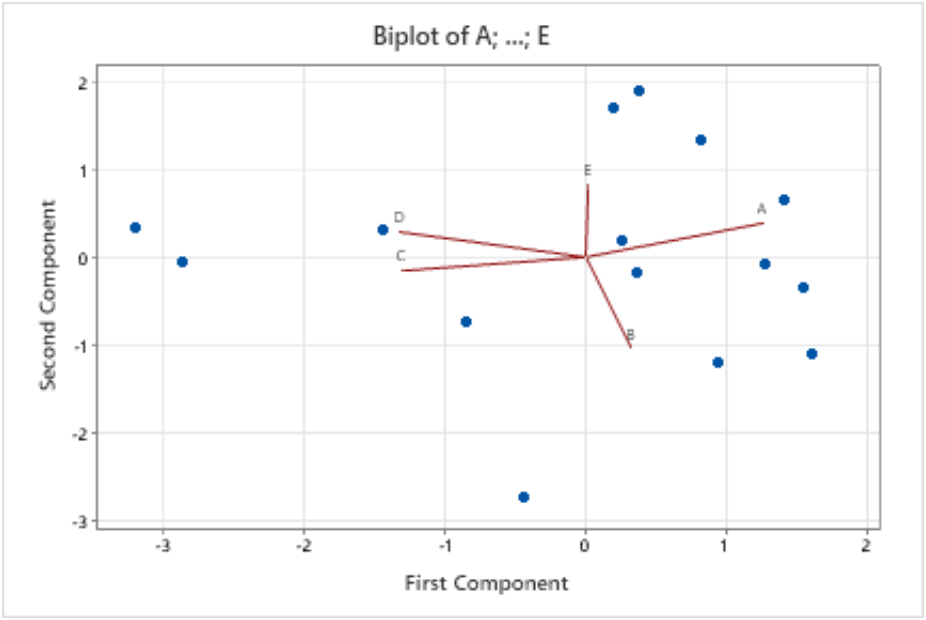

Figure 7. *The results of the biplot analysis of respondents' preferences for attributes*

In Figure 4, it is obtained from this biplot analysis that the diversity is explained by the x and y axes where the diversity of variables (attributes) is described from the length of the vector, the longer the vector of an attribute, the higher the diversity of attributes, and vice versa. In Figure 4 it can be seen that the attributes of knowledge of anti-radiation products, interest in products made from biomaterials and also consumer satisfaction with anti-radiation sticker products have a longer vector than the other vectors. This diversity value indicates that respondents' perceptions of the three attributes are more diverse than the other attributes.

Based on the analysis that has been done, the positioning of anti-radiation products can be formulated as follows. “Anti-radiation sticker is a minimalist and universal anti-radiation sticker product for all electronic devices. An anti-radiation product made from biomaterial composites and environmentally friendly, namely hemp seed fiber and brother tongue plant extract 's tongue leaves. This product is one of the Green Products with a minimalist, flexible design, and also elevates the aesthetic value of batik motifs as a brand identity. The verbal logo or tagline of anti-radiation products is: "Anti-radiation, Reduce Radiation Safe Protected". It can be seen that several brands of anti-radiation products that are market competitors for these anti-radiation products include Gray Jack and Screen Guard products as described in the table below as follows.

Aspect	Anti-radiasi products		
Brand	Grey Jack	Screen Guard	Stiker Anti-radiasi
Form	Glasses	Screen Case Sheet	Slim Trinkets
Price	Rp 279.000	Rp 177.000	Rp 29.500
Size	Not minimalist	Minimalist	Sheer Minimalist
Characteristic	Unisex	Custom	Universal
Art elements	There isn’t any	There isn’t any	There is

Table 2. *Positioning of Anti-radiation Products*

Based on Table 2. it can be seen that anti-radiation sticker products have good product positioning and have advantages over other anti-radiation brand products. The anti-radiation sticker has the shape of a slim knick-knack with the most affordable price of Rp. 29,500 with a minimalist and thin size and has universal properties and also elevates elements of artistic aesthetics from the application of Banyumas Batik which also elevates the green product nature of the biomaterials used. The competitor analysis that has been carried out will support determining the target market. Companies that have seen market share by looking at competitors will be more precise in determining their positioning [23].

Conclusion

Based on the results of the research that has been done, the conclusions that can be drawn from this study are based on hierarchical analysis *clusters* formed, Cluster 3 is recommended as the target of anti-radiation sticker

products because it has the highest number of respondents. Respondents in cluster 3 have the criteria for graduating from SMA/SMK/MA with status as students/students aged less than 20 years and have a monthly income of less than IDR 1,500,000 with an average monthly expenditure of IDR. 500,000 – Rp. 1,500,000. The results of the biplot analysis can be used as a standard of company value in creating a value proposition because the position of the attribute is at the strongly agree level. These attributes include functional aspects as an environmentally friendly antiradiation alternative that can reduce the level of radiation exposure in the use of electronic devices and the aesthetic value of Banyumas batik as one of the brand identities. The verbal logo or tagline of the anti-radiation innovation product is "Anti-radiation, Reduce Radiation, Safely Protected".

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