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SINTA 2

Knowledge, Perception, and Public Attitude on Biotech Crops in Indonesia

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ABSTRACT

Until now, many genetically engineered products have met our basic needs and provided various benefits. However, there are still many who doubt or even reject them. This raises the question of how the public's knowledge and understanding of these biotechnological plants stand. This research aims to analyze whether public actions in adopting biotechnology are influenced by their knowledge and perceptions. This survey used a questionnaire with 535 respondents. The results show that about 70% of respondents have limited knowledge about biotechnology, with information channels including print media, social media, and interpersonal communication. About 75% of respondents agree that biotechnology can enhance agricultural productivity, the economy, and farmers' welfare, as well as contribute to food security. Furthermore, 76% of respondents agree to purchase these products. PLS-SEM analysis reveals a strong positive relationship between knowledge, perceptions, and positive attitudes toward biotechnology products. Therefore, enhancing information dissemination through various alternative media and involving stakeholders need to be strengthened in the future.

Keywords**:** biotech crops, knowledge, perception, PLS-SEM, public attitude

INTRODUCTION

Genetically engineered (GE) crops are flourishing in Indonesia. This plant was produced for human and or animal use using the most recent molecular biology techniques, including genetic engineering (Prianto and Yudhasasmita 2017; Gupta *et al*. 2017). GE crops are also known as biotech crops. Over the years, this aspect of biotechnology has sparked much debate and argument, and many people, including the more informed public, seem to be unsure of the advantages and disadvantages of using GE crops (Maghari and Ardekani 2011).

This new technology is often seen as the key to the next green revolution which has the potential to fundamentally change the way society organizes the production and distribution of its food. It is widely acknowledged that

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biotechnology is one of the most innovative technologies developed in the 20th century with a more promising future in the 21st century. Many GE products have entered the world food distribution network. These products have the potential to not only meet our basic needs but also bring a variety of economic, environmental, and health benefits. The n6eed for these products is even more acute as many countries in the developing world are already struggling to meet their citizens' food and nutritional needs and the global population is expected to increase by 50% between 2006 and 2050.

The result of a study in China, Indonesia, and the Philippines shows that the majority of consumers are aware that GM crops are present in their daily diet and they are not worried about it (AFIC 2002). Those who admitted to consuming GE crops also indicated that they had taken no action to avoid it. In addition, they also expressed their willingness to try GE plant samples. More than 90% said they were most concerned about nutritional value, microbial contamination, and pesticide residues, but not GE crops, which was the least of their concerns (Hoban 2004).

Various studies mentioned above that also discuss Indonesia, shows that public knowledge, perceptions, and attitudes toward biotechnology crops in Indonesia are essential for several reasons, such as the diverse understanding of the benefits of biotech crops, public perceptions and concerns about biotech plants, and the varied attitudes and acceptance within society. Similarly, regulations and safety issues regarding biotech crops are crucial, especially to help inform the debate on biotechnology.

Based on the description above, this research's problem statement primarily concerns the extent of the Indonesian public's knowledge and understanding of biotech crops and the level of public acceptance of these crops. This is very important as it can support or hinder public adoption of this technology.

Thus, this study analyzes people's understanding, perceptions, and attitudes toward agricultural biotechnology products, especially biotech crops in Indonesia.

MATERIALS AND METHODS

Material

This study *was* carried out by survey method considering the limited time and cost. The research locations were chosen purposively, namely in the provinces on the island of Java, considering that Java is a center for the production and consumption of food crops, especially the provinces of West Java/DKI Jakarta, Central Java, and East Java. Other considerations in determining the location of the research include the existence of an institution connected to the Biotechnology Information Center (BIC), better public access to basic knowledge about biotechnology, and the data collection process which is expected to be easier during the COVID-19 pandemic.

The main data used are primary data supported by secondary data. Primary data was collected from respondents to research object samples which included *consumers, producers, extension workers, community leaders, policymakers, religious leaders, and scientists* by filling in data collection instruments in the form of questionnaires that were sent; interviews using a questionnaire and or *focus group discussion* (FGD). Meanwhile, secondary data was

collected through literature studies published offline and online. The method of collecting data through interviews using questionnaires is mainly done online due to the Covid-19 pandemic.

Data Analysis Method

The types of data collected for analysis include knowledge (whether they have heard of it, news sources, whether it is available in the market, whether they have consumed it, government or ulema regulations related to biotechnology), perceptions (responses to the product, its benefits, and impacts), and attitudes (whether they accept it or not, whether it is harmful or not, level of concern, whether they use it or not).

To answer the study objectives, several analytical methods were used including descriptive analysis, qualitative Likert scale analysis, and quantitative analysis. The PLS Structural Equation Model (SEM) was the quantitative approach employed in this investigation.

In developing this research model, there are several underlying theories. Bloom mentions three domains of behavior: knowledge, attitude, and practice (Notoatmodjo, 2018). The theoretical framework illustrates the relationship among these three, where knowledge refers to the information and understanding that individuals have about a topic, in this case, biotechnology. Furthermore, attitude or perception evaluates positively or negatively towards the object. In the context of biotechnology, attitude can encompass feelings, beliefs, and individual views on the use of biotechnology. Additionally, actual actions taken by individuals based on that knowledge and attitude manifest in behavior. In this context, behavior may involve the decision to adopt or reject biotechnology products.

PLS-SEM analysis steps include model conceptualization, analytical approach decision-making, resampling technique determination, path diagram creation, model assessment, and evaluation. The link between knowledge, attitude, and behavior is examined in this study utilizing the Structural Equation Modeling (SEM) model and the Partial Least Squares (PLS) approach. The Partial Least Squares (PLS) approach is a version of the Ordinary Least Squares (OLS) technique that addresses the drawbacks of regression analysis when data characteristics have constraints such as small data size, missing values, non-normal data distribution, and multicollinearity symptoms. PLS testing is carried out using SmartPLS 3.0. Variance-based SEM analysis allows for simultaneous structural and measurement model testing.

The testing steps begin with a descriptive study of the respondent profile, followed by a path diagram that depicts the links between latent variables and their indicators. The created model's parameters are then estimated. Several tests, including the Convergent Validity and Discriminant Validity Test, are used to investigate the relationship between the square root of the average variance extracted (AVE) and other latent variables in the model for each latent variable in order to find discrepancies between variables (Chin 1998). A latent variable is said to have good discriminant validity if the square root of its AVE exceeds the correlations with all other latent variables. It is recommended that the AVE value exceeds 0.50.

$$AVE = \frac{\sum \lambda i^2}{\sum \lambda i^2 + \sum i \; var(\varepsilon i)} \quad \ldots (1)$$

with λ_i is component loading to indicator and

Composite $var(\varepsilon_i) = 1 - \lambda_i^2$ Reliability, a metric for assessing hidden variables' consistency. If a latent variable's composite reliability is more than or equal to 0.7, it is said to have good reliability.

$$pc = \frac{(\sum \lambda i)^2}{(\sum \lambda i)^2 + \sum i\ var\ (\varepsilon i)} \quad (2)$$

with λ_i is component loading to indicator and

Evaluating the $var(\varepsilon i) = 1 - \lambda_i^2$

Structural Model

The endogenous latent variable's R-Square, which has the same meaning as the regression, is used to assess how well the data and model fit. When measuring the accuracy of a model's observed values and parameter estimations, structural models employ the Q-Square predictive relevance metric. Q-Square is calculated using the following formula:

$$Q^2 = 1-(1-R_1^2)(1-R_2^2)(R_P^2) \quad (3)$$

with R_1^2, R_2^2, ..., Rp^2 is the R-square of the equation model's endogenous latent variables. The magnitude of Q^2 has values with a range of $0<Q^2<1$, the closer to 1 (one), the better the model. Because PLS does not assume a normal data distribution, the path coefficient's significance level is determined using a nonparametric test. The underlying premise under H0 is that there is no link between the variables, but H1 indicates that there is a relationship between the variables. Next, examine the t (t-statistics) values produced by SmartPLS' bootstrapping procedure. The first hypothesis is rejected if the significance level is less than 5% or the t-value exceeds 1.96.

RESULTS AND DISCUSSION

Overview of Respondents' Socio-Economic Characteristics

Respondents in this study include several professions that have a close relationship with the object of study, especially biotechnology plants or food products. The number of respondents was 535 people from various backgrounds, such as *regulators*, farmers, agribusiness entrepreneurs, lecturers and researchers, religious and community leaders, NGOs, students, and consumers.

Of the 535 respondents to this study, more than half (60%) were women. The majority of respondents are married (53,0%). Age-wise, there is no dominant trend, however, 35,8% of all respondents are between the ages of 41 and 50. In terms of education level, in total it shows that the education level of the respondents is mostly diploma to postgraduate (> 80%). Farmers and students, quite a lot of them have high school education levels because of student professions, some of them are still studying at the undergraduate level in addition to currently studying postgraduate studies. For consumers and the government, the level of education varies more from high school to post-graduate levels but is dominated by bachelor's degrees (Table 1).

Knowledge of Plant Biotechnology

Until now, the legal base for the commercialization of Genetically Engineered Products (PRG) in Indonesia is available due to the Ministry of Agriculture's Agency for Agricultural Research and Development has not completed the Guidelines for Monitoring and Control of PRG according to PP No. 21/2005. So the farmers have not been able to plant this biotechnology crop. Thus,

PRG commodities consumed by the public still come from imports. So far, including drought-resistant rice, salt-resistant rice, high-productivity rice, virus-resistant tomatoes, and tomatoes with few seeds.

Public knowledge about plant biotechnology is still very limited. This is shown in Table 2, of the respondents only a small proportion knew about biotechnology crops. Furthermore, from that little, only a small portion knows the topic in question.

Table 1
Respondents' Education Level

Level of education	Senior High School	Diploma	Bachelor	Postgraduate
Percentage	12,68	5,43	40,98	34,98

Table 2
Respondents ' Knowledge and Adequacy of Information on Biotech (%)

Respondent type	Adequate	A little	Uninterested	Nothing but interested	Nothing, not interested
Knowledge	21,47	69,78	2,58	5,96	0,20
Adequacy level of information	18,89	72,36	2,58	5,96	-

Sources of Biotechnology Information

For some respondents who have access to information, most of the information sources they access are social media, scientific writings and seminars, and print and electronic media. Social media information sources are the most accessed by all respondents. This trend illustrates that stakeholders get a lot of information from social media and then attendance at seminars is the next most accessible source of information (Figure 1). This source of information has changed and developed compared to the results of previous studies (Hossain *et al*. 2003).

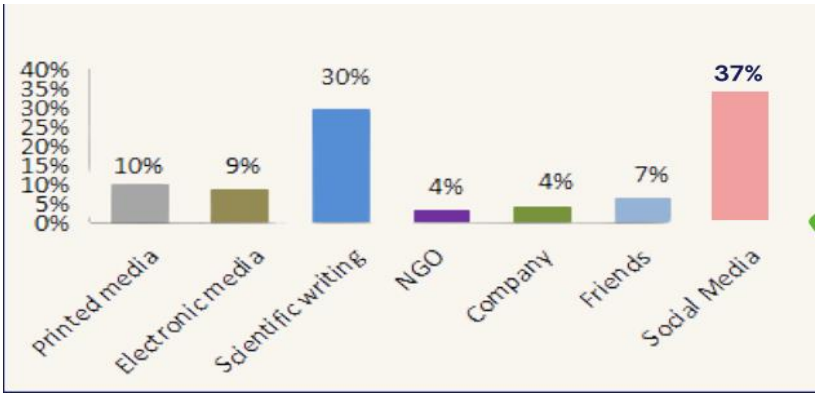


Figure 1
Biotech Information Resources

Knowledge of Biotech Products

In respondents' knowledge about whether there are agricultural/food products produced from biotechnology in local/regional/national markets, most said there were (82,0%). Other than saying don't know and nothing (Table 3).

The biotech products are soybeans (32,5%), corn (29,6%), rice (18,03%), and potatoes (12,3%). Most of the respondents knew that these biotechnology products came from abroad/imported (46%) and some said they came from within the country (39%). While there is widespread support for the use of biotechnology in plants and optimism for it generally, empirical findings from other studies indicate that public acceptance of its application in animals may be less (Torres 2006).

Figure 2, shows that some respondents stated that they had eaten or used these biotechnology products (60,3%). The main reason for using biotechnology products is for consumption (53,1%).

Table 3
Presence of Biotech Products in the Domestic Market (%)

Respondent's type	There is	There aren't any	Don't know
Total	82,00	3,20	14,80

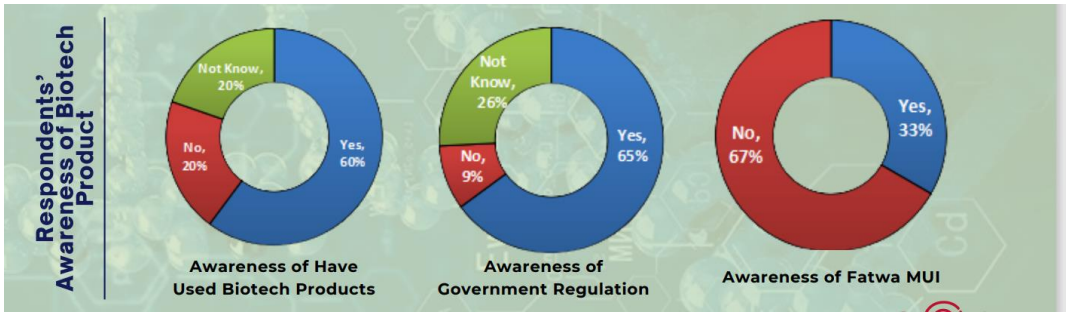


Figure 2
Awareness of Biotech Product

Stakeholder knowledge of whether the government regulates and supervises the commercialization of biotech crops to the market and most of the answers obtained say that they know (64.96%). The rest said they did not know and a small number said the government did not regulate.

Furthermore, when asked whether they knew that the Indonesian Ulema Council issued Fatwa Number 35 of 2013 related to biotechnology, most stakeholders stated that they did not know (66,67%). Although most academics do not know and only agribusiness entrepreneurs claim to know about the fatwa.

Respondents' Perceptions of Plants and Food Biotechnology

When asked about the opinions of respondents regarding the development of biotech crops or food, they generally agreed and strongly agreed. Most of the entrepreneurs and farmers stated that they strongly agreed and agreed. While consumers,

lecturers-researchers, students, and the government mostly agree and strongly agree (Figure 3). Besides that, the Indonesian Ulema Council (MUI) has also issued a fatwa related to biotechnology. The contents of the MUI Fatwa Number 35 of 2013 regarding biotechnology, state that genetic engineering (biotech) is permissible and the engineered products are halal *with conditions; (a)* useful; (b) does not harm humans and the environment and (c) does not use genes or other parts that come from the human body and are unclean. The MUI Fatwa, the majority of respondents agreed and strongly agreed with the fatwa (Figure 3).

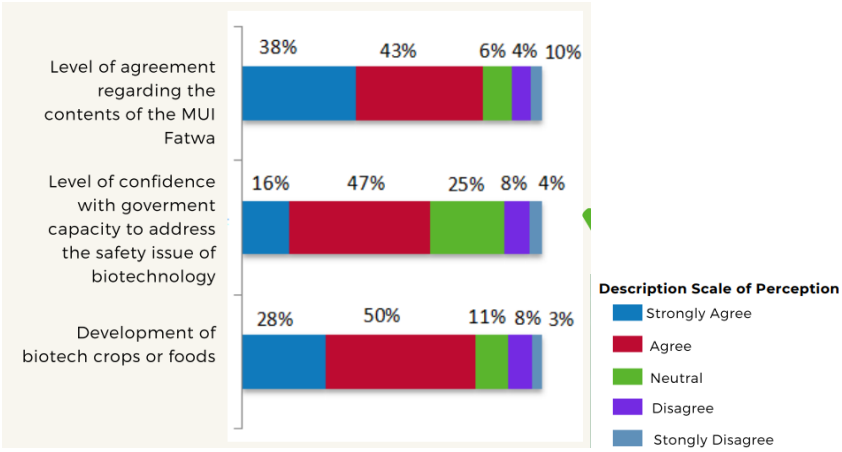


Figure 3
Respondents' responses regarding the development of biotechnology plants

The positive opinion of the majority of respondents regarding the development of biotech crops is related to their level of confidence in the ability and capacity of the Government to deal with the safety issues of biotech crops. Most respondents said they believed that the government could handle the issue of biotechnology safety.

Then, the assessment of the views of the respondents continued to the superiority of the biotechnology plants. Respondents' perceptions regarding the reliability of biotechnology plants can increase productivity, so most believe and believe. But there are still those who don't believe it, and the number is indeed very small but it is spread among each group of respondents. It is understandable that because none of these biotechnology products have been commercialized, so there is no real evidence in Indonesia that can be shown, except that they are still only the results of small-scale trials and not exposed to the public.

Attitudes towards Agricultural Biotechnology

In the respondent's assessment of whether biotech crops have a negative impact or not, the results show that almost half (45.9%) rated it as neutral (Table 4). This means that there are doubts from respondents about the safety of biotechnology products because only 8,9% strongly disagree that biotechnology products have a negative impact and only 8,2% say that the use of agricultural biotechnology is really dangerous.

Table 4
Biotechnology hurts human health (%)

Respondent's type	Strongly agree	Agree	Neutral	Don't agree	Strongly disagree
Total	8,18	19,36	45,91	17,56	8,98

Table 5
Respondents' Acceptance of Biotech Products (%)

Respondents	No	Not Sure	Yes
Total	3,95	20,37	75,68

Respondents' Responses in Receiving and Purchasing Biotechnology Products From the previous perception, the question leads to stakeholder attitudes. They partially refused, reasons based on suspicion of negative health effects (36 %), and felt that information about biotech products was unclear (25 %).

Based on the knowledge and perceptions that have been conveyed by the respondents, the majority of respondents will accept and buy food crop commodities or food made from biotechnology food plants. Furthermore, some were still unsure and a small number said they did not accept it (Table 5).

Respondents who "No or Not Sure" will accept/buy biotechnology products spread across all groups of respondents. Their reasons are relatively varied, but most of them are related to religion and further fear of hurting health. Furthermore, when asked respondents who believe and accept these biotechnology products, their main reason is that these products do not conflict with religion and believe that these products are also safe for health.

PLS Structural Equation Modeling (SEM) Analysis Evaluation of Measurement Models

Convergent Validity

The loading factor value (standardized loading) can be used to test the item's reliability (indicator validity). This factor loading is defined as the magnitude of the correlation between each indicator and its latent variable. A loading factor value greater than 0,7 is considered optimal, indicating that the indicator is valid as a measure of latent variables.

Standardized loading factor values indicate indicators validity tests in measuring each variable. There are several indicators whose value is <0,7 so they must be reduced from the model. Furthermore, re-estimating the model after being reduced produces a valid indicator.

Figure 4 shows the results of the structural model with standardized loading factor values in the invalid indicator reduction model. This figure shows that the standardized loading factor for each indication is more than 0,7. This signifies that the indicators in the model are valid as a measurement instrument for latent variables and so can be utilized for modeling.

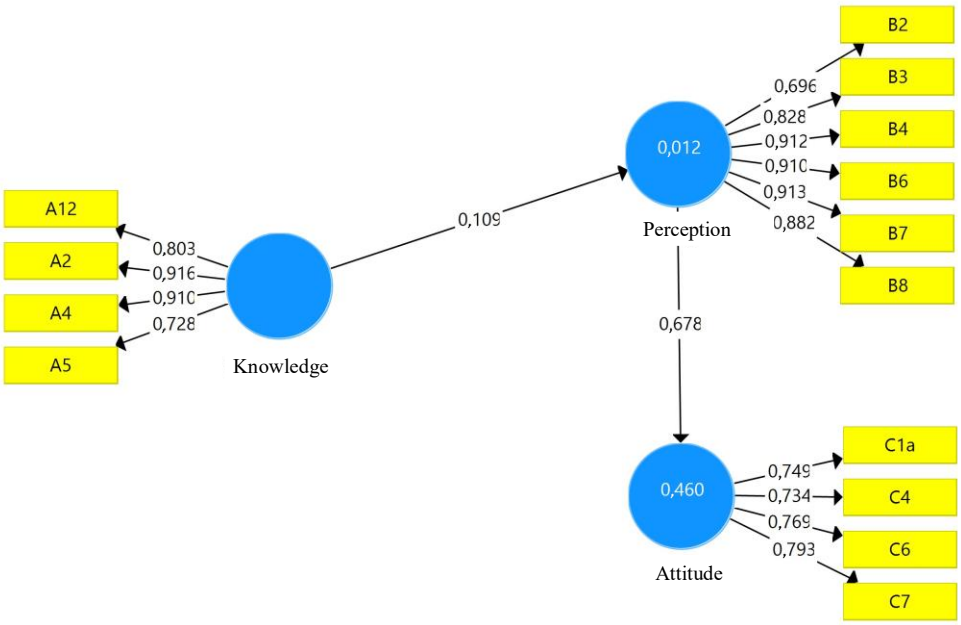


Figure 4
Standardized loading factor in the indicator reduction model

Table 6
Results of Direct Effect

Latent Variable Relations	Original Samples	Standard Deviations	T-Statistics	P-Values
Knowledge -> Perception	0,109	0,053	20,44	0,042**
Perception -> Attitude	0,678	0,026	26,082	0,000**

Note: **: Significant at the 5% level
*: Significant at the 10% level

Structural Model Evaluation

The structural model describes the relationship between exogenous latent variables (X) and endogenous latent variables (Y) or the relationship between endogenous variables (Y) and other endogenous variables. The table below shows the results of calculating the structural model's standardized path coefficients.

Based on Table 6, the following conclusions can be drawn:

1. The Knowledge variable has a 5% significant effect on Perception, with a positive estimation efficiency value of 0,109 in the original sample. It is reasonable to suppose that any gain in a person's knowledge will boost their perception.
2. At a 5% significance level, the perception variable has a significant impact on attitude, with a positive estimation efficiency value of 0,678 (original sample). It is possible to conclude that any increase in a person's perception will increase their attitude.

Model Goodness Test

Evaluation of the Coefficient of Determination (R^2)

To assess the structural model, apply the determinant coefficient (Test R^2). The R-squared value (R^2) is used to determine how much influence specific independent latent variables have on the dependent latent variable (Ghozali, 2012).

Table 7
R-Square values in the Structural Model

Latent Variables	R-Square
Perception	0,012
Attitude	0,460

Based on the Table 7 above, it can be described as follows:

1. The Perception variable has an R-Square value of 0,012, indicating that the Knowledge variable explains 1,2% of the variance, while other variables outside the model account for the remainder.
2. The Attitude variable has an R-square value of 0,460, indicating that the Perception variable explains 46% of the variance, while other variables outside the model account for the remainder.

Evaluation of Predictive Relevance (Q^2)

The overall R^2 value is used to determine Predictive Relevance (Q^2). To validate the model, we use the Q^2 value. If the Q^2 value is larger than 0,5, the model has good predictive validity. The value of Predictive Relevance (Q^2) is written as follows:

$$Q_2 = 1 - \{(1 - R_1)(1 - R_2)\}$$
$$= 1 - \{(1 - 0{,}988)(1 - 0{,}539)\}$$
$$= 0{,}994$$

From the calculation above, it is obtained that the value of Q^2 = 0,994 is greater than 0,5**,** meaning that the model in this study *has* a fairly good predictive relevance.

Goodness of Fit

The goodness of fit (GoF) method was utilized to validate the model as a whole, as described by Tenenhaus et al. (2004). The GoF index is a single metric used to validate the combined performance of the measurement and structural models. The GoF value is calculated by multiplying the average communality index by the model's R^2 value. GoF scores of 0,1; 0,25, and 0,38 indicate that the structural model is weak, moderate, or good. The goodness-of-fit model calculation yields the following results.

Table 8
Results of Goodness of Fit

Latent Variables	**Average Variance Extracted (AVE)**	**R-Square**
Knowledge	0,710	
Perception	0,740	0,012
Attitude	0,580	0,460
AVERAGE	0,677	0,236
GoF	**0,400**	

According to Table 8 above, the GoF value is 0,400, which classifies it as moderate GoF because it is near 0,38, indicating that the model is quite good at describing empirical data.

Managerial Implications

This research produces several managerial implications that can be applied to address existing issues. The problem encountered is the lack of public knowledge about biotechnology, which can be addressed with alternative strategies through increased information dissemination, both via conventional media and digital media such as AI. Companies should prioritize awareness and educational campaigns to improve public knowledge about biotech crops, focusing on their benefits and safety. This information dissemination needs to start from elementary school children to university students. Additionally, engaging with farmers, consumers, and policymakers is crucial to addressing concerns and misconceptions about biotech crops, and fostering a more informed public dialogue. These alternative strategies are the result of analysis and alternative business model approaches.

Another managerial implication regarding attitude issues relates to the government. companies should advocate for policies that support the research, development, and adoption of biotech crops, ensuring that regulations are based on scientific evidence.

Moreover, aspects of risk communication also need to be developed. Developing effective communication strategies to convey the safety and advantages of biotech crops can help mitigate public concerns and enhance acceptance. This includes concerns about compliance, such as producers properly labeling their products, and allowing consumers to choose whether or not to purchase biotech products. The implications of these issues will enhance stakeholder trust in both the government and producers of biotech products. This can be achieved by companies through clear regulations from the government and by meeting consumer rights and needs."

CONCLUSION

In Indonesia, public understanding, views, and attitudes about the adoption of biotechnology goods remain mostly limited. This limitation is because they have low exposure to information sources. In accessing this information, they use social media sources and interpersonal communication. Even though their knowledge of biotech was small, (1) almost all of them were interested in knowing more about biotech products, and (2) most of them stated that they were aware and confident that they had already used products suspected of being imported biotech products such as soybeans and corn. The reason for respondents using biotech products is that these biotech products have more positive benefits than negative ones for health and the environment. In addition, to the knowledge of respondents, the government has regulated and supervised the commercialization of biotech products in Indonesia.

Furthermore, the perceptions and attitudes of respondents are more favorable towards agricultural biotechnology. Positive perceptions regarding the development of biotech products are shown by the answers of the majority of respondents who agree to strongly agree, because (1) they believe in the government's capacity to oversee the commercialization of biotech products, although there are

still quite several respondents who do not and do not believe (37%); (2) development of biotech products under the guidance of the MUI fatwa; (3) believe that biotech products can increase the productivity performance of farming and agro-industry.

Based on the SEM analysis, it shows that significantly the attitude of respondents in accepting biotech products is influenced by their perceptions where these perceptions are significantly influenced by their knowledge. To further increase public knowledge of these biotechnology products, it is necessary to further enhance biotech communication in various media by creating analytical content. This will help to understand why certain sources of information have favorable or negative perspectives and attitudes regarding biotechnology. Communication techniques to encourage the adoption of agricultural biotechnology must focus on biotech products that are safe, cost-effective, nutritional, and useful.

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