

Balinese Perception on Acceptance of Biotechnology and GM Crops

Dase Hunaefi^{1,3,4} M. Syaefudin Andrianto^{2,*} Yuli Sukmawati³

Puput Noerfitriani Muzzayyanah⁴

¹ Department of Food Science and Technology, FATETA, IPB University

² Department of Management, FEM, IPB University

³ SEAFast Center, LPPM, IPB University

⁴ International Collaboration Office, IPB University

* Corresponding author. Email: syaefudin1@apps.ipb.ac.id

ABSTRACT

Genetically Modified (GM) crops for cultivation actually has been applied in many countries including Indonesia. However, sometimes facing limited acceptance by consumers because of some reasons. Bali one of the Indonesian strategic islands with agricultural local wisdom also has controversial perceptions about the effects of Biotechnology and GMOs. The Bali Provincial Government issued Regional Regulation No. 8 of 2019 with an organic agricultural system, which prohibits the use of seeds derived from the genetically modified organism in accordance with the rules of SNI Organic Farming System 6729 of 2013. This study aims to assess the role of awareness to increase acceptance of Biotechnology and GMOs in Bali. This is surveyed due to the fact that Bali is the only province in Indonesia that issued the organic farming regulation. There were 100 respondents had surveyed. To test the proposed hypotheses, Structural Equation Modelling using Partial Least Square (SEM-PLS) is applied. The results of this study can be input for policymakers as well as stakeholders who are concerned about Biotechnology and GMO adoption. The results showed that despite the Bali provincial regulation, most respondents are still open to transgenic. The respondents need assistance in terms of transgenic adoption to support the organic system. Public Bali's knowledge about the superiority of transgenic over nonorganic agricultural products and transgenic is organic will affect the trend in the future, especially to improve than conventional products and be ecofriendly and more sustainable. It is implicitly that we have to revisit the standard SNI Organic Farming System 6729 in 2013 to reconsider the exclusion of transgenic.

Keywords: *Farmers, Consumers, Risk/Benefit Perception, Knowledge.*

1. INTRODUCTION

According to [1], Indonesia's population will grow by 1% in 2020 compared to 2019. Along with population growth, there will be an increase in food requirements. Food security is inextricably linked to the agricultural sector. Indonesia's agricultural sector is confronted with a number of challenges, including shrinking land area, pest and disease attacks, and low productivity. This reinforces the importance of plant breeding in order to develop plant varieties that are both productive and resistant to pests and diseases.

Plant breeding is both an art and a science that focuses on the improvement of characters in plants that are inherited genetically from one population to the next [2]. The plant breeding program's objective is to develop plant

varieties with beneficial or desirable characteristics for the community. Plant breeding entails confinement, cross-breeding, and selection. Plant breeding begins with germplasm collection as a source of diversity. Following collection, the second step is to identify and characterize plant morphology and physiology. Thirdly, diversity is induced through crosses, and then the desired characters are selected. Following the development of superior plant varieties, testing and evaluation are conducted. This process is known as conventional plant breeding.

Conventional plant breeding has a number of limitations and disadvantages. This is because traditional breeding selection is made on the basis of morphological and phenotypic characteristics. Because morphological

characteristics are an expression of the interaction between genetics and environment, diversity is extremely high and environment-dependent [3]. This results in inconsistency in the character, which frequently results in a change in the character of the offspring and can result in incorrect line selection. Apart from these inconsistencies, conventional plant breeding requires a significant amount of time and land. This is regarded as a less effective and efficient method.

Plant breeding using molecular markers is carried out on the basis of genes that control a trait or character. A marker is a characteristic or trait that can be inherited or passed on to offspring. When compared to conventional breeding, this is expected to be more effective and efficient. This is because molecular markers are influenced exclusively by plant genetics, which is constant and unchanging.

Transgenic plants are more commonly used to refer to plants that have had their genetic material modified. Globally and in Indonesia, research on transgenic plants has accelerated. The Indonesian government has enacted a number of regulations to foster the development of transgenic crops. Despite the fact that processed foods derived from transgenic plants, such as tempeh, have been widely distributed in the community, many people are unaware of these transgenic plants. Public perception and education about transgenic plants will influence people's attitudes toward their acceptance.

The Bali Provincial Government issued Regional Regulation No. 8 of 2019 with an **ORGANIC AGRICULTURAL SYSTEM**, which prohibits the use of seeds derived from genetically modified organisms in accordance with the rules of SNI Organic Farming System 6729 of 2013. This certainly piques researchers' interest in determining the extent to which the community understands the organic farming system. An organic system is defined broadly as an agricultural cultivation system that is free of pesticides. However, the uniqueness, as defined in SNI Organic Farming System 6729 Year 2013, serves as a reference for the Bali Regional Regulation to include a statement in the Regional Regulation's contents that the organic farming system does not use seeds derived from genetically modified organisms (GMOs), as defined in SNI Organic Farming System 6729 Year 2013. Interestingly, this is obviously detrimental to the overall implementation of biotechnology in Indonesia. This demonstrates the importance of *revising or updating the definition of an organic farming system*. This is also interesting to observe in terms of the Balinese people's perceptions of organic farming and transgenic biotechnology.

This study aims to determine the knowledge and perceptions of the community to the Regional Regulation No. 8 of 2019 on organic agricultural system, and its influence on people's attitudes towards the acceptance of transgenic plants in the Bali Province.

2. MATERIALS AND METHODS

2.1. Variables

2.1.1. Acceptance

The use of transgenic plants continues to generate debate in society. The community debated the benefits and drawbacks of these transgenic plants [4]. The pro-GMO crop group stated that genetic engineering has limitless potential for resolving food shortages, producing plants with high nutritional value, and reducing pesticide use. The group opposed to transgenic plants asserts that they will disrupt natural ecosystems and that their safety is unknown [5].

Positive (accept) or negative (reject) attitudes toward an object are possible. Each person's attitude toward an object can be unique because it reflects their judgment, feelings, and actions toward that object. This distinction is due to individual differences in comprehension, experience, and considerations. A person's attitude can only be determined through their behavior. The willingness of an individual to act/ behave is always accompanied by feelings of pleasure or displeasure, sympathy or anticipation [6].

2.1.2. Knowledge and perception

Knowledge arises as a result of humans sensing an object using their five senses. According to [7], knowledge-based behavior outlasts non-knowledge-based behavior. Perception is a social psychological phenomenon that determines an individual's involvement in developmental dynamics and plays a strategic role [8]. As a result, public perception and knowledge about transgenic plants have a significant impact on the adoption of this technology. This understanding of public perception and knowledge can aid in the dissemination of genetically modified organism crop technology.

Perception is a factor in determining an individual's attitude toward transgenic plants acceptance. As a result, it is critical to consider the factors that influence perception. According to [9] perception is influenced by two groups: (1) Frame of Reference, which refers to a frame of mind acquired through education, reading, research, or other means, and (2) Field of Experience, which refers to self-experience. Perception is influenced by two factors [10]: (1) internal factors such as feelings, prejudices, hopes, concerns, interests, individual characteristics, learning processes, physical conditions, psychiatric disorders, values, and motivation, and (2) external factors such as family background, knowledge, obtained information, intensity, size, and repetition of motion.

Additionally, knowledge can influence how people feel about transgenic plants. The two factors that affect a

person's knowledge are internal and external factors [11]. Education, occupation, and age are all internal variables. The environment and sociocultural system are examples of external factors.

Along with perception and knowledge, economic considerations should be made when it comes to the spread of genetically modified crops. From an economic standpoint, public policy, producer expectations, and consumer demand all have an effect on people's attitudes [12]. Farmers in Kenya are willing to accept genetically modified crops due to their perceptions of risk and benefit [13]. Along with economic perceptions, people's attitudes are influenced by long-term factors such as the environment, health, morals, ethics, and religion.

Numerous researchers have conducted research on public perceptions of transgenic plants. The importance of attention/focus in influencing perceptions regarding transgenic plant acceptance was highlighted in [14]. The risks associated with transgenic plant development were investigated in [15]. This is consistent with [16], which reported that risk factors were a significant factor in transgenic plant rejection.

2.1.3. Regulation

Biotechnology is a developing applied science. Biotechnology is defined as the application of biological principles, systems, and processes to engineering for the benefit of humans [17]. Biotechnology has been used to develop superior crops and foods. Superior plants are those that exhibit beneficial characteristics for the community. The food in question possesses nutritional value, flavor, functionality, shelf life, and other characteristics as a result of the addition of enzymes, microbes, or transgenic plants and animals [18].

Biotechnology techniques are classified into two categories: conventional and modern biotechnology. The term "biotechnology" refers to the broad application of microorganisms. Biotechnology in the modern era is inextricably linked to genetic engineering, which seeks to increase plant productivity and improve plant properties [19]. Typically, researchers apply genetic engineering techniques at the gene level. Genetic engineering techniques based on a single gene were used to assemble pest- and disease-resistant plants [20]. Transgenic plants are plants that have been genetically modified.

According to the Republic of Indonesia's Government Regulation No. 21 of 2005, genetically engineered products are living organisms, their components, and/or processed products that have a new genetic composition as a result of the application of modern biotechnology. The altered genetic arrangement is the result of altered gene expression or the integration of desired genes into the plant genome. These genes of interest may originate in fungi,

bacteria, viruses, insects, animals, or other plants [21], [22], [23].

Prior to granting a permit for the release of a transgenic plant, several stages are required, including food safety, feed safety, environmental safety, and halal compliance. Since 2004, there have been regulations governing the biosafety of transgenic plants. These regulations include the following:

1. Law Number 21 of 2004
2. Government Regulation No.21 of 2005
3. Law No. 32 Year 2009
4. Law No.18 of 2012
5. Regulation of Minister of Environment No.25 of 2012
6. Regulation of the Minister of Agriculture No.36 of 2016
7. Regulation of the Head of the POM Agency No. 6 of 2018 MUI Fatwa No. 35 of 2013

This research has the hypothesis that (H1) Knowledge and perception affect acceptance, (H2) regulation effect on acceptance and(H3) regulation will reinforce acceptance on Biotechnology by increasing knowledge and perception (Figure 1). Description of variables are presented on Table 1.

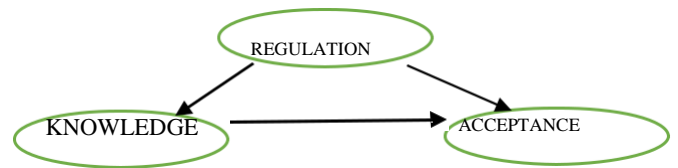


Figure 1 Biotechnology acceptance model

2.2. Data Collection

The study of public perceptions and knowledge about transgenic plants in Bali Province was conducted via an online survey due to time and financial constraints. As a result, the research location was purposefully chosen, specifically in the province of Bali, which is the only region in Indonesia to have a policy regarding organic plants (Regional Regulation No. 8 of 2019).

Additionally, the Province of Bali, the study's location, is one of the areas where agriculture is critical to the economy. In 2020, agriculture will account for 15.46 percent of Gross Domestic Product (GDP). In the province of Bali, plantation crops accounted for 1.93 percent of total output. Bali's agricultural Gross Regional Domestic Product (GRDP) increased by 0.2% in 2020, compared to 2019. This demonstrates the critical role of agriculture in strengthening the national economy. This study lasted approximately three months, from July to September 2021. The research time period encompasses the process of planning and implementing research, as well as the preparation of proposals and data collection instruments, as well as the process of collecting, processing, and analyzing

Table 1. Coding and description of knowledge and acceptance variables

Code	Variables
Knowledge & Perception	
KN1	Do you know about organic and non-organic farming systems in Bali?
KN2	Have you ever heard/knew about biotechnology products or transgenic plants?
KN3	Do you know that transgenic plants have been implemented in Indonesia, especially in the province of Bali?
KN4	Do you know about organic agricultural products as well as transgenic plants?
KN5	Do you know the benefits/advantages of transgenic plants compared to non-organic agricultural products?
Regulation	
RG1	Are you concerned about regulations/policies, especially the Regional Government regarding the Agricultural System in the Province of Bali?
RG2	Do you know the regulations/regulations/policies of the Government of Bali regarding organic agricultural products, including in this case the exclusion of transgenic plants?
Variable Acceptance	
AC1	Do you agree that organic farming is better than non-organic farming?
AC2	In your opinion, are GM crops superior and have many benefits compared to conventional agricultural products?
AC3	In your opinion, is the use of biotechnology in agricultural commodities supportive and environmentally friendly?
AC4	In your opinion, can the use of biotechnology in agricultural commodities become a trend in future agricultural systems?
AC5	In your opinion, can Bali become one of the pilot areas for the application of biotechnology to agricultural commodities?

data, as well as the process of writing a report on the findings. Primary data were collected from a sample of respondents who were the subject of the research, including public perceptions and knowledge of transgenic plants, via a questionnaire sent via Google Forms; and a webinar/focus group discussion (FGD). Secondary data is gathered through a review of the literature or a review of the literature pertinent to the study. The data collection method was used twice, prior to and during the webinar's implementation. Prior to the webinar's implementation, a survey of the entire province of Bali was conducted, but after the webinar, respondents focused on only two areas. Buleleng Regency and Udayana University/Denpasar City were the institutions. Primary data were collected from respondents in accordance with the study's purpose, and Questionnaires were distributed to respondents using Google Forms which can be accessed at: <https://ipb.link/biotechnology-bali>.

2.3. Sampling Methods

The sample that becomes the respondent is part of the observed population and is a collection of sample units. Based on data from the Central Statistics Agency (BPS) for the province of Bali in 2021, the population of Bali is 4,317,404 people (2020) with the majority being ethnic Balinese. In this study, the target population is the community, academics, farmers, and stakeholders related to agriculture in Bali, where the study is carried out, where the sampling unit or unit of analysis is the individual.

In this survey, respondents are selected using a non-probability sampling technique combined with a purposive sampling technique. Purposive sampling is a sampling technique in which researchers select samples based on their specific characteristics and their ability to address research problems (Etikan et al. 2016). The Slovin formula is used to determine the required number of respondents:

$$N \text{ (sample respondents)} = \frac{N}{1 + N \cdot e^2}$$

Nota bene: n denotes the sample size.

N denotes the population size.

e = maximum fault/error tolerance (10 percent)

The required sample size (number of respondents) is at least **100**, using the Slovin formula as a population size.

2.4. Data Analysis Methods

Numerous analytical techniques were used in the research, including descriptive analysis, qualitative analysis using the Likert scale, and quantitative analysis.

2.4.1. Descriptive Analysis

Descriptive analysis, and particularly descriptive statistics, is an analytical technique for explaining, summarizing, reducing, simplifying, organizing, and presenting data in an orderly fashion. It is straightforward to read, comprehend, and conclude. In general, this descriptive analysis entails three components: frequency distribution, central tendency measurement, and variability measurement. The descriptive analysis presents the data in the form of tables, diagrams, and graphs. This is to aid in the comprehension of the data presented.

In this study, descriptive analysis was used to examine the characteristics of the respondents and to analyze their knowledge, perceptions, and attitudes toward transgenic plants, particularly in the province of Bali.

2.4.2. Likert Scale Qualitative Analysis

The Likert scale analysis technique is used to ascertain an individual's or group's attitudes, opinions, and

perceptions about social phenomena. The Likert scale is a scale of measurement invented by Likert (1932). The Likert scale consists of four or more questions that are added together to create a score/value that represents individual characteristics such as knowledge, attitudes, and behavior. Because each question item indicates the variable it represents, the sum of all questions is valid.

The Likert Scale results are classified ordinally, and some are organized on an interval scale. To begin, the Likert scale is categorized as an ordinal scale. The Likert scale's response categories have levels, but the distance between them cannot be considered equal; thus, the Likert scale is an ordinal scale class. If the statistical

analysis is incorrect, the likelihood of the conclusion being incorrect increases as well. If the Likert scale is regarded as an ordinal scale, the mean and standard deviation are incorrectly calculated. The questionnaire in this study used a Likert scale of 1-5 to calculate the score (**1. Strongly disagree; 2. Disagree; 3. Uncertain; 4. Agree; 5. Strongly agree**).

Structural Equation Model Analysis or SEM PLS

The structural equation model (SEM) is a popular multivariate research technique in economics and management because it is an effective technique for identifying causal relationships between variables. This model enables social science researchers to conduct path analysis on latent variables. This analysis is frequently referred to as multivariate analysis's second generation. The advantage of SEM over the first generation of multivariate is that it allows researchers to more easily relate theory to data. SEM encompasses a number of critical terms, including manifest variables, endogenous variables, exogenous variables, endogenous latent variables, and exogenous latent variables.

Due to the fact that SEM is based on covariance analysis, it produces a more precise covariance matrix than linear regression analysis. The SEM technique is used to analyze the data in order to explain the overall relationship between the variables in the study. SEM with PLS estimates the value of the latent variable by linearly combining the manifest variables associated with the latent variable and the action used to replace the manifest variable. SEM with PLS is composed of three components: structural models, measurement models, and weighting schemes. This third component is unique to SEM with PLS and is absent from covariance-based SEM.

In the initial model measurement, it is necessary to analyze convergent validity (loading factors must be > 0.7), internal reliability (Composite Reliability and Cronbach's alpha for exploratory research > 0.6), and discriminant validity indicated by Average Variance Extracted (AVE) >0.5 and the indicator weight (weight) must be statistically significant and the Variance Inflation Factor (VIF) less than 3.3. Meanwhile, the structural model is measured from R square. Value 0.75;

0.50; 0.25 can be interpreted as substantial, moderate, and weak.

3. RESULTS AND DISCUSSION

3.1. Characteristics of Respondents

The study gathered 100 respondents from the province of Bali with main respondents are Agricultural Extension worker and students (Table 2).

Table 2. Characteristics of respondents by type of work

Occupation	Percentage
Lecturer	3
Teacher	3
Student	29
Agricultural Extension	40
Farmer	13
Civil Servant	11
Unemployment	2
Total	100

About agricultural awareness, only half respondents knowing about main Bali Agricultural product (55%). Majority know (72%) and agree that organic farming better than conventional (89%).

Related with biotechnology, they know about biotechnology product or transgenic plant (78%), benefit of transgenic plant (68%) and biotechnology/transgenic product have been implemented in Indonesia (58%). Although transgenic plants have superiority compare to conventional (68%), it also has disadvantages perception (66%). Biotechnology in agricultural is believed supportive and environmentally friendly (75%) and become trend in the future (83%) and Bali can become pilot project application of Biotechnology (78%).

Connected with regulation, only half of respondents know about local regulation (Regional Regulation No. 8 Year 2019) (53%) and concern about this local regulation (58%). Perception respondents on awareness organic farming, transgenic plant and regulation presents on Table 3.

3.2. Analysis of the Relationship between Knowledge and Acceptance of GMO Products

In the initial stage, three indicators were eliminated, namely KN1, AC1, and AC5. After elimination and recalculation, it produces an acceptable Outer loading (Table 4). Composite reliability, Cronbach alpha are above 0.7 as well as AVE above 0.5 (Table 5) and final

Table 3. Descriptive perception

Kode	Variables	1	2	3	4	5	Total Score	Conversion (%)
KN1	Do you know about organic and non-organic farming systems in Bali?	9	5	31	29	26	358	71,6
KN2	Have you ever heard/knew about biotechnology products or transgenic plants?	5	4	14	45	32	395	79
KN3	Do you know that transgenic plants have been implemented in Indonesia especially in the province of Bali?	1	2	40	24	5	292	58,4
KN4	Do you know about organic agricultural products as well as transgenic plants?	9	1	46	25	10	317	63,4
KN5	Do you know the benefits/advantages of transgenic plants compared to non-organic agricultural products?	7	1	34	30	18	341	68,2
RG1	Are you concerned about regulations/policies, especially the Regional Government regarding the Agricultural System in the Province of Bali? (Regional Regulation No 8 Year 2019)	1	2	32	17	14	294	58,8
RG2	Do you know the regulations/regulations/policies of the Government of Bali regarding organic agricultural products, including in this case the exclusion of transgenic plants?	1	2	41	14	3	265	53
AC1	Do you agree that organic farming is better than non-organic farming?	1	1	9	28	61	447	89,4
AC2	In your opinion, are GM crops superior and have many benefits compared to conventional agricultural products?	5	9	46	30	10	331	66,2
AC3	In your opinion, is the use of biotechnology in agricultural commodities supportive and environmentally friendly?	1	4	34	41	20	375	75
AC4	In your opinion, can the use of biotechnology in agricultural commodities become a trend in future agricultural systems?	1	3	14	43	39	416	83,2
AC5	In your opinion, can Bali become one of the pilot areas for the application of biotechnology to agricultural commodities?	1	0	32	40	27	392	78,4
AC6	In your opinion, are there any disadvantages of using agricultural biotechnology/GMO crops/transgenic plants)	5	9	46	30	10	331	66,2

Table 4. Initial and last model measurement

Code	Acceptance	Knowledge	Regulation	Acceptance	Knowledge	Regulation
AC1	0.449					
AC2	0.724			0.775		
AC3	0.716			0.763		
AC4	0.787			0.794		
AC5	0.520					
KN1		0.537				
KN2		0.805			0.819	
KN3		0.736			0.773	
KN4		0.836			0.863	
KN5		0.840			0.867	
RG1			0.672			
RG2			0.942			1.000

Table 5. Composite Reliability, Cronbach’s Alpha, AVE

	Cronbach’s Alpha	Rho_A	Composite Reliability	Average Varian Extracted
Acceptance	0.676	0.680	0.821	0.605
Knowledge	0.852	0.879	0.899	0.691
Regulation	1.000	1.000	1.000	1.000

model result (Figure 2). R Square adjusted for acceptance and knowledge have value 0.25 and 0.39 indicate model weak and moderate.

Based on the path analysis it can be concluded that acceptance of GMO was affected by knowledge and regulation was not significant effect (Table 6). However, based on total effect, that can be concluded regulation reinforcement acceptance via knowledge (Table 7).

The respondents agree in the future biotechnology in agricultural system can be a trend (AC4), supportive and eco-friendly (AC3) and have many benefits (AC2). However, it should be supported by knowledge about benefit of GMO (KN5), organic product as well as transgenic plan (KN4), transgenic plants have been implemented in Indonesia (KN3), and transgenic products (KN2)>

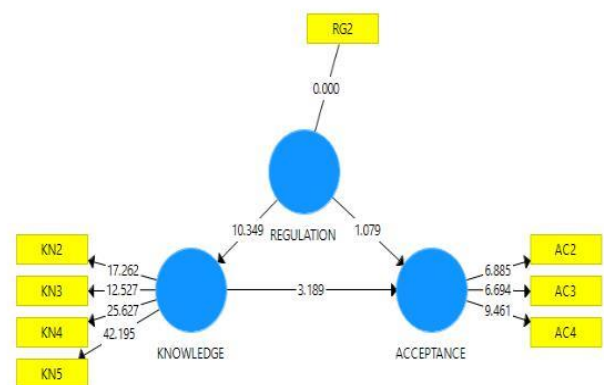


Figure 2. Final model result

Table 6. The Path Coefficient of knowledge, regulation and acceptance

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
Knowledge-> Acceptance	0.411	0.426	0.133	3.092	0.002
Regulation → Acceptance	0.124	0.117	0.118	1.051	0.294
Regulation → Knowledge	0.624	0.624	0.054	11.529	0.000

Table 7. Total Effect knowledge, regulation and acceptance

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
Knowledge -> Acceptance	0.411	0.426	0.133	3.092	0.002
Regulation -> Acceptance	0.380	0.3.82	0.101	3.779	0.000
Regulation -> Knowledge	0.624	0.624	0.054	11.529	0.000

4. CONCLUSION

According to the results of a survey of 100 respondents, the community in general remains receptive and accepting of biotechnology, specifically transgenic agriculture in the province of Bali. Although transgenic technology, particularly transgenic seeds, should not be used in organic farming systems by definition, in accordance with Regional Regulation No. 8 of 2019. However, the Balinese are still unaware of the existence of Regional Regulation no. 8 of 2019, which only 31% of respondents knew about when it came to organic farming systems. According to a survey, only 17% of respondents understand the exact definition of organic farming, which excludes the use of transgenic seeds.

This is reinforced by data indicating that 91 percent of 100 respondents require assistance, specifically in the areas of education and implementation of biotechnology-based agriculture.

AUTHORS' CONTRIBUTIONS

Dase Hunaefi: Designing study, collecting and analyzing data, and drafting manuscript

M Syaefudin Andrianto: Designing study, processing and analyzing data, and drafting manuscript

Yuli Sukmawati: Collecting and processing data, and drafting manuscript

Puput Noerfitriani Muzzayyanah: Provided proposal and literature review

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