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EFFECTIVENESS OF COLLABORATIVE STRATEGY TO REDUCE AFLATOXIN CONTAMINATION IN CORN

BUDIANTO[1,3] Alif G. ARUMSARI[1] Andriza LENIN[1]
Anik SUPARMI[2,3] Muh J. ARIFIN[1, 3]
Ratna HARYANI[4]

Abstract: ***Background:*** *The number of birds that die from diseases caused by aflatoxins in corn is the motivation in this study.* ***The purpose*** *of this research is to a) measure the success of aflatoxin treatment in the pre-harvest, post-harvest, and Innovative Reduction of Aflatoxin (IRA) processes, b) measure the effect of pre-harvest (PRE) and post-harvest (POST) handling on standard control maize (SQC) with IRA mediation.* ***The test method*** *used Structural Equation Modeling (SEM) with the Partial Least Square (PLS) approach.* ***Findings*** *show that Innovative Reduction Aflatoxin (IRA) is able to play a role as a mediation of activities in pre-harvest and post-harvest after continuous improvement is carried out in each of its activities.* ***The originality*** *of the research can be seen from the process of forming corn aflatoxin control strategy as a practical recommendation for farmers in Indonesia.*

Key words: *Aflatoxin, Corn, Structural Equation Modeling (SEM), Pre-harvest aflatoxin treatment (PRE), Post-harvest aflatoxin treatment (POST).*

1. Introduction

Indonesia is a country with tropical climate (the average relative humidity is quite high, around 70-80%) which is an ideal environment for maize and the development of various types of molds such as *Aspergillus flavus* as the main producer of aflatoxin B1 [20]. The high demand for maize as a raw material for animal feed has caused the quality of the available maize to be paid less attention to so that the available maize on farms is contaminated by fungi. This condition results in losses to poultry farmers due to diseases caused by aflatoxins in maize. Corn handling at the farmer level is still done manually with the help of very

[1] Chemical Engineering, Institute Science and Technology Al-Kamal, Jakarta, Indonesia;
[2] SMA Negeri 3 Tarakan, Kota Tarakan, Kalimantan Utara, Indonesia;
[3] SMK Negeri 3 Madiun, Jawa Timur, Indonesia;
[4] SMK Negeri 1 Cilegon, Banten, Indonesia;
Correspondence: Budianto; email: budianto_delta@yahoo.com.

simple equipment. Drying is done by hand drying and threshing. This condition is very susceptible to damage the corn kernels and a decrease in their nutritional content.

This is the reason for the authors to study the problem of aflatoxin growth on the shelf life of corn kernels. This research focuses more on recommendations for handling corn for farmers and breeders. There are many studies concerning aflatoxins in maize, as well as ways to overcome them, preventing aflatoxin contamination when planting corn [6] by always paying attention to soil conditions [11], weed control [27], and the use of superior sedes [17]. The method used by the previous researchers was considered effective in minimizing aflatoxin from the start.

The same research was carried out at the post-harvest time. This was due to the increase in the growth of *Aspergillus flavus* which produced aflatoxin in these conditions [31], treatment at sorting [26], drying [17], storage [20]. The different view on aflatoxin contamination between pre-harvest and post-harvest corn was closed by the study using two methods, namely aflatoxin analysis at pre-harvest and post-harvest maize [17, 20]. The two researchers did not conclude the effectiveness of these methods (pre-harvest and post-harvest). The study focused more on sustainable activities (integrated pre-harvest handling at post-harvest). This becomes a gap in this research.

Other relevant studies have continued to develop to obtain the high effectiveness in the treatment of aflatoxins from *Aspergillus flavus*, Recent research also makes superior seeds by making the host resistant to aflatoxin [5], superior seeds with isolation of *Aspergillus flavus* non-aflatoxin [1], application of nontoxigenic strains to pre-harvest aflatoxin contamination [11], sorting by absorbance wavelength [26] and a suite of technologies to regulate the growth of aflatoxins [32]. This research is effectively applied in advanced industries with adequate technology.

There is no research comparing the effectiveness between PRE and POST with large-scale samples. This study was to fill in the gaps related to the differences in the effectiveness of pre-harvest, post-harvest, pre-post-harvest integration, and innovation. Which one has the effect of reducing aflatoxin contamination in corn kernels in Indonesia? This also provides practical and effective recommendations for this case.

2. Research Hypothesis

The research hypothesis refers to the previous research to obtain indicators of each measured variable.

2.1. Pre-Harvest Aflatoxin Treatment (PRE)

This handling includes the process of cultivating the soil as a planting medium, irrigation, crop rotation, weed control, and insect control [20, 28]. Other efforts include selecting superior seeds that are resistant to aflatoxin [1, 22] and tillage by inoculation of nonaflatoxigenic strains of *Aspergillus flavus* and *A. parasiticus* [11]. Referring to the literature, the hypothesis formed is:

- **H1**: PRE has a direct positive effect on corn quality standards (SQC);
- **H2**: PRE has a direct positive effect on post-harvest handling (POST);

- **H3**: PRE has a direct positive effect on Innovative Reduction Aflatoxin (IRA).

2.2. Post-Harvest Aflatoxin Handling (POST)

Post-harvest handling, including drying and storage processes, is considered the last step in the corn product control process. Quick-drying and short storage processes are recommended by previous researchers [20, 16]. This process can control water content so that *Aspergillus flavus* growth is inhibited. Storage is also a critical point in this stage, maintaining moisture and moisture content of the corn during the storage process [9] and making air circulation in the container or storage area. Aeration is a process of adding air or oxygen to a storage product. Treatment of cold air aerated corn at low flow rates can reduce the growth rate of insect, fungal populations and maintain the quality of the maize [3]. Referring to this literature, the hypotheses formed in this study are: **H4**: POST has a direct positive effect on SQC, and **H5**: POST has a positive direct effect on IRA.

2.3. Innovative Reduction Aflatoxin (IRA)

IRA is a manifestation of technological progress; in this case, it can overcome and even eliminate aflatoxins at the PRE, POST, and integration of both (PRE-POST) stages. Technology, in this case, includes biological control [1, 16, 32], sorting process [27], electromagnetic radiation [4, 12, 22, 35, 36], ozone fumigation [15, 21, 30], chemical control [10, 29]. The hypothesis built from the above literature is **H6**: IRA has a direct positive effect on SQC.

2.4. Integrated Handling

At this stage, the process is mediated by other variables to obtain a standard quality of maize. A series of processes including PRE and POST are expected to reduce aflatoxins [16, 20] so **H7**: PRE has positive effect on SQC if it is mediated by POST. Utilization of technology, innovations for PRE processes, such as soil control by biological processes [1, 17, 32], chemical control [10, 29]. The integration of PRE and IRA is formed. **H8**: PRE has positive effect on SQC if it is mediated by IRA. The use of IRA to increase POST can be seen in the sorting process [27], electromagnetic radiation [4, 12, 33, 25, 36]. This makes **H9**: POST has positive effect on SQC if it is mediated by IRA. A series of c4 formed **H10**: PRE has positive effect on SQC if mediated by POST and IRA. The conceptual framework of this research is shown in Figure 1.

3. Materials and Methods

3.1. Sampling area

This study was to see the effect of PRE, POST, and IRA on SQC as an effort to control aflatoxins in maize in Indonesia. Data were taken from corn farmers in West Sumatra, Lampung, West Java, Central Java, East Java, NTB, NTT, South Sulawesi, and Gorontalo (Figure 2). Data collection involved a team in measuring pH, RH, aflatoxin levels, and chemical composition in the PRE and POST areas. The team has been permitted to collect the data from farmers without having to ask permission from official government agencies. This is done to obtain the real data and direct involvement related to the description of the PRE and POST processes. There are total of 140 sampling scattered across Indonesia's maize-producing provinces. Observations were made for 1 year ranging from March 2019 to April 2020.

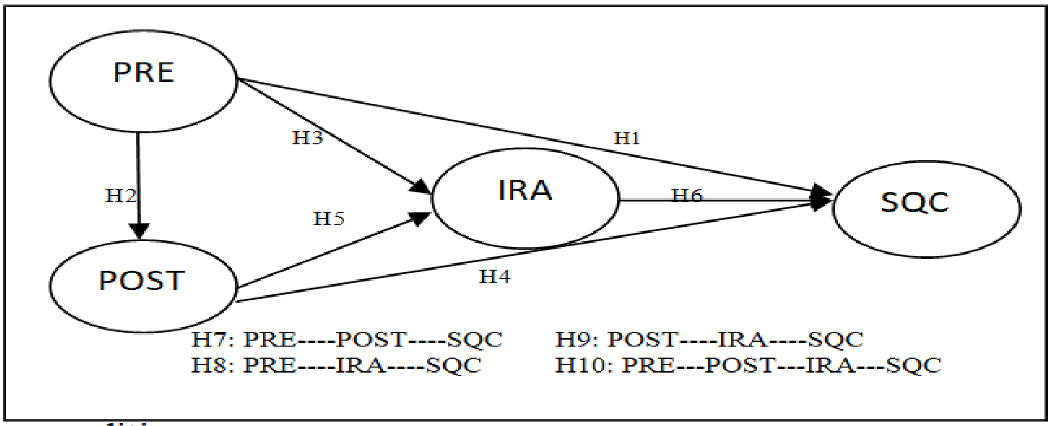

Fig. 1. *Conceptual framework*

Fig. 2. *Research sampling area*

3.2. Statistical Analysis

Descriptive statistics and Principal Component Analysis (PCA) test using SPSS software was carried out to determine the indicators. The function of PCA is basically to make new variables or new dimensions by reduce several variables [2, 18, 19, 34]. Testing the influence of variables using Structural Equation Modeling (SEM), with the Partial Least Square (PLS) version 6.0 software. The validity test used a cross-loading value > 0.7 [8] and the value of Square Root of Average Variance Extracted (AVE) > 0.50 [13], and the reliability test, with Cronbach's Alpha value > 0.6, Composite Reliability > 0.7 [14]. Testing the structural model by accommodating all construct variables are formulated in hypothesis testing.

4. Results

The PCA test helps in sorting the indicators from the construct so that the selection of indicators is based on the coefficient value ≥ of 0.6 [2].

Extraction method principal component analysis Table 1

INDICATOR	Parameter	CODE	Descriptive statistics			Principal component analysis VARIABLES (* = *p*: 0.05)			
			n	Mean	Std. Error	PRE	POST	IRA	SQC
Nitrogen Fertilizer (frequency)	3	A1	140	3.43	.109	.431	.231	.343	.122
Phosphate Fertilizer (frequency)	3	A2	140	3.42	.127	.421	.322	.236	.161
Separated from other plants		A3	140	3.52	.153	.521	.313	.129	-901
Rainfed Water		A4	140	3.41	.135	.431	.204	.22	-741
Irrigation		A5	140	3.42	.-834	.421	.295	.185	.284
Soil pH (alkaline)	8.0 - 10.0	A6	140	3.52	.112	.521	.286	.192	-.581
Soil pH (acid)	4.5-5.5	A7	140	3.43	.091	.431	.177	.299	-421
soil pH	6.5 - 7 .5	A8	140	3.64	.081	.661 *	.243	.414	.285
Humidity (RH) climate	≤60%	A9	140	3.82	.105	.832 *	-260	.308	-261
Superior seeds (aflatoxin resistant)	-	A10	140	3.86	.135	.860 *	-100	.140	-101
pest control	-	A11	140	3.72	.982	.720 *	.321	- .054	.214
The harvest is not in the rainy season	-	B1	140	3.40	.134	.415	.410	.272	-.59
Drying without removing the stub	-	B2	140	3.41	.096	-442	.432	.281	-219
Release of seeds with weevils after drying	-	B3	140	3.43	.065	.416	.467	.148	.215
Drying sun temperature	-	B4	140	3.47	.075.	-441	.646 *	.270	.232
RH place to store	≤60%	B5	140	3.65	.062	.417	.851 *	.283	.294
Aeration system storage (RH)	≤60%	B6	140	3.86	.034	-196	.874 *	.296	-319
Storage of fumigation systems		B7	140	3.87	.038	.217	.417	.309	-265
Shelf deadline (months)	18	B8	140	3.42	.086	.240	.440	.322	-101
FIFO (First In First Out) system		B9	140	3.44	.053	.218	.418	.335	.283
Fumigation storage time (frequency)	2	B10	140	3.42	.095	-197	.497	.348	.191
Unstable air circulation RH value (%)	60-80	B11	140	3.50	.078	.218	.418	.361	-219
Adequate air circulation in the storage area (RH)	≤ 60%	B12	140	3.42	.097	-345	.829 *	.374	.366
Quick peel machine	-	C1	140	3.83	.065	.083	.160	.387	-220
Fast harvesting machine	-	C2	140	3.40	.086	-310	.178	.400	.367

Aeration control machine	-	C3	140	3.41	.076	.084	.196	.413	-221
Biological control	-	C4	140	3.70	.089	-.311	.214	.788*	-180
Seed sorting tool		C5	140	3.45	.091	.085	.232	0.457	-139
Chemical control	-	C6	140	3.76	.081	.085	.232	.762*	.417
Electromagnetic treatment	-	C7	140	3.37	.105	-.312	-317	.367	-181
The container for the packaging of the stored product	-	C8	140	3.45	.135	.086	.293	.450	.418
Aflatoxin detection tool	-	C9	140	3.41	.982	-313	-318	.414	-182
Electromagnetic sort (dry product)	-	C10	140	3.85	.134	-137	.294	.855*	-196
Ozone Fumigation	-	C11	140	3.83	.096	-439	-319	.835*	-345
Aflatoxin levels	≤ 35 ppb	Y1	140	3.803	.065	.214	.366	.203	.803*
Weight loss (aflatoxin breakdown)	max 5%	Y2	140	3.47	.075.	-438	-320	.198	.478
% Corn product poisoning	max 2%	Y3	140	3.48	.062	.219	.367	.193	.478
Product return (aflatoxin content> 35 ppb)	max 2%	Y4	140	3.53	.065	-437	-321	.188	.531
Increased demand		Y5	140	3.48	.086	.216	.368	.183	.487
Decreased poultry mortality		Y6	140	3.49	.076	-436	-322	.178	.498
% Poultry mortality due to aflatoxin	≤ 2 %	Y7	140	3.88	.093	.242	-180	-181	.882*

Note: Size scale of descriptive statistics: 1. Very difficult to apply; 2. Difficult to apply; 3. Neutral; 4. Easy to apply, and 5. Very easy to apply.
Aflatoxin levels: 5. ≤ 35 ppb; 4. 35-40 ppb; 3. 40-45 ppb; 2. 45-50 ppb; 1. ≥ 50 ppb;
% Poultry mortality due to aflatoxin: 5. ≤ 2%; 4. 2-4%; 3. 4-6%; 2. 6-8%; 1. ≥ 8%.

In Table 1, statistical descriptive analysis based on respondents' perceptions based on ease of application, then laboratory analysis (Figure 3) was carried out to determine aflatoxin levels in all sample areas (n: 140). PCA test is used to reduce indicators of variables before analyzing the effect of variables based on SEM.

Before improvement, aflatoxin levels were evenly distributed at all levels, even reaching 50 ppb for H7, H8, H9, and H10. The condition was reversed after evaluation and improvement were carried out based on the obstacles that appeared, the aflatoxin level was dominated at the level of 35 ppb and the highest at the level of 40-45 ppb.

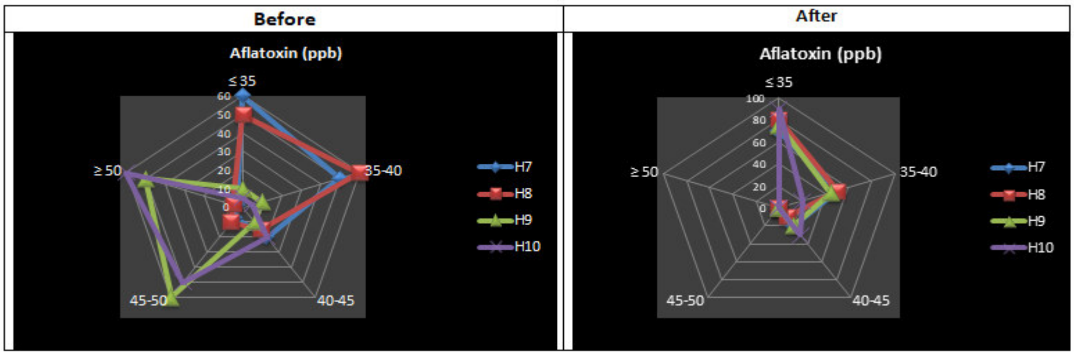

Fig. 3. *Aflatoxin (ppb) levels.* ***Before****: aflatoxin levels before evaluation and improvement.* ***After****: aflatoxin level after improvement*

Figure 4 below shows the data processing using SEM PLS with Algorithm and bootstrapping processes. In the figure, the outer model test results (the validity and reliability of the instruments used) and the Inner model test results can be seen.

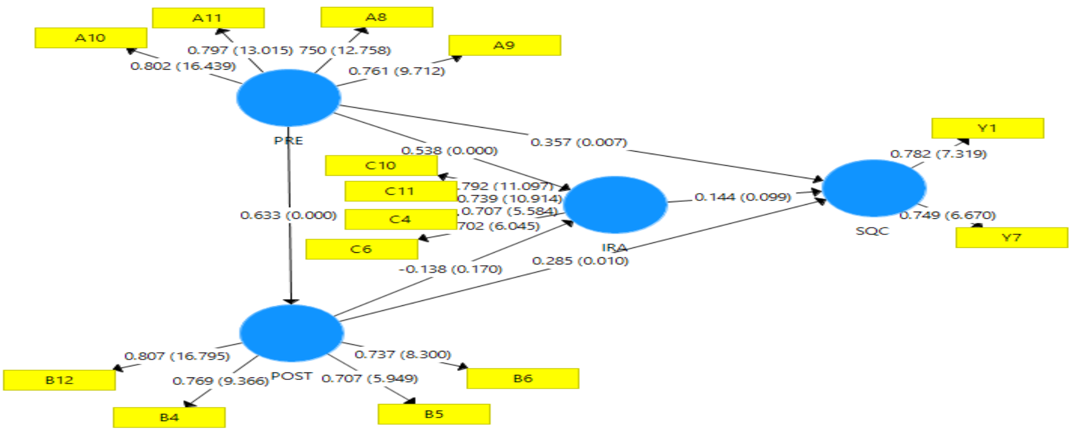

Fig. 4. *SEM PLS Data processing results*

Figure 4 shows the coefficient data, T statistical value, p-value, and f^2 value. Likewise, the relationship between variables are direct and indirect (mediation). Table 4 answers the hypothesis formed by referring to the T statistical value and p-Value. The value of f^2 is to see the magnitude of the influence of the relationship between the variables. The R^2 value measures how far the model's ability to explain the endogenous variations.

The results of the outer model test include convergent validity, discriminant validity, and reliability. Table 2 below shows that all the checked items meet the requirements for further processing.

Outer model test results Table 2

Test	Parameter	Standard	Research result
Convergent Validity	Loading factor (outer loading)	> 0.7	0.707 -0.807
	AVE	> 0.5	0.542 - 0.605
	Communality	> 0.5	0.542 - 0.605
Discriminant Validity	Root Square AVE and correlation latent variables	Root Square AVE> Discriminant validity	Root Square AVE> Discriminant Validity
	Cross Loading	> 0.7	0.702 - 0.807
Reliability	Cronbach's Alpha	> 0.6	0.719 - 0.803
	Composite Reliability	> 0.7	0.739 - 0.860

Inner model test results (structural model) Table 3

No.	Routes	Coefficient (β)	T statistics > 1.65	p-Value <0.05	f^2	Information
H1	PRE - SQC	0.357	2,487	0.007	0.188	be accepted
H2	PRE - POST	0.633	9,813	0.000	0.699	be accepted
H3	PRE - IRA	0.538	3,957	0.000	0.221	be accepted
H4	POST - SQC	0.286	2,345	0.010	0.083	be accepted
H5	POST - IRA	-0.138	0.954	0.170	0.015	rejected
H6	IRA - SQC	0.144	1,287	0.099	0.028	rejected
H7	PRE - POST - SQC	0.180	2,174	0.015	0.15	be accepted
H8	PRE - IRA - SQC	0.078	1,197	0.116	0.108	rejected
H9	POST - IRA - SQC	-0.087	0.892	0.186	0.055	rejected
H10	PRE - POST - IRA - SQC	-0.013	0.637	0.262	0.099	rejected
f^2: 0.02- 0.15 Weak influence; f^2: 0.15-0.35 Moderate effect; f^2: ≥ 0.35 strong influence						
R^2: IRA 0.516; POST 0.482; SQC 0.532 Goodness of Fit : 0.38						

Based on the results of the analysis above, the accepted hypotheses are H1, H2, H3, H4, and H7. On the other hand, the rejected hypotheses are H5, H6, H8, H9, and H10, with the categories having a positive but insignificant impact (H6, H8), having a significant negative impact (H5), and having an insignificant negative impact (H9, H10). The magnitude of the effect of the direct relationship on SQC is as follow: PRE (18.8%), POST (8.3%), and IRA (2.8%).

5. Discussion

To extract the information from the data above, the author wants to discuss sequentially by classifying the discussion based on direct relationships and indirect relationships (mediation). The types of variable relationships help in grouping based on the magnitude of effects, activities that have an impact so that practical solutions can be found.

Figure 5 helps understand the relationship and influence between variables, while the path of the relationship is as follows:

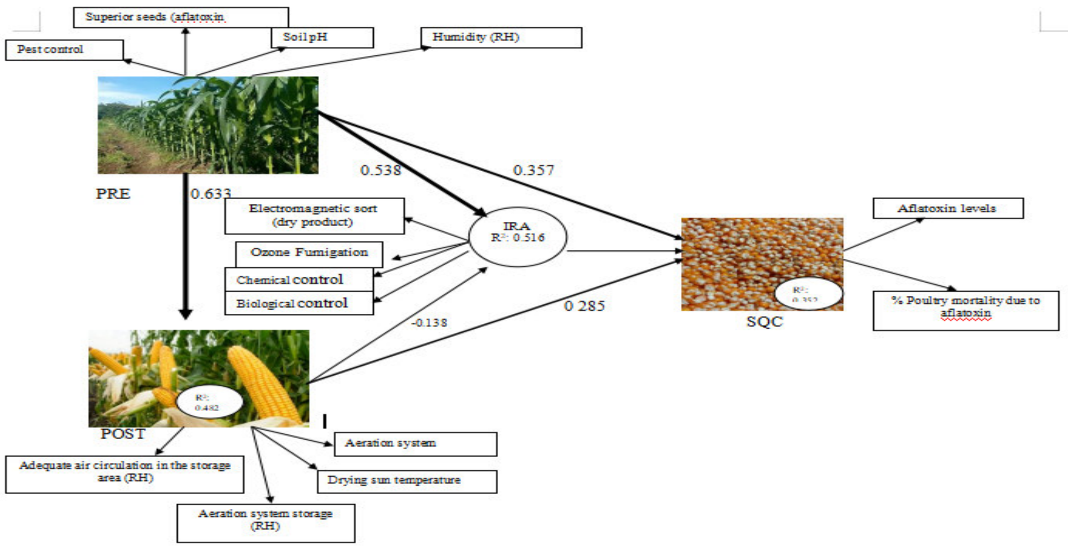

Fig. 5. *Relationship and influence of variables*

5.1. Direct Relationship

The direct relationship between variables without mediation is seen in H1, H2, H3, H4, and H5. The significant positive impact (H1, H2, H3) shows that the implementation of activities on the variables has gone well. The positive impact is insignificant (H4) which indicates that the implementation has not progressed as expected. The negative impact is not significant (H5) showing that the implementation of variable activities is going badly. PRE activity has direct positive effect on SQC, POST, and IRA (H1, H2, H3). In H2, PRE activity shows the greatest effect (60.9%) compared to the relationship of other variables. PRE direct linkage to POST (H2) is the routine of farmers in maintaining the quality of maize in Indonesia. PRE has a fairly positive scale (22.1%) effect on IRA. This can be seen from the IRA's efforts to make superior seeds through biological control, suitable growing media (chemical control). In H1, it shows that PRE can increase SQC (18.8%) because PRE activity can control aflatoxin levels and reduce mortality in poultry. This study shows that PRE plays a greater role in POST and technological innovation in controlling aflatoxins in maize. These results are in harmony with Bruns and Abbas [7] and Kinyungu et al.

[20], which states that the pre-harvest process can control aflatoxins more than post-harvest and applied innovation.

POST activity has direct positive effect on SQC (H4) and has negative effect on IRA (H5). The H4 condition indicates that POST activity has weak effect (8.3%) on SCQ. This result confirms the findings of Converse et al. [9]. POST activities show positive correlation between spacious room storage with air circulation and sun drying. Meanwhile, the unsupportive POST activities, such as storage of aeration systems to obtain standard RH have mostly been carried out by farmers with the implementation not yet strictly implemented. In the H4 phenomena, POST activity has insignificant negative effect on IRA. The innovations offered by the IRA for POST include electromagnetic sorting and ozone fumigation. IRA innovations will be successful if applied by large-scale agricultural companies. IRA offers are not attractive for implementation at POST so that POST activities and do not have positive effect. The factor of rejection of H4 is due to technology costs, complicated usage, and training.

IRA activity has no significant positive effect on SQC (H6). This shows that the implementation of IRA activities has not been going well. There are activities already running such as biological control and chemical control for PRE but electromagnetic sorting activities, ozone fumigation implementation is still poor. This condition becomes a gap to increase the implementation of IRA related to activities that are still bad. The implementation of IRA activities, if it is continuous, will have positive effect on SQC. Although there are other obstacles, the complexity of its use can be overcome by training.

5.2. Indirect Relationship (Mediation)

An indirect relationship between variables (mediation) is seen in H7, H8, H9, H10. The significant positive (H7), insignificant positive (H8), and negative (H9, H10) effects of all relationships are mediated by one or two variables. The significant positive effect (H7) shows that the treatment of aflatoxin processed by PRE can increase activity at POST so that it affects SQC (aflatoxin levels and % poultry mortality). POST succeeded in mediating the PRE to SQC relationship by 18%, the POST variable was able to explain the activity in PRE by 48.2% (R2). The phenomenon in H8 shows that only part of the IRA activities is supported by PRE. IRA is unable to mediate the potency present in PRE to control aflatoxins.

The negative effect on H9 has been seen in the direct relationship (H5), and continues in the indirect relationship. IRA has not been able to mediate the potential of POST to SQC. H10 is almost the same as H9. If there is one endogenous variable (IRA) that does not contribute to the exogenous variable (PRE, POST), then the mediation relationship will not work. Referring to H8, H9, H10 the failure factor lies in the IRA.

5.3. Effect of Mediation

The mediation process was successfully demonstrated by H7, POST succeeded in mediating PRE against SQC through activities commonly carried out by farmers (B4, B12). Aflatoxin conditions that have been controlled in PRE (A8, A9, A10, A11) will facilitate POST in increasing SQC (Y1, Y7). Mediation runs smoothly because the activities are carried out continuously. This result is supported by previous researchers [16, 20] to find aflatoxin control strategies. The main key, in this case, is that the farmers are assisted/convenient in terms of analysis in the PRE and POST areas.

IRA has not been able to mediate the PRE (H8) and POST (9) variables on SQC. IRA succeeded in encouraging some PRE practices (A10, A11) in technological but failed to take advantage of POST activities (B4, B5, B6, B12) in innovation. Based on the results of direct observation by still referring to the data, the failure of IRA is caused by the high price of the technology, and it is also complicated to operate. Furthermore, there is no optimal education regarding the operational innovation offered by IRA. IRA activities (C10, C11) have not been able to be implemented in POST areas by Indonesian farmers. The failure in H9 continues to H10 because the role of the IRA has not been fully adopted.

5.4. Aflatoxin Control Strategy

Referring to the results of the analysis and direct observations in the field, the aflatoxin control strategy (Figure 6) in corn in Indonesia has not been maximized, so efforts are needed to get maximum results. The strategy is prepared based on the results of the analysis of the influence test after improvements have been made.

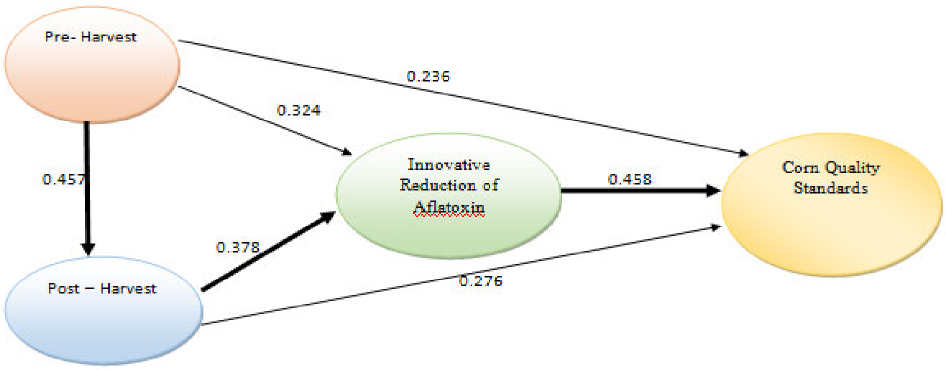

Fig. 6. *Strategy based on the results of improvements in the field (SEM PLS- Goodness of fit: 0.39)*

Aflatoxin handling strategy from pre-harvest to post-harvest with an active mediating role (IRA) on corn quality standards. The role of mediation which initially only affected 14.4%, increased to 45.8 after improvements were made.

5.5. Strategy in the PRE Area

Soil as a planting medium is maintained at a neutral pH (6.5-7.5) assisted by Nitrogen fertilization because cultivation relies on rainfed, with low levels of fertilizer. If possible, the soil is given a strain of *Aspergillus flavus* (a toxic fungus) which can reduce aflatoxin toxin by 70 to 99% [16]. The High environmental humidity is anticipated by appropriate planting times (avoiding humidity ≥80%) and the use of superior seeds (aflatoxin resistant) which are resistant to fungal growth [5, 22]. Pests (insects) and fungi collectively contribute 50% of the damage

[24] so that the role of insecticides is very necessary in this case.

5.6. Strategy in the POST Area

Rapid drying after harvesting in the sun is still effective according to the findings [16, 17, 24]. Storage process that always maintains Relative Humidity ≤ 60%, with adequate air circulation or storage with aeration [3, 16, 24, 32]. The improvement results from field observations can be seen in Figure 8, where the aeration process storage is strongly influenced by humidity (RH) which is a factor in the development of aflatoxins. The results of field observations found that there was still much storage with the fumigation process. This method was still considered effective even though the implementation was still not good. The effectiveness of smoking was proven by previous researchers [16, 25, 26].

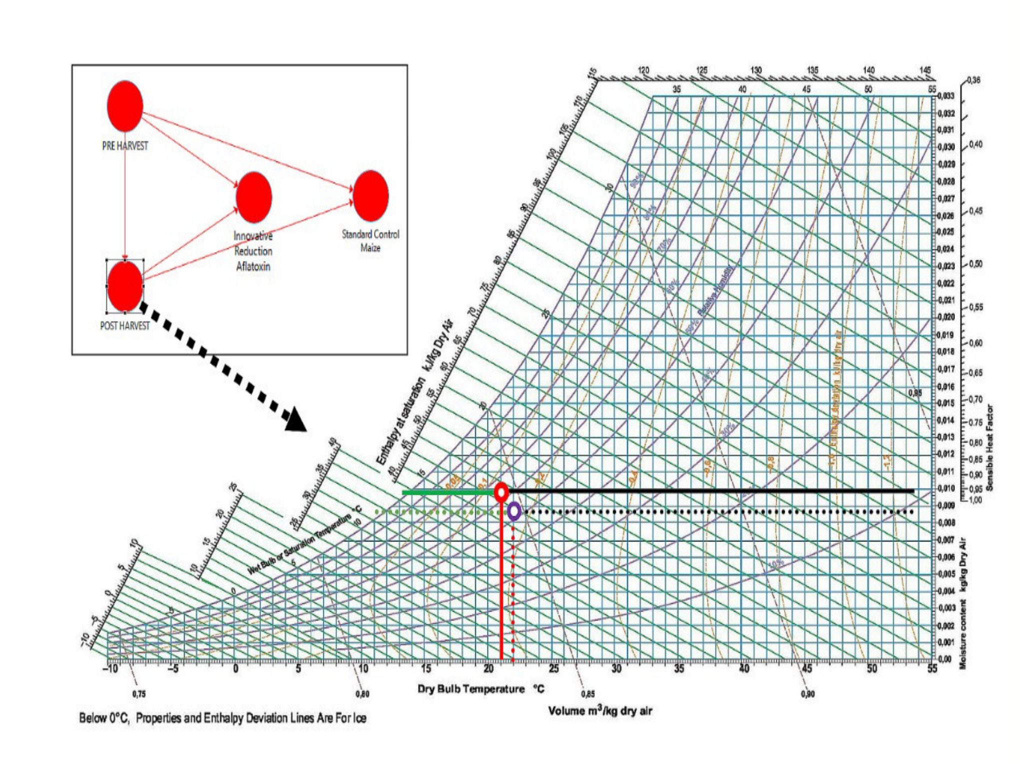

Fig. 7. *POST area strategy related to airflow storage systems*

The focus of improvement in the aeration system based on the results of the aflatoxin level data is recommended for maximum and minimum conditions, while these conditions include: : Maximum conditions (RH) in the Aeration system: **RH**: 60%; **Moisture Content** 0.01kg/kg Dry Air; **Volume** 0.84 m^3/kg dry air; **Dry Bulk Temperature** 22°C; **wet Bulk or Saturation temperature** 14°C; **Enthalpy saturation**: 40 Kj/kg dry air. : Minimum conditions (RH) in the Aeration system: **RH**: 50%; **Moisture Content** 0.009kg/kg Dry Air; **Volume** 0.84 m^3/kg dry air; **Dry**

Bulk Temperature 23°C; **Wet Bulk or Saturation temperature** 12°C; **Enthalpy saturation** : 30 Kj/kg dry air.

5.7. Collaboration Strategy (PRE, POST, IRA)

Optimizing IRA (C4) activity are related to the use of biology as aflatoxin control which is applied in the form of superior seeds that are resistant to aflatoxins, non-aflatoxigenic inoculation of *A. flavus* [1], inoculation of strains of fluorescent *Pseudomonas, Bacillus,* and *Trichoderma spp.* [32]. *Simplify the application of chemical* control (C6) in the insecticide process, such as the use of CH_3COOH, $Na_2S_2O_4$ in the degradation of Aflatoxin B1, B2 [23], Utilization 2, 6-di (t-butyl) -p-cresol (BHT) for storage disinfectant. Optimization of the ozone process can reduce 20% of moisture content of stored-processed corn [21]. The IRA innovation requires education on utilization so that innovation can provide maximum benefits in the strategy to reduce aflatoxins in maize.

6. Conclusions

The aflatoxin control strategy before the *Innovative Reduction Aflatoxin (*IRA) was affected was that the PRE-harvest activity had the greatest effect on aflatoxin control compared to POST-Harvest and *Innovative Reduction Aflatoxin (*IRA) activities.

*Innovative Reduction Aflatoxin(*IRA) is able to play a role as a mediation of activities in pre-harvest and post-harvest after continuous improvement is carried out in each of its activities. evaluation of the constraints needs to be done to obtain information on the causative factors and practical solutions

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