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A Study on The Technology Content Assessment Based on Aspects of Food Safety in The Food Ingredient Company

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ABSTRACT

Food ingredient companies must ensure that their products meet customer food safety and quality requirements. If this is not achieved, the company will lose in market competition. Continuous improvement needs to be implemented in its business processes, one of which is through the assessment of technological complexity. This study aims to assess the level of technological sophistication based on food safety aspects using technometric and AHP integration. Technological assessment is carried out on the production process of pregelatinized starch as premium and specialty product and its supporting processes within the company. The technometric approach will assess the level of sophistication of each technology component (technoware, humanware, infoware, and orgaware). Meanwhile, AHP is used to determine the contribution of each technology component. Finally, the technology contribution coefficient is calculated to determine the company's technology level. The results showed that the highest to lowest value of the contribution of sophistication of each component of technology is orgaware with a sophistication value of 1.064, then infoware with a value of 1.047, followed by humanware 0.868, and lastly is the technoware component which is 0.692. The TCC value of the company is 0.909 which indicates that the company has a highly sophisticated technological with modern technology levels.

INTRODUCTION

The advancement of technology in industrial systems in today's world demands very stiff competition. The industry is required to have strategies, innovations, and produce products according to the needs of customers. The product should meet quality and reach the perspective of markets and consumers. Maximum product quality and ability to attract customers are two of business goals (Cahyono, 2016). Technology becomes the most important one for the purpose of reaching the consumer market that has different needs of community. Customer wants and needs determine the cycle of applied technology, where technology becomes a dominating element in improving a company's competitiveness (Gudanowska, 2017).

Technology provides a creative avenue for food safety agencies to leverage resources in supply chain management and other public bodies through collaboration to prevent food hazards (Wang et al., 2016; Bouzembrak, et. al., 2019). Consumers need for products that are safe and risk-free requires manufacturers to ensure their products do not potentially threaten health (Gerssen et al., 2019). In this regard, food safety standards and certifications are essential to ensure safety, for trade, and consumer confidence (Kotsanopoulos et al., 2017; Guo et. al., 2019).

The concept of technology is divided into several components, those are technoware, humanware, infoware, and orgaware used in technometric to conduct assessments of technological sophistication. Technometric is used to measure the combined contribution of the components of technology (Guntoro, et. al. 2019; Antesty et al., 2020; Indriartiningtias, 2021).

Technology comes in many forms and resources. Processes, structures, tools, methods and expertise including technology, it can be used as a source of emergence of strategies that can provide a sustainable competitive advantage (Zaidi, 2020). One strategy that can be used to win the market is to take advantage of technological advances to implement continuous improvements. Continuous process improvement can be implemented with the assessment of the sophistication of technological components. Assessment of the level of sophistication of technology components can help companies by providing the gaps between existing companies with the most advanced technology (state of the art).

This research was conducted to find out the index of technology components based on a food safety perspective, knowing the components of technology with contribution value to the company. The assessment of technology components is also expected to be the basis of recommendations related to the company's development strategy, especially based on a food safety perspective. Measurement of the level of technology is important, so that the company has an idea of the extent of the technological update applied so that it affects the development of the company and industry competition.

RESEARCH METHOD

There are five steps to estimate the value of the four components, and the value of the intensity of contributions, as explained below.

Estimation of the degrees of sophistication

The estimation of increasing degrees of sophistication of THIO can be found based on questionnaire distributed in table 1. According to the result, upper limit (UL) and lower limit (LL) were obtained for each technology component (Yulherniwati et al., 2020).

Table 1. Technology components sophistication degree

Technoware	Humanware	Inforware	Orgaware	Score
Manual facilities	Abilities to operate	Familiarizing facts	Striving framework	1 2 3
Powered facilities	Setting Up abilities	Describing facts	Tie-Up framework	2 3 4
General purpose facilities	Abilities to repair	Specifying facts	Venturing framework	3 4 5
Special purpose facilities	Abilities to reproduce	Utilizing facts	Protecting framework	5 6 7
Automatic facilities	Abilities to adapt	Comprehending facts	Stabilizing framework	6 7 8
Computerized facilities	Abilities to improve	Generalizing facts	Prospecting framework	7 8 9
Integrated Facilities	Abilities to innovate	Assessing facts	Leading framework	8 9 10

When the degrees of sophistication are being identified and determined at the site, it would be required to determine the lower limits and the upper limits of the technological sophistication.

State of the art assessment (SOTA)

In this assessment, technical knowledge is needed related to the current technological conditions. Each criterion is given a score of 0 for the lowest and a score of 10 for the highest. The equations for calculating SOTA values for technoware (STi), humanware (SHj), infoware (SI) and orgaware (SO) are as follows (Rumanti et al., 2018).

$$\mathrm{ST_i} = \frac{1}{10}\left[\frac{\Sigma_{kt}\, T_{ik}}{kt}\right] \quad \mathrm{k} = 1,2, \ldots\ldots k_t \tag{1}$$

$$\mathrm{SH_j} = \frac{1}{10}\left[\frac{\Sigma_{ih}\, H_{ji}}{ih}\right] \quad \mathrm{j} = 1,2, \ldots\ldots i_h \tag{2}$$

$$\mathrm{SI} = \frac{1}{10}\left[\frac{\Sigma_m\, f_\mathrm{m}}{\mathrm{m}f}\right] \quad \mathrm{m} = 1,2, \ldots\ldots m_f \tag{3}$$

$$\mathrm{SO} = \frac{1}{10}\left[\frac{\Sigma_{no}\, n}{\mathrm{n}o}\right] \quad \mathrm{n} = 1,2, \ldots\ldots n_o \tag{4}$$

Determination of component contributions

Each component of technology is determined by the value of its contribution obtained from the upper and lower limits of the degree of sophistication and the results of SOTA calculations. The equation is as follows (Rumanti et al., 2018).

$$\mathrm{T} = \frac{1}{9}[LT + ST\ (UT - LT)] \tag{5}$$

$$\mathrm{H} = \frac{1}{9}[LH + SH\ (UH - LH)] \tag{6}$$

$$\mathrm{I} = \frac{1}{9}[LI + SI\ (UI - LI)] \tag{7}$$

$$\mathrm{O} = \frac{1}{9}[LO + SO\ (UO - LO)] \tag{8}$$

Assessment of the component contribution intensities

In this assessment, the intensities of the component technology is calculated using the in pairs comparison matrix approach. The procedure is known as analytical hierarchy process (AHP) may be summarizes as follows (Rimantho et al., 2016).

1. Provides a definition of the problem and details of the solution.
2. Determine the hierarchical structure.
3. Create a pairwise comparison matrix. The scale at AHP ranges from 1 to 9 where one implies that both criteria are equal or equally important and the number 9 implies that one element is extremely more important than the criteria of another (Sharma, et. al., 2020; Taherdoost, 2018).

Table 2. Scores for the importance of variable

Importance Scale	Definition
1	Equal importance
2	Weak
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very, very strong
9	Extreme importance

4. Give the necessary consideration to develop the matrix.
5. Determine priorities and conduct consistency testing.

Calculation of technology contribution coefficient (TCC)

Based on Rumanti et al., (2018) the value of Technology Contribution Coefficient (TCC) can be obtained with the following equation.

$$\mathrm{TCC} = T^{\beta t} \times H^{\beta h} \times I^{\beta i} \times O^{\beta o} \tag{9}$$

RESULTS AND DISCUSSION

Identification of criteria of the technology component

The initial stage conducted was identify the criteria of each technology component. Literatur review, observation and interview toward food ingredient company were conducted to determine the criteria of each technology. Table 3 shows the criteria obtained for each technology component.

Table 3. Classifications of the component of technology

Component	Criteria	Source
Technoware	Production machine	(Neio Demirci et al., 2016)
	Transportation	(Neio Demirci et al., 2016)
	Technique dan Lean Production	(Zaidi, 2020)
	The monitoring and measuring equipment	(Neio Demirci et al., 2016)
Humanware	Employee perspective	(Zaidi, 2020)
	Resources	(Zaidi, 2020)
	GMP awareness	-
	Personal hygiene	(Neio Demirci et al., 2016)
Infoware	Traceability	(Allata et al., 2017)
	Document control system	-
	Detection and prevention of cross contamination system	-
	Allergen management	-
Orgaware	Commitment of management	(Chen et al., 2020)
	Hazard analysis and hazard assessment	(Chen et al., 2020)
	Determination of Critical Control Point (CCP)	(Chen et al., 2020)
	Process control measure (OPRP)	-
	Internal audit	-

Estimation of the degrees of sophistication

The classification of the degree of sophistication for each technological component can be seen in table 4. Estimates are made from the collection of information on all relevant facilities and technological information that exist within the company.

Table 4. Degree of sophistication of technoware.

Component	Criteria	Lower Limit	Upper Limit	Classification
Technoware	Production machine	7	9	Computerized facilities
	Transportation	3	5	General purpose facilities
	Technique dan Lean Production	5	7	Special purpose facilities
	The monitoring and measuring equipment	6	8	Automatic fasilities
Humanware	Employee perspective	6	8	Adapting abilities
	Resources	6	8	Adapting abilities
	GMP awareness	7	9	Improving abilities
	Personal hygiene	6	8	Adapting abilities
Infoware	Traceability	8	10	Assessing facts
	Document control system	8	10	Assessing facts
	Detection and prevention of cross contamination system	7	9	Generalizing facts
	Allergen management	8	10	Assessing facts
Orgaware	Commitment of management	8	10	Leading framework
	Hazard analysis and hazard assessment	8	10	Leading framework
	Determination of Critical Control Point (CCP)	8	10	Leading framework
	Process control measure (OPRP)	8	10	Leading framework
	Internal audit	8	10	Leading framework

State of The Art

The first stage of state of the art rating is for each of the criteria of technoware, which are then continued by humanware, infoware, and orgaware. The assessment is developed for each technology component by using specific criteria. The results of state of the art in each technology component are summarized in Table 5.

Technological sophistication and TCC

After getting the value of the SOTA, the next stage is to determine the contribution of each technological component criteria. The component contribution intensities of the four components of technology can be calculated using a paired comparison matrix approach from importance-level based on questionnaire data. Technological sophistication is obtained by multiplying the value of the result of the shortening of the contribution value by the value of contribution intensities on each of the criteria of the technological component.

Table 5. State of the art rating of technoware.

Component	Criteria	State of The Art
Technoware	Production machine	0.780
	Transportation	0.775
	Technique dan Lean Production	0.725
	The monitoring and measuring equipment	0.778
Humanware	Employee perspective	0.768
	Resources	0.788
	GMP awareness	0.756
	Personal hygiene	0.789
Infoware	Traceability	0.806
	Document control system	0.790
	Detection and prevention of cross contamination system	0.750
	Allergen management	0.780
Orgaware	Commitment of management	0.838
	Hazard analysis and hazard assessment	0.800
	Determination of Critical Control Point (CCP)	0.800
	Process control measure (OPRP)	0.795
	Internal audit	0.750

Table 6. Technological sophistication of orgaware.

Component	Criteria	State of the Art	Contribution	Contribution Intensities	Technological Sophistication
Technoware	Production machine	0.780	0.951	0.210	0.692
	Transportation	0.775	0.506	0.374	
	Technique dan Lean Production	0.725	0.717	0.192	
	The monitoring and measuring equipment	0.778	0.840	0.224	
Humanware	Employee perspective	0.768	0.837	0.362	0.868
	Resources	0.788	0.842	0.150	
	GMP awareness	0.756	0.946	0.277	
	Personal hygiene	0.789	0.842	0.211	
Infoware	Traceability	0.806	1.068	0.339	1.047
	Document and control system	0.790	1.064	0.255	
	Detection and prevention of cross contamination system	0.750	0.944	0.147	
	Allergen management	0.780	1.062	0.260	
Orgaware	Commitment of management	0.838	1.075	0.088	1.064
	Hazard analysis and hazard assessment	0.800	1.067	0.134	
	Determination of Critical Control Point (CCP)	0.800	1.067	0.205	
	Process control measure (OPRP)	0.795	1.066	0.318	
	Internal audit	0.750	1.056	0.256	

Table 6 shows the highest to lowest value of the contribution of sophistication of each component of technology. In the first order is the orgaware component with a sophistication value of 1.064, then infoware with a value of 1.047, followed by humanware 0.868, and lastly is the technoware component which is 0.692. The final stage calculation is to determine the TCC that can be seen in table 7.

Table 7. Technology Contribution Coefficient

Technology Components	Technological Sophistication	Contribution Intensities	Technology Contribution Coefficient (TCC)
Technoware	0.692	0.243	0.909
Humanware	0.868	0.240	
Infoware	1.047	0.271	
Orgaware	1.064	0.247	

The results of the assessment of technological sophistication can be seen from the value of Technology Contribution Coefficient (TCC). The TCC value can be seen in table 7. Referring to table 8 and table 9 on technology level classification, the total contribution coefficient (TCC) on FSMS application systems and production processes on this company has a sophistication level that is highly sophisticated and modern. The TCC value shows above 0.9 with a value of 0.909 which means this company needs to develop technology based on food safety aspects in order to realize a continuous improvement program.

Table 8. TCC classification assessment.

Nilai TCC	Klasifikasi
0 ≤ TCC ≤ 0,1	Very low
0,1 ≤ TCC ≤ 0,3	Low
0,3 ≤ TCC ≤ 0,5	Normal
0,5 ≤ TCC ≤ 0,7	Good
0,7 ≤ TCC ≤ 0,9	Very good
0,9 ≤ TCC ≤ 1	Highly sophisticated

(Rumanti et al., 2018)

Table 9. TCC's level for technology

Nilai TCC	Classification
0.1 ≤ TCC ≤ 0.3	Traditional
0.3 ≤ TCC ≤ 0.7	Semi modern
0.7 ≤ TCC ≤ 1	Modern

(Rumanti et al., 2020)

Based on the processing of data technological sophistication, contribution intensity and TCC, THIO diagrams can be drawn in the form of radar diagrams, as shown in figure 1.

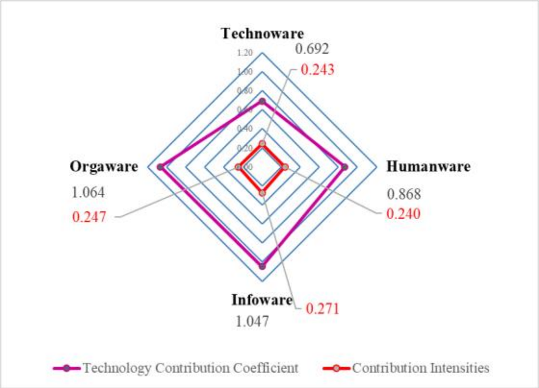

Figure 1. THIO diagram

Figure 1 shows that the four components of technology can present data for evaluation based on a technological perspective. In this case the existing criteria are based on the point of view of food safety. The component of technology with the lowest contribution value is the technology component with the highest priority of improvement and vice versa. The component of technology with the highest intensity value is the component of technology that is a concern for development.

Based on figure 1, it can be recognized that orgaware contributes the most with a value of 1.064. The second contribution is from the infoware with a value of 1.047. The third is humanware which is 0.868. And lastly is technoware with a value of 0.692. While the contribution intensity value of the highest to the lowest is infoware with a value of 0.271, orgaware with a value of 0.247, technoware with a value of 0.243, humanware with a value of 0.240. Priority improvement of technology components in the company based on the perspective of food safety from the highest priority to the lowest priority is technoware, humanware, infoware, and the last is orgaware.

CONCLUSION

The technology components of technoware, humanware, infoware, and orgaware can serve as an analytical tool for the evaluation of food safety management system from a technological complexity perspective. The results of the technology contribution assessment of the food ingredient showed the orgaware component had the highest value of 1.064, the second highest was infoware with a contribution of 1.047, followed by humanware with a contribution of 0.868, and the lowest was the technoware with a contribution of 0.692. Priority improvement of technology components in the company based on food safety aspects from the highest priority to the lowest priority is technoware, humanware, infoware, and lastly orgaware components.

REFERENCES

Allata, S., Valero, A., & Benhadja, L. (2017). Implementation of traceability and food safety systems (HACCP) under the ISO 22000:2005 standard in North Africa: The case study of an ice cream company in Algeria. *Food Control*, *79*, 239–253.

Antesty, S., Tontowi, A. E., Kusumawanto, A., Mada, U. G., Mada, U. G., & Mada, U. G. (2020). *MAPPING THE DEGREE OF TECHNOLOGICAL CAPABILITY IN SMALL*. 13–19.

Bouzembrak, Y., Klüche, M., Gavai, A., & Marvin, H. J. (2019). Internet of Things in food safety: Literature review and a bibliometric analysis. *Trends in Food Science & Technology*, *94*, 54-64.

Chen, H., Liu, S., Chen, Y., Chen, C., Yang, H., & Chen, Y. (2020). Food safety management systems based on ISO 22000:2018 methodology of hazard analysis compared to ISO 22000:2005. *Accreditation and Quality Assurance*, *25*(1), 23–37.

Didik Eko Cahyono, H. C. W. (2016). Penilaian Teknologi Mengunakan Analytical Hierarchy Process Dan. *Jurnal Ilmiah Teknik Industri*, 122–129.

Gerssen, A., Bovee, T. H. F., van Ginkel, L. A., van Iersel, M. L. P. S., & Hoogenboom, R. L. A. P. (2019). Food and feed safety: Cases and approaches to identify the responsible toxins and toxicants. *Food Control*, *98*, 9–18.

Gudanowska, A. E. (2017). Modern Research Trends within Technology Management in the Light of Selected Publications. *Procedia Engineering*, *182*, 247–254.

Guntoro, I., Rezavidi, A., & Wibowo, S. S. (2019). Technometric Analysis of The Capabilities of The Photovoltaic Manufacturing Industry in Indonesia. *Int. J. Adv. Eng. Res. Sci*, *6*, 422-427.

Guo, Z., Bai, L., & Gong, S. (2019). Government regulations and voluntary certifications in food safety in China: A review. *Trends in Food Science & Technology*, *90*, 160-165.

Indriartiningtias, R. (2021). Measurement of Technology Capability with Technometric Methods: Case Study at Batik Anugerah, Bangkalan, Madura Island. *Jurnal Metris*, *22*(01), 10-14.

Kotsanopoulos, K. V., & Arvanitoyannis, I. S. (2017). The Role of Auditing, Food Safety, and Food Quality Standards in the Food Industry: A Review. *Comprehensive Reviews in Food Science and Food Safety*, *16*(5), 760–775.

Neio Demirci, M., Soon, J. M., & Wallace, C. A. (2016). Positioning food safety in Halal assurance. *Food Control*, *70*, 257–270.

Rimantho, D., Rachel, M., Cahyadi, B., & Kurniawan, Y. (2016). Aplikasi Analytical Hierarchy Process

Pada Pemilihan Metode Analisis Zat Organik Dalam Air. *Jurnal Ilmiah Teknik Industri*, *15*(1), 47.

Rumanti, A. A., Reynaldo, R., Samadhi, T. M. A. A., Wiratmadja, I. I., & Dwita, A. C. (2018). Bridging Technometric Method and Innovation Process: An Initial Study. *IOP Conference Series: Materials Science and Engineering*, *319*(1).

Rumanti, Augustina Asih, Wiradmadja, I. I., Ajidarma, P., & Hidayat, M. (2020). *Application of Technometric to Improve Productivity in Indonesian Small Medium Industries (SMI)*. *2*, 217–223.

Sharma, D., Sridhar, S., & Claudio, D. (2020). Comparison of AHP-TOPSIS and AHP-AHP methods in multi-criteria decision-making problems. *International Journal of Industrial and Systems Engineering*, *34*(2), 203-223.

Taherdoost, H. (2018). Decision Making Using the Analytic Hierarchy Process (AHP); A Step by Step Approach. *International Journel of Economics and Management Systems*, *2*(January 2017), 244–246.

Wang, C. S., & Van Fleet, D. D. (2016). Reconceptualizing the US strategic food safety system. *British Food Journal*, *118*(5), 1208–1224.

Yulherniwati, Y., & Ikhsan, A. (2020). *Assessment of Institution Readiness in Adopting Technology: A Study on Vocational Education Internal Quality Assurance System*.

Zaidi, A. F. A. (2020). Propositions on the Relationships between Technology Complexity , Industry 4.0 and Halal Sustainability. *Journal of Engineering and Science Research*, *4*(1), 52–58.