Factors influencing food waste in restaurants and their impact on processing: an interpretative structural modelling approach

Atikha Sidhi Cahyana[1*], *Sakina* Ainiyah[1], *Intan Rohma* Nurmalasari[2], and *Ida Agustini* Saidi[3]

[1]Department of Industrial Engineering, Faculty of Science and Technology, Universitas Muhammadiyah Sidoarjo, Indonesia.
[2]Department of Agrotechnology, Faculty of Science and Technology, Universitas Muhammadiyah Sidoarjo, Indonesia.
[3]Department of Food Technology, Faculty of Science and Technology, Universitas Muhammadiyah Sidoarjo, Indonesia.

Abstract. Food waste is a significant issue in Indonesia, with approximately 1.3 billion tonnes generated annually. A substantial portion of this waste originates from restaurants, often due to customers not finishing their meals. The contribution of this research is to provide proposals for handling food waste. This study employs Interpretative Structural Modelling (ISM) to identify and analyse factors influencing food waste in restaurants. The study identifies 23 factors affecting food waste in restaurants, which are classified using the SCOR method. ISM analysis reveals a hierarchical structure of these factors based on expert opinions. Food packaging is identified as a critical factor contributing to food waste due to its potential to damage food. Addressing packaging issues should be prioritized to reduce food waste, whereas factors related to food delivery have a relatively lower impact.

1 Introduction

Supply chain as the integration of critical business processes from end users to initial suppliers that provide products, services and information that add value to customers and other stakeholders [1]. This definition was also used by the Global Supply Chain Forum (GSCF) in 2000. In simple terms, a supply chain is a series of flows of physical goods, information, and processes used to deliver products or services from a source location (supplier) to a destination location (customer or buyer). The food chain is different from other product and service supply chains. The fundamental difference between food chains and other supply chains is that there are continuous and significant changes in food quality throughout the supply chain until the last point where the product is consumed. In the food chain, food (product) moves continuously from producer to consumer through the processes of production, processing, distribution, retail and consumption. Thus, food moves from farmers to consumers (farm to table). In addition, the risk of wastage or loss at each stage of the supply chain can be very high, especially in perishable or perishable foods, further reducing the profitability and quality of the food chain products.

According to the type of production and marketing of plant and animal products, the food chain can be divided into two (2) types [2], namely: 1. Fresh food chain (e.g. vegetables, flowers, fruits). In general, this supply chain includes: farmers, collectors, wholesalers, importers and exporters, retailers and speciality stores. Basically, all these stages of the supply chain are different, the products are grown or made in the country. The main processes are the handling, storage, packaging, transport and especially the trading of these products. 2. Processed food supply chain (such as snacks, meals, canned food). In this supply chain, agricultural and fishery products are used as raw materials in the production of foods that have more added value. In many cases, storage and freezing processes extend the shelf life of ready-to-eat foods.

Currently, food waste has become a major problem in the world that has become a Sustainable Development Goals (SDG) which aims to halve the distribution and consumption of food waste per inhabitant in the world by 2030. Indonesia is the second largest producer of food waste in the world after Saudi Arabia, which according to BCF (2019)[3] is 300kg/year. In fact, the exact amount of food waste generated in urban areas is unknown, as food waste generated by households, traditional markets, retail trade, and food services are combined without separation and called waste. According to the Department of Hygiene and Green Areas, waste is divided into two types, namely organic waste and inorganic waste. Organic waste is waste that comes from living things, such as leaves and kitchen waste. Organic waste is very easy to decompose naturally. Meanwhile, inorganic waste is non-biodegradable waste, such as rubber, plastic, cans, and metals. Food waste itself is classified as organic waste [4].

Indonesia has a waste problem that is rarely cared for by the community. The Food and Agriculture Organization (2017) states that one-third of the food

* Corresponding author: atikhasidhi@umsida.ac.id

produced annually is 1.3 billion tons of food waste. According to Word Hanger News (2016), that 7.6 billion people or around 85 million people are hungry and malnourished, while the food waste produced is very large. Food waste is food that is fit for consumption but some of it is damaged or expired. Meanwhile, food loss is food that is not in accordance with the wishes of producers on the market, especially the people of Indonesia. Currently, the restaurant business, especially fast food, is growing rapidly, not only in big cities but also in small towns. Because fast food is very popular among the people, the basic reason is its practicality. The rest of the food also experienced a high spike.

Population growth, development and community demands in cities have resulted in restaurants being very popular with the people. So institutions that handle municipal waste must be responsive, adaptive, and committed to a professional team work, which has a transparent, participatory, effective and efficient attitude and can guarantee public accountability. To develop institutions that are in accordance with population conditions and population development, it is necessary to review the municipal waste management agency again, so that municipal waste management can be carried out efficiently.

To reduce food waste generated, especially in Indonesia. The research target was carried out in a restaurant in the Sidoarjo and Surabaya areas. The contribution of this research is to provide proposals for handling food waste using the ISM (Interpretative Structural Modeling) method. The ISM method will handle and find out the factors that cause food waste that are interrelated. Some of these factors can be mapped in the form of diagrams to make it easier to take strategic policies.

1.1 Food waste

The definition of food waste can be viewed from different perspectives, so that different institutions and organizations can use different definitions of food waste [5]; [6]. Food waste can be studied according to its type, generation method and origin [7]. In poor and developing countries, a large part of food is wasted during production and processing, because the processes are inefficient. At the same time, more food is wasted in industrialized countries, and each person can waste around 100 kg of food per year [8]. Table 1 shows some definitions of food waste.

The definition used in this study is that food waste is good quality food that people can eat but for some reason is not consumed or used. The areas where food waste occurs according to Betz [13] and Liu [8] occur during retail distribution and sales, catering and consumption, thus using urban areas because almost all the actors are in urban areas [10], [15].

Conducted a study investigating the largest number of sources of food waste in the supply chain. According to Silvennoinen [16],[17], the most common food waste in the supply chain are vegetables and potatoes. Based on the study, the percentage curve of food waste is shown in Figure 1. Food waste can be defined as the amount of edible material that is wasted or lost at different stage of the food chain, including harvest, post-harvest storage and material handling, manipulation, processing, distribution and consumption. Food waste at the end of the food chain (retailers and final consumption) is more commonly referred to as food waste, where food waste is strongly linked to retailers and consumers behavior [18]; [19]. According to Reynolds [20], the causes of food waste are not food processing. eating out of proportion, buying or cooking food that is not liked, lifestyle (prestige) consuming food in front of people.

Table 1. Some definitions of food waste from researchers and institutions.

Source	Food waste
[9]	Food that is fit for human consumption but not consumed by retailers or consumers and should not be spoilt or discarded due to exceeding the expiry date, improper storage, purchase and handling of excess or unwanted food. Example: brown-skinned bananas discarded by the shopkeeper.
[8], [10]	Edible material intended for human consumption produced at any point in the food chain that is otherwise discarded, lost or spoiled.
[11]	Occurs during distribution and marketing and in connection with consumption.
[12]	This is due to poor handling systems (especially packaging and refrigeration during distribution) that result in a decrease in the quality and safety of perishable food.
[13]	Consumer products that can no longer be used due to shelf life, quality requirements, hygiene requirements.
[14]	Food of a quality that a person can eat, but for some reason does not consume or discards.

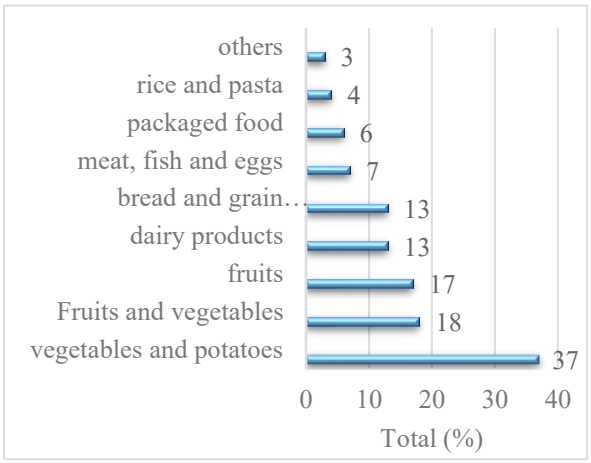

Fig. 1. Percentage of total food waste in the supply chain.

Food waste is a concern for many parties because it is directly related to public health, cleanliness and environmental beauty, especially in urban areas [20]. Some of the phenomena of food waste, which are harmful to society, show the value of economic lasses torisk of increasing food waste, which affects

sustainable food security and even causes hunger and malnutrition, according to the world food agency, together with research institutes and the London School of Economics. or direct losses amounting to a trillion US dollars per year [21]. [22] argued that food waste affects food safety, the environment and the economy. In total, 1.3 billion tons of edible food (a third of the world's food production) is wasted in the food chain from production to consumption [23]. This amount of food wastcan cover an eighth of the world's population, which suffers from food and nutrition insecurity. In addition, this amount can also decrease global food supply, which is expected to increase by 50 – 70 percent by 2050 [24].

Food waste that is simply throw into landfills without proper treatment can become a source of methane, which causes global warming. According to Xu [25] , food waste deposited in landfills turns into methane, which is a greenhouse gas with a global warming potential 21 times greater than of carbondioxide. In addition, Liang [26] added that food waste tends to decompose faster and the methane produced is higher than other landfill organic materials. Getting rid of food waste is the same as getting rid resources. Economically, food waste causes economic loss that is used to produce food, such as buying food, water, energy, etc. [27] In addition to the costs or damage caused by food waste, the negative impact is estimated to be US $ 700 billion in global environmental costs and US $ 900 billion in social costs. Thus the total loss caused by food waste reaches US $ 2.6 trillion per year, or 4 percent of the world's gross domesticproduct [28]. Khalid [21] analysed that food waste leads to environmental problems, hunger and malnutrition in the long run, making food waste an important sustainability issue.

The factors affecting the occurrence of food waste studied are usually analyzed from the consumer or community side. These factors did not consider the policy of the local government, nor of the business or restaurant, for example the environment (environmental efficiency, environmental management and environmental conditions), nor did they affect the process of sustainable development [29]. Food waste management in urban areas generally involves government institutions, the participation of non-governmental organisations (NGOs) and the community and industry. The actors related to food waste management in urban areas include road users, waste transporters, temporary and final disposal officers, administrative officers and other services. Walsh [30] states that there are a number of aspects that affect the management of food waste in urban areas, namely socio-political aspects concerning the government's concern and commitment in determining the APBN budget through the ministry or APBD for environmental management, socio-demographic aspects which include socio-economic (tourism activities, markets and shops, and household activities), socio-cultural aspects concerning the existence and interaction between village / customary institutions, customary rules, ritual activities, spatial structure values, sincere social devotion, mental attitudes and behaviour of apathetic citizens, aspects of the existence of land for landfills, financial aspects (finance), aspects of the existence of NGOs, aspects of coordination between institutions involved in overcoming environmental problems.

Some urban food waste management issues according to Rispo [31] include: (1). The amount of food waste is increasing because (a). the population continues to grow due to natural factors or urbanisation, (b). increasing economic, production, and consumptive capabilities, (c). The role of the community and the business world is very low in efforts to reduce food waste. (2). Service capacity is limited because: (a). Still applying the old paradigm of food waste management equated with waste management, namely relying on the collect-transport-dispose process, (b). Funding priorities are low and not proportional to the needs of food waste processing services, (c). Inadequate institutional capacity (status, authority, planning, supervision, human resources), (d). The operational performance of the service has not met the minimum service standards and there is no regulation governing it. (3). The capacity of the community and private sector as partners has not been built and developed because (a). Attention to socialisation, guidance, and community education is very low, (b). The partnership climate is not conducive and attractive for the private sector to invest.

2 Research method

Data processing is an activity carried out to obtain results from data collection obtained with the aim of producing a value or work process that is used as a reference in analyzing. Data collection was carried out by interviewing several experts who were related to restaurant food waste. Interviews were conducted with restaurant heads, academics, the Environment and Hygiene Service, and zero waste organizations. So that the results obtained regarding the factors for the occurrence of food waste are maximized. The flow chart of this research is shown in figure 2.

The definition of ISM according to Darmawan [32] Interpretive Structural Modeling (ISM) is a well-established methodology to identify relationships between certain variables that define a problem or issue. ISM is used when there is a desire to use logical and systematic thinking as an approach to solving complex issues at hand.

The ISM method aims to prioritize the factors qualitatively and make a hierarchical proposal based on the standard food waste hierarchy, namely its structure and category. Interpretive Structural Modeling (ISM) analyzes and solves system elements in graphical form of direct relationships between elements and hierarchical levels. The purpose of the elements is to provide policies, organizational targets, and assessment factors.

The steps in working on Interpretative Structural Modeling (ISM) are as follows:

1. Identify the problem.

Elements relevant to the problem under consideration. This can be done by field checks or group problem solving.

2. Building Elements
   Establish contextual relationships between elements with respect to pairs of elements to be examined.
3. Develop a Structural Self-Interaction Matrix (SSIM) of elements.
   This matrix shows the pairwise relationship between system elements. This matrix needs to be checked for transitivity.
4. Develop Reachability Matrix of SSIM.
   The results of the assessment of the Structural Self-Interaction Matrix (SSIM) made in the form of a Reachability Matrix (RM) table by replacing V, A, X, O, into numbers 1 and 0. The explanations of these symbols are as follows:
   V if eij = 1 and eij = 0
   A if eij = 0 and eij = 1
   X if eij = 1 and eij = 1
   O if eij = 0 and eij = 0
5. Partition the Reachability Matrix to different levels.
6. Convert the Reachability Matrix to conical form.
7. Draw a digraph based on the relationships in the Reachability Matrix and remove the transitive links.

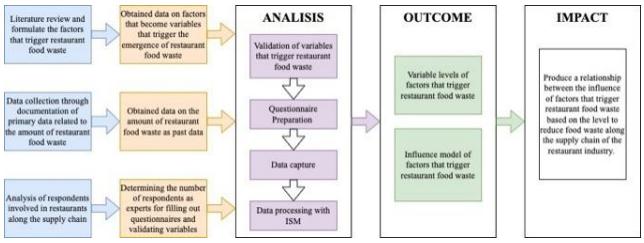

Fig 2. Research flowchart.

3 Results and discussion

3.1 Processing of interview 1

From the results of interview 1 with respondents there are additional factors for the emergence of food waste from previous sources. Table 2 is the results of interview 1 with respondents and their additional factors.

Table 2. Results of interview 1.

Scor	Code	Food waste factors	Description	Source
Plan	P1	Delivery schedule	The delivery schedule to the customer does not match the order of purchase. Because one of the things speed in the delivery of food to customers is a very important thing.	[33], [34], [35]
	P2	Food overload	The estimated amount of food in a day is not scheduled according to customer needs. So that the finished food becomes excessive.	[34]
	P3	Inventory planning	Inventory planning per commodity (rice, chicken, potatoes, vegetables) in the restaurant does not exist.	36
	P4	Food waste processing planning	Planning in food waste processing does not exist in restaurants because they only think that after food from consumers there are leftovers that are just thrown away and not separated.	
	P5	Appropriate amount of food	Adjust customer food portions according to restaurant standards. And sometimes there are still too many and don't match the photos or pictures provided by the restaurant	[37], [38]
	P6	Organization management	Restaurant organization management is very important, useful for determining processes that are considered not in accordance with restaurant standards.	[33]
	P7	People's culture without planning when buying	Planning in buying also affects the emergence of food waste because if there is no planning then any food will be purchased and cause food to not run out as needed.	Expert Opinion
	P8	Number of restaurant customers per day	There should be a plan for the number of customers who will come every day because there is already previous and predictable data according to the food supply needs of the restaurant.	
	P9	Planning for sales in every day	Planning in sales affects the amount of food inventory every day and the number of consumers so that the food in the restaurant runs out.	Expert Opinion
Source	S1	restaurant head and restaurant crew skills	Knowledge and expertise in food processing is very important, in order to know how to minimize the occurrence of food waste. Both the head of the restaurant and the restaurant crew must always conduct training on food waste.	[35]
	S2	Coordination between buyers and sellers	Communication and coordination when making transactions and ordering according to what was ordered are often too fast in dealing with buyers because the queues are long and do not match what was ordered.	[37]
	S3	Urban people who donate food waste due to work shifts or temporary residences	Urban communities are one of the food contributors because of the displacement of their workplaces and places of residence	Expert Opinion
	S4	Socialization to the	One of the things that affect food waste is the lack of	Expert

Scor	Code	Food waste factors	Description	Source
		community and restaurant crews, especially fast food consumers, the dangers that arise from food waste	public knowledge about the dangers posed by the leftovers they eat because of their culture of wasting food in vain. Socialization of the dangers that arise from food waste greatly affects and can minimize the occurrence of food waste and food waste.	Opinion
Make	M1	Food emptiness	The restaurant crew performs a cooking process that is not in accordance with the standard of doneness and causes the food to burn and be served to customers. The food is empty when it reaches the customer and the customer does not know about it so throw the food away.	[37], [38]
	M2	Dirty storage	The cleanliness of the food storage area, there are still food residues scattered in the storage area.	
	M3	Food spill	Accidentally in the process of cooking and serving to consumers can balance food waste.	[34]
	M4	Storage temperature	The temperature in food storage is not properly conditioned. Because to maintain the resilience of food to stay delicious.	[34' [37]
	M5	Food standard	Food standards must be in accordance with BPOM and MUI, in order to convince customers that the food sold is halal.	
	M6	The cooking process is not modern	The cooking process does not have modern facilities and the food served in the following years does not have any innovations that attract customers.	
Deliver	D1	Communication between the crew and the head of the kitchen	The ordering process from the restaurant crew to the head of the kitchen sometimes goes wrong because there is a communication error.	[38]
	D2	People's culture of throwing away food	People take lightly about leftovers because it is a common thing. And this has become a culture for people to throw away food scraps and even food that is not tasty and does not suit consumers' tongues, especially in restaurants.	[34], [39]
	D3	The existence of the squad will spend the food in the restaurant and will not produce food waste in the restaurant	As a developing country, Indonesia has difficulty handling food waste that arises, especially in restaurants. The existence of regulations from the government will spend food in restaurants and not produce food waste in restaurants, it needs to be applied little by little, in order to minimize the food waste produced.	Expert Opinion
Return	R1	Food packaging	Packaging that is easily damaged so that the food returns and also causes the food to go stale quickly	[37], [36]

Table 3. Sample questionnaire Interview 2.

X				Y
Weak (1)	Medium (2)	Strong (3)	Very strong (4)	
			✓	Food Overload (P2)
✓				Inventory Planning (P3)
✓				Food waste processing planning (P4)
			✓	Appropriate amount of food (P5)
			✓	Organizational management (P6)
		✓		Purchase planning (P7)
			✓	Number of customers (P8)
		✓		Sales Planning (P9)
		✓		restaurant head and restaurant crew expertise (S1)
		✓		Coordination between buyers and customers (S2)
		✓		Urban Society (S3)
			✓	Socialization of the dangers of food waste (S4)
		✓		Food void (M1)
			✓	Dirty Storage (M2)
			✓	Food spill (M3)
			✓	Storage temperature (M4)
			✓	Food standard(M5)
		✓		Non-modern cooking process (M6)
			✓	Communication between crew and kitchen head (D1)
			✓	Community culture of throwing away food (D2)
			✓	presence of regulation (D3)
			✓	Food packaging (R1)

From table 2, it is known that the additional factors from experts as respondents are community culture without planning when buying (P7), the number of restaurant customers in every day (P8), planning for sales every day (P9), urban communities who donate food waste due to job shifts. or temporary residence (S3), outreach to the community and restaurant crews, especially fastfood consumers, the dangers that arise from food waste (S4), the existence of regulations will spend food in restaurants and do not produce restaurant

food waste (D3). In addition, the highest amount of waste is found in the type of food, rice is 4 kg and fried potatoes is 3 kg.

To facilitate the distribution of criteria for food waste factors, the supporting method is using the SCOR (Supply Chain Operation Reference Model) method, because the existing classification in the SCOR method is in accordance with the restaurant's food waste factors. And have carried out other classification methods, namely the SIPOC method and the supply chain sub, but they are not in accordance with the grouping criteria according to the method. And the most suitable with the results of the factors is using the SCOR method.

3.2 Processing of interview 2

The results of the second interview to determine the relationship between factors with the help of a questionnaire using a weighting scale of 1 until 4. Questionnaires were distributed to 4 respondents with the following details: academics, assistant manager of Burger King Surabaya, environment department Sidoarjo, Sidoarjo zero waste pepilingasih organization.

Example of the results of the second questionnaire with respondents and respondents giving their opinions where if the delivery schedule (P1) has a relationship with other variables and is given a value on a scale of 1 (weak), 2 (medium), 3 (strong) and 4 (very strong). Identification of the relationship between factors was carried out by conducting pairwise comparison questionnaires. The purpose of the questionnaire was to reach an agreement between the previous sources with experts in their fields and academics. Questionnaires are given to experts who have been interviewed both face-to-face according to government health protocols and virtually via zoom. Respondents are given based on known experts with positions, areas of expertise, and years of service. The cumulative results of the respondents are in appendix 2 and this is the result of the respondent's questionnaire.

The relationship between the results of the questionnaire respondents explained that if the value of 4 means the result of the relationship is very strong, if the value of 3 means the result of the relationship is strong, if the value is 2, it means the result of the relationship is moderate and if i the value is 1, it means that the result of the relationship is weak.

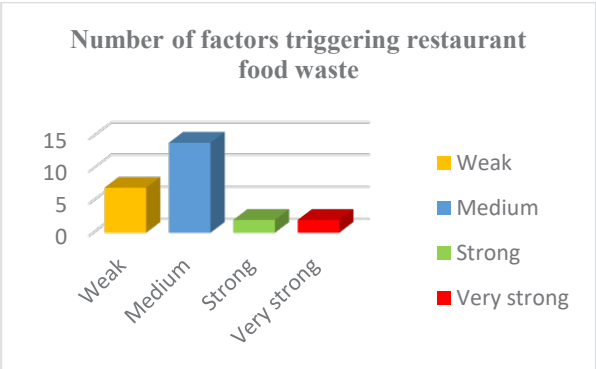

Fig. 3. Number of triggers for restaurant food waste.

From Figure 3, it is explained that there is one factor, namely the amount of food according to customer expectations, has a very strong relationship between the influence of food waste and other factors. There is one factor, namely the customer delivery schedule has a strong relationship with other food waste factors. Then there are 14 factors that trigger food waste, namely food overload, inventory planning, food waste processing planning, organizational management, purchasing planning, number of customers, sales planning, restaurant head expertise and restaurant crew, socialization of food waste hazards, storage temperature, food standards, communication between the head of the kitchen and the restaurant crew, the culture of the community in disposing of food and packaging damaged there is a relationship with other factors in the moderate category. And for the 7 factors that trigger food waste, namely coordination between buyers and customers, urban communities, burnt food, dirty storage, food spills, non-modern cooking processes, and the existence of regulations that have a relationship with other factors with weak categories.

Next, identify the variable elements of the triggering factors for restaurant food waste that have been described in the SCOR method. And identify the factors of food waste in accordance with the place. Then develop the results of these elements into a Structural Self-Interaction Matric (SSIM). Structural Self-Interaction Matric (SSIM) can be seen in the table below, there are 23 variable elements that trigger the emergence of restaurant food waste arranged in row and column format. variables in rows and columns are represented by the letters i (row) and j (column), respectively. Thus, for each pair of variables there are four keywords that will be used to direct the relationship between a set of variables (i and j), where: (a). V indicates that variable i affects variable j, (b). A indicates that variable j affects variable I, (c). X indicates that variable i influences variable j and vice versa, (d). O indicates that the variables i and j are not related.

Table 4. Structural Self-Interaction Matric (SSIM).

v/y	p1	p2	p3	p4	p5	p6	p7	p8	p9	s1	s2	s3	s4	m1	m2	m3	m4	m5	m6	d1	d2	d3	r1
p1	X	V	V	V	V	V	V	V	O	A	A	A	A	O	O	A	A	V	A	V	A	A	A
p2	A	X	A	A	A	A	V	V	O	A	A	A	A	A	O	A	A	A	A	V	A	A	A
p3	A	A	X	A	A	A	A	A	A	A	V	A	A	A	A	O	A	A	A	A	A	A	A
p4	V	A	A	X	A	A	A	V	A	A	A	A	A	A	A	O	A	A	A	A	V	A	A
p5	A	V	V	V	X	V	V	V	V	A	A	V	V	O	V	O	V	V	V	V	V	V	V
p6	A	A	A	A	V	X	A	A	A	A	A	A	A	A	A	O	A	A	A	A	A	A	A
p7	A	A	A	A	A	A	X	A	X	O	V	A	V	A	A	O	A	A	A	A	A	A	A
p8	A	A	A	V	A	A	A	X	A	A	A	A	A	A	A	O	A	A	A	A	A	A	A
p9	A	A	V	V	V	A	A	A	X	A	A	A	A	A	A	O	A	A	A	A	A	A	A
s1	A	A	A	A	A	A	A	A	A	X	A	A	A	A	A	V	A	A	A	A	A	A	A
s2	A	A	A	A	A	A	A	A	A	A	X	A	A	A	A	O	A	A	A	A	A	A	A
s3	A	A	A	A	A	A	A	A	A	A	A	X	A	A	A	O	A	A	A	A	A	A	A
s4	A	V	V	V	A	A	A	A	A	A	A	A	X	A	A	O	A	A	V	V	V	A	A
m1	A	A	A	A	A	A	O	A	A	A	A	A	A	X	A	O	A	A	A	A	A	A	A
m2	A	A	A	A	A	A	O	A	A	A	A	A	A	A	X	O	A	A	A	A	A	A	A
m3	O	O	O	O	O	O	O	O	O	V	O	O	O	O	O	X	O	O	O	O	O	O	O
m4	A	A	V	A	A	A	A	A	A	A	A	A	A	A	A	O	X	A	A	A	A	A	A
m5	A	V	A	A	A	A	A	O	A	A	V	O	A	A	A	O	V	X	A	A	A	A	A
m6	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	O	A	A	X	A	A	A	A
d1	A	A	A	A	V	A	A	A	A	A	A	A	A	A	A	O	A	V	X	V	X	V	A
d2	A	A	V	A	A	A	A	A	A	A	A	A	A	A	A	O	A	A	A	X	X	A	A
d3	A	A	A	V	O	O	O	O	A	A	A	A	A	A	A	O	A	A	A	A	X	X	A
r1	A	A	A	A	V	A	A	A	O	O	V	V	A	A	A	O	V	V	A	A	A	A	X

The relationship between variables in the model is presented in a matrix called the Structural Self-Interaction Matric (SSIM) with the value of the questionnaire from the expert. The researcher uses the professional 2.0 website version of the software because it has been statistically tested. The material contained in the tutorial is in the form of the initial process of entering

questionnaire data from the opinions of experts, until obtaining structural results in the form of levels (key elements) of each factor. The steps in using software in processing research data on the influence of restaurant food waste in Surabaya are as follows: determining the value of the Structural Self-Interaction Matric (SSIM).

The result of an expert questionnaire where the relationship between restaurant food waste factors is changed to VAXO. Then the results of this questionnaire are run using professional software 2.0 ISM on the website. From the table above, it is known that row 1 column 1, p1 with p1 has a value of X which means they are related and preferably, for p1 with p2, p3, p4, p5, p6, p7, p8, p9, m6, d2, has a value of V which means p1 is more important affects p2, p3, p4, p5, p6, p7, p8, p9, m6, d2. For p1 with s1, m2, m3 has a value of O which means not interconnected, p1 with s2, s3, s4, m1, m4, m5, d1, d3, r1 has a value of A which means s2, s3, s4, m1, m4, m5, d1, d3, r1 more importantly affect p1, and the output produced from professional software 2.0 is in the appendix.

Furthermore, the SSIM table is changed back to the reachability matrix (RM) table, where entering the numbers 1 and 0 into the reachability matrix (RM) table can be seen in table 5. The results of the ISM software are then reprocessed with the provisions that if the value of V, A, X has a correlation value, then it is changed to a value of 1 and if the value is 0 then it is changed to 0 because there is no relationship.

Table 5. Final Rechability Matric (RM).

x/y	p1	p2	p3	p4	p5	p6	p7	p8	p9	DP	R
p1	1	1	0	1	0	1	0	1	0	5	3
p2	0	1	0	1	0	0	0	1	0	3	5
p3	1	1	1	0	0	0	1	0	0	4	4
p4	1	0	1	1	0	0	0	0	0	3	5
p5	1	1	1	1	1	0	0	0	0	5	3
p6	0	1	1	1	1	1	0	0	0	5	3
p7	1	1	0	1	1	1	1	0	0	6	2
p8	1	0	1	1	0	1	1	1	0	6	2
p9	1	1	1	1	1	1	1	1	1	9	1
D	7	7	6	8	4	5	4	4	1		
L	2	2	3	1	5	4	5	5	6		

And then determine dependence (D) and level (L) at the end of the line after the last element of the study by adding up the value of 1 and leveling it according to the highest order. To determine the value of driver power (DP) and rank (R) are in the last element column, and the DP value adds up the value of 1 per row and R is the rank on the number of DP. Next, get a graph plot of the results of the reachability matrix (RM), divided by 4 areas. For the first area, the independent value means very strong, the second linkage has a strong value of 2, the third autonomous value has a strong value of 3, and the last area is dependent on the lowest value.

The graph plot of the results of the rechability matrix (RM), divided by 4 quadrant areas. This independent value means that it is very strong and has 9 factors, namely food packaging (A23), non-modern cooking processes (A19), communication between crew and restaurant heads (A20), community culture of disposing of food (A21), presence of regulation (A22), temperature storage (A17), food spillage (A16), socialization of the dangers of food waste (A13), dirty storage (A15), the 2nd strong linkage value includes food standards (A18), urban communities (A12), restaurants and restaurant crews (A10) , food burn (A14). The value of autonomous is strong to 3, but in this quadrant there are no factors that arise. The lowest dependent values include sales planning (A9), coordination between buyers and sellers (A11), appropriate amount of food (A5), purchase planning (A7), number of customers (A8), food overload (A2), inventory planning (A3), delivery schedule (A1), food waste processing planning (A4), and finally organizational management (A6).

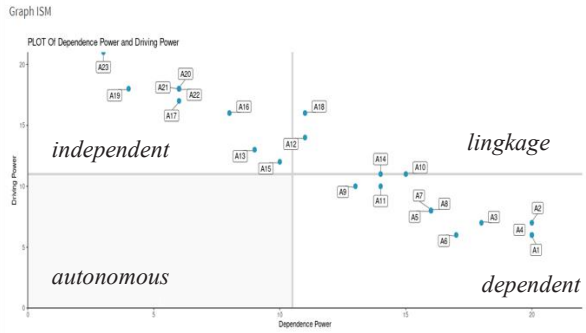

Fig. 4. Graph ISM.

From figure 5 it was found that the most influential factor is food packaging because if the packaging is not durable it can cause stale food and cause food waste. And for a factor that has a low influence, namely the delivery schedule to customers, because it is rare for restaurants to provide poor service in terms of food delivery to customers.

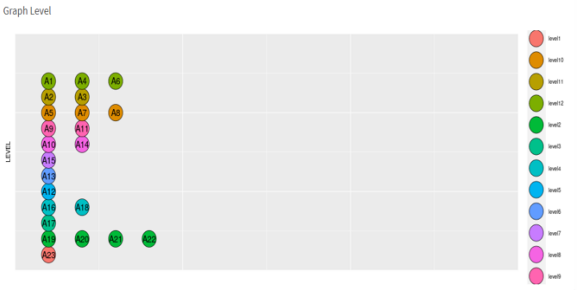

Fig. 5. Level chart.

Coloring on the level chart is used to make it easier to read, the explanation of the color on the level chart is beside the chart with an adjustment in the order from bottom to top. Level graph with professional 2.0 ISM software, it was found that the results of triggering the emergence of restaurant food waste with experts as respondents as follows: the first level with pink color is prioritized in handling that food packaging is a triggering factor for restaurant food waste with code (A23). Green color means the 2nd level, namely the non-modern cooking process (A19), communication between the crew and the head of the restaurant (A20), the culture of people throwing away food (A21), the existence of regulations (A22), the green color means

the 3rd level, namely the storage temperature (A17), the color Tosca means level 4, namely food spills (A16), food standards (A18), the color navy blue means level 5, namely urban communities (A12), the color blue means level 6, namely socialization of the dangers of food waste (A13), the color purple old means level 7 which is dirty storage (A15). And for the next level, purple means level 8, namely the expertise of the head of the restaurant and restaurant crew (A10), burnt food (A14), pink means level 9, namely sales planning (A9), coordination between buyers and sellers (A11), orange color means level 10 which is the appropriate amount of food (A5), purchasing planning (A7), number of customers (A8), brown color means level 11 which is food overload (A2), inventory planning (A3), light green color means level 12 which is schedule delivery (A1), food waste processing planning (A4), and the last is organizational management (A6). This is the output of the professional 2.0 ISM software with experts as respondents. And then it can be known which will be resolved first in restaurant food waste.

The highest value is in the pink color, namely food packaging which is a factor in the occurrence of food waste, because if the packaging is not in accordance with the resistance of the food, the food can spoil easily. And the lowest factor is in the food delivery schedule to consumers.

The level hierarchy of the influence of restaurant food waste has 12 levels. The levels start from the top down, meaning that the order of level 1 is a very important level because food packaging if not good and easily damaged causes food to spoil quickly and cannot be eaten which will be wasted. This is in accordance with what is conveyed by Sugianto [37] and Gilliland [36], namely packaging that is easily damaged so that food returns and also causes food to spoil quickly. And for level 12 is weak because this factor produces little food waste and its handling is not given much attention. These factors are delivery schedules, food waste processing planning, and organisational management. This is also in accordance with the research of Hoehn [33], Isshangulyev [34], Rimanto [35].

4 Conclusions

From the results of the research that has been done there are several suggestions that need to be considered, among others, as follows :(1). Implement stricter quality control measures to ensure packaging integrity and improve the resilience of packaging materials. Additionally, enhance monitoring and inspection protocols for temporary food storage to prevent damage and reduce the incidence of returns. (2). Develop targeted strategies for reducing food waste in restaurants by implementing waste tracking systems and optimizing waste disposal processes in collaboration with government waste management programs. (3). Explore and implement methods for reprocessing food waste, such as converting surplus rice into value-added products like karak or dried rice for resale. Additionally, develop systems to process food waste into animal feed, ensuring that the reprocessing methods are sustainable and economically viable. (4). Future research should focus on identifying and analyzing additional factors contributing to restaurant food waste, including consumer behavior, inventory management, and operational practices. Developing comprehensive strategies to address these factors can enhance waste reduction efforts. The study highlights key areas for improving food waste management, including packaging, disposal, reprocessing, and future research. By addressing these suggestions, stakeholders can enhance efficiency, reduce waste, and contribute to more sustainable practices. Implementing these recommendations can lead to significant improvements in food waste management, benefiting both the environment and the economy.

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