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Bacterial communities as induced by volatile gases releasing from organic compounds in food wastes and bio-wastes in Bangkok, Thailand

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ABSTRACT

The objective of this study was to investigate the aerobic bacterial communities induced by aroma or volatile gas released from 3 different organic wastes. The food and cooked meat wastes were sampled from Kasetsart university canteen, while the bio-wastes were sampled from Span-mai fresh food market, both of them located in Bangkok, Thailand. The organic waste samples were analyzed for physical and chemical characteristics and microbiological analysis. The analysis in 3 organic wastes results showed that total bacteria were found highest in bio-waste following by food waste and cooked meat waste with the value of 2.37×10^5, 7.60×10^4 and 3.51×10^2 CFU/g, respectively, and the same trend were found for bacterial communities for amylolytic bacteria, proteolytic bacteria, lipolytic bacteria and cellulolytic bacteria. However, cellulolytic bacteria were found highest in bio-waste following by cooked meat wastes and food wastes with the value of 1.87×10^4 CFU/g, 1.60×10^1, and 1.150×10^1 CFU/g, respectively. In terms of genus, wastes from 3 sources are similarly composed of *Micrococcus* spp., *Staphylococcus* spp. *Corynebacterium* spp., *Pseudomonas* spp., *Bacillus* spp. *Enterobacter* spp., *Aeromonas* spp. The study was indicated that there was no difference in the composition of bacterial communities from the 3 wastes, but there were different in quantities. The similar physical and chemical characteristics emitted similar odor or volatile chemical and induced similar bacterial communities.

Key words : *Aerobic bacteria, Food wastes, Cooked meat wastes, Bio-wastes*

Introduction

Understandable information on community garbage composition indicated the daily organic waste about 60% which can be identified as food waste over 50%. Generally, Thai food waste are composed of ingredients not only carbohydrates, proteins, cellulose and fibers but they are also included some spicy, chili, hot pepper and herbs because of traditional consumption of taste-like meals in which they produce from tropical-climatic favors of food crops growing. Nowadays, some amount of hot food waste from restaurants and food courts in the cities are intentionally separated for feeding to pig farms, no matter it is spicy or tasteless organic matters. It is understood that the organic wastes are composed of carbohydrate, proteins, lipid (oil and grease), vitamins, salt and minerals, cellulose, and fibers. Besides, microorganisms, especially bacteria, are naturally contaminated in food scraps which play vital role in bacterial organic digestion processes by aerobic and anaerobic processes for converting organic matters to inorganic materials plus gases, liberated heat and leachate.

In general, there are more than 1000 volatile gases as produced by organic carbons from carbohydrates, proteins, cellulose and lignin (called as organic compounds) which are the main components of organic wastes. Compounds of nitrogen and sulfur are among more than 100 gases, some of them set up the odors, such as hydrogen sulfide (H_2S), nitrous oxide (N_2O), etc. Theoretically, volatile gases and odors are generated by biochemical processes and its own hydrocarbon properties which are transferred to attract to the microorganisms before they respond to excrete their enzymes to digest the organic wastes. However, there are some factors to catalyze the bacterial organic digestion process, such as pressure, temperature or heat, pH, alkalinity, salinity, inhibitors, stimulants, C/N ratio, etc. In fact, there are a lot of bacterial species that play a role in the organic digestion processes by either aerobes or anaerobes, but it is not that all species are effective for converting organic matter to inorganic materials (mostly plant nutrients).

In Thailand, the home garbage are produced is about 1 kg/capita/day, 115 million tons/year, and 425 disposing sites (95 landfills 330 dumps) as found by Chiemchaisri and Visvanathan (2008). Fortunately, the latest report 2018 (up to September 2018) of Ministry of Natural Resources and Environment informed the amount of solid wastes in the whole Kingdom of Thailand about 130 million tons/year but the daily product is still 1 kg/capita/day. Not only in Bangkok but also around the world, the community or municipal garbage was composed of organic wastes ranging 40-70% by weight, plastic 10-15%, papers 5-10%, glasses 5-8%, textile 4-8%, leather 4-7% and others such as inert, wood, metals, debris and rubble) as reported (JICA, 1981, 1982, 1991), Sakai, 1996; Chiemchaisri *et al*., 2007; PMO, 2011; Mezah *et al*., 2015; Singh *et al*., 2017; Hosseini *et al*., 2018). And Remarkably, the other parts of garbage (plastic, inert, metals, paper, wood, textile, glass, leather and chemicals) were varied from high to low dense population, from community to community, from country to country, from one human activity type to another one, from season to season and from high to low season tourism. Interestingly, the organic compounds play a significant role in problem establishing in communities as well as internalities and externalities from point sources by odors of VOCs and transferring contaminants (Ahmed and Ali, 2004; Grazhdani, 2016).

The garbage consists mainly of organic wastes (organic compounds) which are identified as carbohydrates, proteins, lipids, lignin, cellulose and fibers (Krzymien *et al*., 1999; Tchnobanoglous and Kreiti, 2002; Komilis *et al*., 2004; Kumar *et al*., 2011, and Pounce-Espinosa *et al*., 2014). From chemical point of view, these organic compounds are comprised of carbon and a few of other elements like H, O, N, P, S and halogens [(F, Cl, Br, I and At (astatine)]. It is well known that the organic compounds are classified into 7 classes: they are 1) hydrocarbon, alkenes and alkynes, 2) alcohols, ethers, and thiols, 3) amines, 4) aldehydes, ketones, and carbonyl if acids, 5) polymers and molecules of long chains by monomers, 6) carbohydrates, lipids, amino acids and proteins, and 7) nucleic acids. Certainly, each of all has their own volatile properties by either organic chemical process, biochemical process, biophysical process, or physical-chemical process to generate some acid or alkaline gases in order to produce volatile gases to specific bacteria types. Then after, Shahriari *et al*. (2013) explained that and Schulz-Bohm *et al*. (2017) the bacteria is taken in response by releasing enzymes to digest that particular types of organic compounds more or less rate of digesting process depending on the involved factors, such as temperature, moisture, constituents of organic compounds (carbohydrates, proteins, lipids, cellulose, lignin, and fibers). However, one constituent of organic compounds is favored by more than one bacterial communities. In fact, all compounds responsible of bacterial life are organic substances as denominated biomolecules, that is carbohydrates, proteins, and lipids, but also nucleic acids, complex molecules involved in genetics, are considered part of them.

The organic wastes are supposed to be the substrate of bacteria as induced by VOCs including odors which are released to the atmosphere through the bacterial organic digestion process to organic compounds (carbohydrates, proteins, oil and fat, cellulose, lignin, fibers, and others). Accordance with the organic compound properties plays vital role in releasing VOCs by its own properties with activating by organic, physical-chemical, biophysical, and biochemical processes in organic wastes as the mixed matters of organic compounds. Consequently, the composition of organic wastes has to be known in order to bring about to bacterial communities identification in relation to the released VOCs by themselves and biochemical process (Obeng and Wright, 1987; Phewnil, 1998; Fleming-Jones and Smith, 2003; Okot-Okumu and Nyenje, 2011; Han and Wang, 2018).

Summarily speaking, this research project will be focused on bacterial communities as induced by volatile gases releasing from organic compounds of food waste, cooked meat waste from Kasetsart university canteen and bio-waste from Span-mai fres-food market at Bangkok, Thailand. In doing so, the in-depth knowledge of organic wastes and bacterial communities will be isolated and identified in order to support how to manage the organic waste disposal.

Materials and Methods

Selection of Experimental Sites

In this study is a study of sampling site in Bangkok metropolitan which collect the organic waste at Canteens was selected at Kasetsart Universit, Bangkhen Campus, (KU canteen) for studying the food waste, and cooked meat waste while the bio-wastes took at Sapan-Mai fresh-food market in Bangkok as shown in Figure 1.

Organic wastes sampling method

In order to study of aerobic bacterial communities which is induced by volatile gas or odor released from the organic compounds (not from composting process), the fresh wastes with no more than 6 hr after generated were collected and studied. The

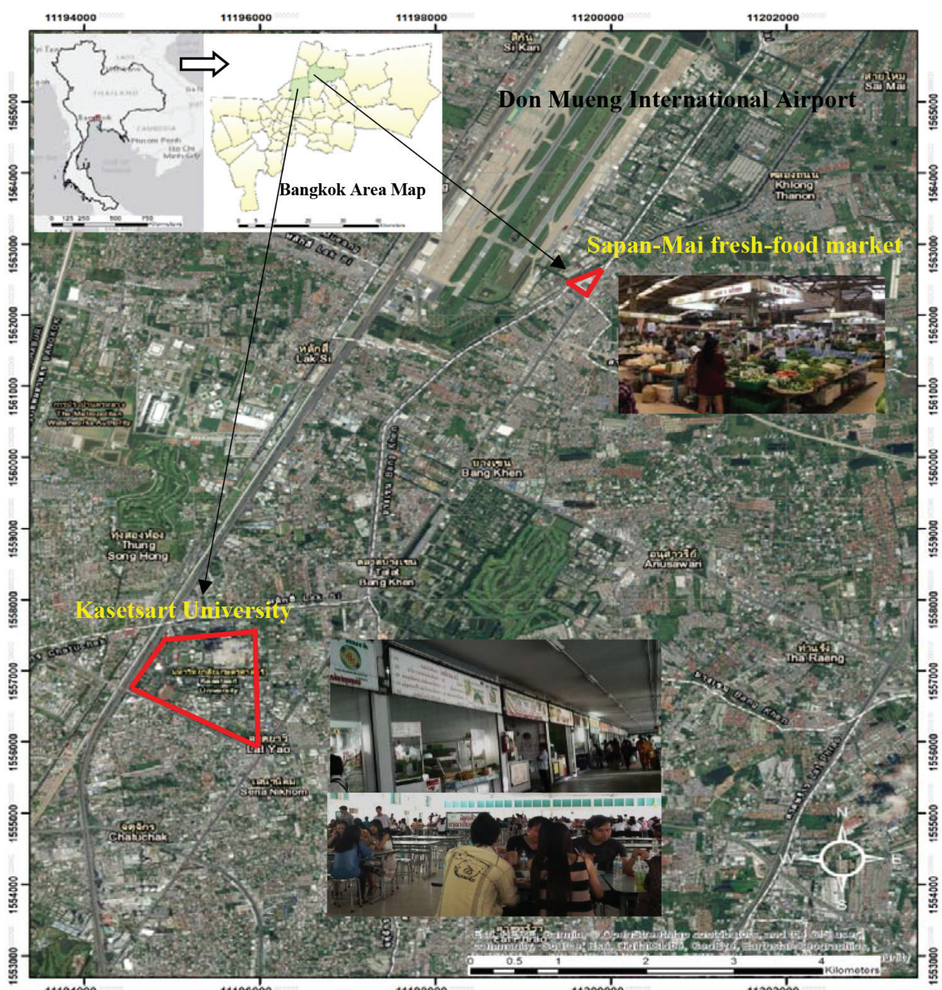

Fig. 1. The geographic location of the study sampling site from Kasetsart university and Sapan-mai fresh-food market at Bangkok, Thailand.

samples of organic compounds in food waste (represent of carbohydrate source) and cooked meat waste (represent of protein source) were collected from KU canteen, and bio-waste (represent of cellulose source) were collected at Sapan-Mai fresh-food market in Bangkok. In each collection; bones and inert material (paper, plastic, etc.) were discarded. Food waste and the bio-wastes were randomly collected by using quartering techniques to obtain 10 kg of organic waste from each source. And cooked meat waste was about 3 kg. The organic waste samples were stored at 4 ^{o}C during the transport and laboratory analysis (Figure 2).

Fig. 2. Organic waste samples collected from 3 sources: (a) food waste at KU canteen (b) cooked meat waste at KU canteen, and (c) bio-waste at Sapan-Mai fresh-food market.

Physical and chemical characteristics analysis

Samples of the organic wastes were subjected to perform of physical-chemical analyses for waste characteristics. Parameters and analytical method according to Ministry of Agriculture and Cooperatives (Thailand) (2008), AOAC (2012), and Srisatit (2016) are summarized in Table 1.

Microbiological analysis

Organic wastes samples were stored at 4 ^{o}C during the transport and analysis. Bacterial isolates identified and were obtained in solid media following the method described by Atlas (2004), Department of microbiology (2011), Kasetsart University (2011) and AOAC (2012) with some modification. The fresh samples were used to determine numbers of culturable aerobic bacteria, using the 10-fold serial dilution method. Initial samples suspensions were prepared by the additions were prepared by the addition of 50 g (w/v) of samples to 450 mL of steriled 0.85% normal saline solutions under aseptic technique. A 0.1 mL aliquot sample was plated on medium for determining enumeration of total bacteria and enzymatic analyses. The microbiological analyses included: 1) enumeration of colony forming units (CFU) of bacteria following dilution plating, 2) Gram stain (classification in bacteria Gram (+) or Gram (-) and specification of cell morphology, 3) enzymatic analysisfor grouping bacteria community of carbohydrate (amylolytic bacteria), protein (proteolytic bacteria), fat and oil (lipolytic bacteria) and cellulose (cellulolytic bacteria), and 4) bacteria identification using biochemical test. Brietly, enu-

Table 1. Various methods used for physical-chemical analysis

	Parameters	Method
Physical parameter	1. Bulk density (BD)	-
	2. Moisture content (MC)	Oven drying method
Chemical parameter	1. pH	A grass electrode pH meter
	2. Electrical Conductivity (EC)	Electrical conductivity meter
	3. Carbohydrate	Calculation
	4. Protein	Kjeldahl method and calculation
	5 Fat and Oil	Extracted by using Petroleum ether
	6. Cellulose	Digestion method
	7. C/N ratio	Calculation
	8. Total Nitrogen (Total N)	Kjeldahl method
	9. Total Phosphorus (Total P_2O_5)	The spectrophotometric method
	10. Total Photassium(Total K_2O)	Flam photometric method
	11. Total organic carbon (TOC), Organic matter (OM)	Walkey-Black method

meration of total aerobic bacteria was carried out on plat count agar (PCA) for 10-fold serial dilution method. Petri dishes were incubated at 35±2 °C and colonies counted after 24-48hr incubation. Enzymatic analysis for classifying bacterial community of carbohydrate, protein, fat and oil and cellulose used media for the assay of each activity for 10-fold serial dilution method were as follows: starch agar (SA) for amylolytic bacteria activity, skim milk agar (SM) for proteolytic bacteria activity, tween 80 agar (TW) for lipolytic bacteria activity and *carboxymethyl cellulose agar (CMC) for* cellulolytic bacteria activity, respectively. Petri dishes were incubated at 35±2 °C and colonies counted after 24-48hr. incubation. Bacteria's biodegradability was tested with iodine solution drops, the results showed as follow: for SA, the white circles formed around the colonies showed that the bacteria could degrade starch. For SM, the clear zone formed around the colonies showed that the bacteria could degrade protein. For TW, the coagulation was formed around the colonies. And CMC was tested with Congo red for 15 min, then rinsed with 1N NaCl for 30 min. The yellow clear zone formed around the colonies showed that the bacteria could degrade cellulose. Gram staining and Biochemical tests were performed to identify genus of bacteria, and the microbes were identified by using Bergey's Manual of Systematic Bacteriology: 9th edition.

Statistical analysis

Three independent replicates were used in all analyses. Differences among food waste, cooked meat waste from KU canteen and bio-wastes from fresh-food market for their enzymatic analysis of bacteria (amylolytic, proteolytic, lipolytic, and cellulolytic), chemical were assessed by one-way analysis of variance (ANOVA) and multiple comparison tests (Duncan's New Multiple Range Test, DMRT). The significance level was at $P \leq 0.05$ level for all analyses.

Results and Discussion

Physical-chemical characteristics

Thai food is normally made from meat and vegetables with stir fly, deep fly, boil with or without coconut milk process and normally contain spices, and served with rice. This make Thai organic wastes from 3 sources have components (carbohydrate, protein, oil and fat, cellulose) in different proportions similarly as reported in Taiwan that studies component in food waste (Chang and Hsu, 2008). The physio-chemical analysis results showed that pH of 3 sources were in weak acidic range from 4.4-4.8 due to high volatile fatty acid as reported (Adhikari *et al.*, 2009; Chori *et et al.*, 2009). Moisture content results of 3 sources showed the value more than 60% because boiling is one of the most popular Thai cooking processes. High water content in food waste (84.5%) and mixed vegetable waste (85%) was also found in wastes as reported (Chori *et al.*, 2009; Bhatia *et al.*, 2013), this made the organic wastes to be used for animal feeds and fertilizers as reported (Xiao *et al.*, 2009; Bhatia *et al.*, 2013; Sarkar *et al.*, 2016; Zhao *et al.*, 2017).C/N ratio were found highest in food waste following by bio-waste and cooked meat waste with the value of 13.73, 12.28, and 4.45, respectively. Total organic carbon results were in the range of 32-45%. Organic matters in 3 sources were in the range of 56-80%, which exceeded the set standard at less than 30%. Total nitrogen and phosphorus exceded the set standard at less than 0.5%. It was found that only bio-wastes that had total potassium at 2.3%, which exceeded the set standard at less than 0.5% (Table 2). In 3 organic wastes compositions that affect chemical characteristics (carbohydrate, protein, oil and fat and cellulose) (Table 2 and Figure 2 and 3). However, comparison in details were as followings:

1). Food wastes from KU canteen: The steam rice was found mostly followed by vegetable scraps and cooked meat scraps. Hence carbohydrates were found mostly at 55.95% following by proteins, oil and fat and cellulose at 21.25%, 12.07% and 9.76%, respectively.

2). Cooked meat wastes from Ku canteen: Pork, fish, and protein composites such as eggs and tofu were found. Hence proteins were found

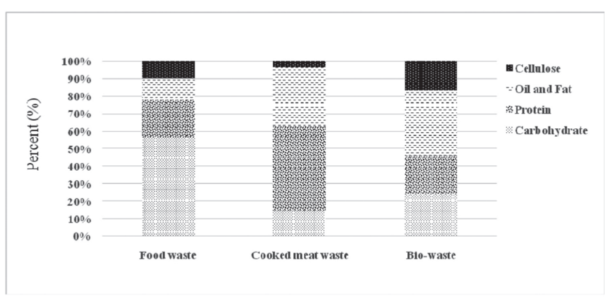

Fig. 3. Amount of nutrient among in the organic waste from 3sources

mostly at 44.87% following by oil and fat, carbohydrate and cellulose at 32.21%, 13.91% and 3.28%, respectively.

3). Bio wastes from Sapan-Mai fresh food market: Vegetable scraps were found mostly following by meat with fat scraps. Hence oil and fat were found mostly at 36.38% following by carbohydrate, protein and cellulose at 23.38%, 21.81% and 16.38%, respectively.

Organic wastes from 3 sources mentioned above contained carbohydrates, proteins, oil and fat, and cellulose. Carbohydrates found in organic waste, rice and vegetables, polyhydroxy aldehyde or polyhydroxy ketone or hydrocarbon compounds, providing 2 products mentioned. Proteins wastes were from cooking and consuming made from plants such as beans or from animals such as pork, beef and fish. Protein were large molecules mostly found in biological systems with high molecular weight composted of carbon (C) hydrogel (H) and oxygen (O) nitrogen (N) and sulfur (S). The smallest structure was amino acid. Fat and oil were lipids composted of saturated fatty acid such as lard, pork, pork liver, chicken, egg, rice etc. and unsaturated fatty acid such as soybean oil and palm oil. The molecule of oil and fat composted of C, H, and O. However, lipids contained oxygen less than carbohydrates, but contain C and H more than carbohydrates. Some lipids contained nitrogen, phosphorus, and sulfur. Celluloses were mostly found from biowastes from fresh food market such as vegetables and fruits. They were homogeneous polysaccharide that mostly found in nature in plant tissues. The molecules were composted of D-glucose from 2,500 to 14,000 units, which contained C, H and O as reported Rotporboonsathit, 2013; Phongsawas *et al*., 2014; Chareonpanich, 2015). The compositions were sources of volatile gases or odor releasing from food

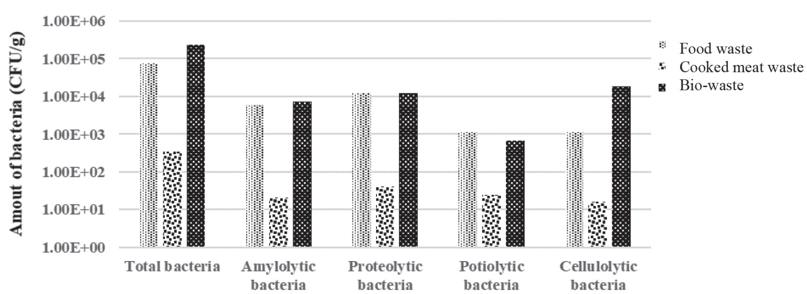

Fig. 4. The number of bacteria collected from organic waste in 3 sources.

Table 2. Physical-chemical characteristics of organic waste from 3 sources

Parameters	Unit	Food Waste	Cooked meat waste	Bio-waste	Standard of Compost in Thailand*
BD	g/cm^3	0.61	0.60	0.39	
MC	%	90.01	70	63.33	≤ 35%*
pH	-log[H$^+$]	4.8	4.5	4.4	5.5-8.5*
EC	dS/m	7.21	5.21	8.64	≤ 6 dS/m
Carbohydrate	%	55.95	13.91	23.38	
Protein	%	21.25	44.87	21.81	
Oil and Fat	%	12.07	32.21	36.38	
Cellulose	%	9.76	3.23	16.38	
C/N ratio	-	13.73:1	4.45:1	12.28 : 1	≤ 20:1*
Total N	%	3.3	7.30	3.5	≤ 1% W/W*
Total P_2O_5	%	0.6	1.10	0.6	≤ 0.5% W/W*
Total K_2O	%	0.40	0.45	2.30	≤ 0.5% W/W*
TOC	%	45.3	32.50	43.0	
OM	%	78.1	56.00	74.1	≤ 30% W/W*

Note:* Standard of Ministry of Agriculture and Cooperatives (Thailand), 2008.

component induced bacteria as follows: 1) aroma compound in foods containing carbon such as aldehydes alcohol, ketone, esters, lactones, carboxylic acids, terpenes, terpenoids, butanol, alkanes, butanedione, butanone and acetoin, 2) Oxygen heterocyclic and phenols such as furans and furanoids, furanones, pyranones and phenols, 3) Nitrogen compound such as amines, pyrroles, pyrrolines, pyridines and pyrazines, aminoacetophenone, trimethylanine and indole, and 4) Sulfur compound such as Sulfides, dimethyl disulfide, thiols, thiophenes, thiazoles, thiazolines, thioesters, mercapto ester and isothiocyanates (Audrain *et al.*, 2015; Parker, 2015). Causing volatile gases that can induce bacteria community to growth. Some reports indicated that, volatile fatty acid degrading and total bacteria abundance was significantly reduced the odour index (Awasthi *et al.*, 2018).

Bacterial enumeration and identities

The 3 organic wastes were different due to food and cooked meat wastes were pass heat-cooking processes, but the bio-wastes did not. Moreover, the compounds that generated volatile gases or odors in the wastes cause attract unequal bacteria in growth were also different. Therefore, aerobic bacteria were found highest in bio-wastes following by food and cooked meat waste at 2.37×10^5, 7.60×10^4, and 3.51×10^2 CFU/, respectively as shown in Table 2. The different quantity of bacteria was affected by contamination during transportation process and collection system as reported (Chomsri, 2012; Chutov, 2015)

Enzymatic analysis (amylolytic bacteria, proteolytic bacteria, lipolytic bacteria, and cellulolytic bacteria) were investigated in 3 sources (food waste, cooked meat waste, and bio-waste). The resulted show that, all sources were consistent with the number of bacteria and sources of nutrients collected from various locations. In food wastes represented carbohydrate sources, proteolytic bacteria were found at 6.00×10^3 CFU/g ($P \le 0.05$), which is more than amylolytic bacteria. In cooked meat wastes

Table 3. Comparison of aerobic bacteria found in organic waste from each sample source using One Way ANOVA

Sources	Total bacteria (CFU/g)	Amylolytic bacteria (CFU/g)	Proteolytic bacteria (CFU/g)	Lipolytic bacteria (CFU/g)	Cellulolytic bacteria (CFU/g)	Genus of bacteria
Food waste at KU canteen	7.60×10^{4b}	6.00×10^{3a}	1.20×10^{4a}	1.13×10^{3a}	1.15×10^{3b}	*Micrococcus* spp. *Corynebacterium* spp. *Staphylococcus* spp. *Bacillus* spp. *Pseudomonas* spp. *Enterobacter* spp.
Cooked meat waste at KU canteen	3.51×10^{2c}	2.10×10^{1b}	4.20×10^{1b}	2.50×10^{1a}	1.60×10^{1b}	*Micrococcus* spp. *Corynebacterium* spp. *Staphylococcus* spp. *Bacillus* spp. *Enterobacter* spp.
Bio-waste waste at Span-Mai fresh-food market	2.37×10^{5a}	7.30×10^{3a}	1.20×10^{4a}	6.70×10^{2a}	1.87×10^{4a}	*Micrococcus* spp. *Corynebacterium* spp. *Staphylococcus* spp. *Bacillus* spp. *Pseudomonas* spp. *Aeromonas* spp.

Note: The same vertical letters represent the mean without statistical difference at a significant level of 0.05 ($P \le 0.05$) analyzed by usingDuncan test a represents the highest difference value of the sample.

represented protein sources, proteolytic bacteria were found with highest amount at 4.20×10^1 CFU/g($P \leq 0.05$), which corresponded to the highest protein at 44.87%. In bio-wastes represented cellulose sources, cellulolytic bacteria were found highest at 1.87×10^4 CFU/g ($P \leq 0.05$), which corresponded to the highest cellulose content at 16.38% (Table 2). The similarity contents in terms of carbohydrates, proteins, oil and fats and cellulose were found in the 3 organic wastes. Those contents were C, N and energy sources for activities and growth as reported by Adhikari *et al*., (2009). Abundant substrates at the beginning of wastes triggered high competition between microbial groups. Then, dominant bacterial groups were the bacteria that were attracted by volatile gases or odor from chemical compounds in wastes and to emit quarum sensing to attract the same species/genus to be accumulated as reported (Solano *et al*., 2014; Audraid *et al*., 2015; Schulz-Bohm *et al*., 2017). The chemical characteristic results in the 3 organic wastes were similar in chemical compounds, but were different in quantity. Then the similar type of bacteria in term of proteolytic bacteria, lipolytic bacteria and cellulolytic bacteria were found with different amount (Table 3 and Fig. 4). During bacterial-enzyme decomposing, the clear zones in SA, SM and CMC substrates were found as reported (Tsai *et al*., 2007) and as shown in Figure 5. Similar bacterial decomposing carbohydrates, proteins, oil and fat, and celluloses were found genus comprising of *Micrococcus* spp., *Corynebacterium* spp., *Staphylococcus* spp., *Bacillus* spp., *Pseudomonas* spp., *Enterobacter* spp., and *Aeromonas* spp. (Table 3).

Relationships between physical-chemical characteristics and bacterial groups in organic wastes

The relationships between bacterial growth on substrates and the bacterial decomposition on nutrient sources in terms of carbohydrates, proteins, oil and fat and celluloses were consistent. Analysis results on enzyme activities from 3 organic wastes disclosed that amylolytic bacteria were significantly found in the food wastes and bio-wastes with high amount at 6.00×10^3CFU/g and 7.30×10^3 CFU/g($P \leq 0.05$), respectively. Proteolytic bacteria were significantly found in food wastes and bio-wastes with the similar highest amount at 1.20×10^3 CFU/g ($P \leq 0.05$). Lipolytic bacteria were insignificantly found in all wastes at 1.13×10^3 CFU/g, 2.50×10^1 CFU/g and 6.70×10^2 CFU/g, with $P \leq 0.05$ respectively. Moreover, cellulolytic bacteria were significantly found in bio-wastes with the highest amount at 1.87×10^4 CFU/g ($P \leq 0.05$). However, bacteria group had similar digesting ability in all 3 organic wastes although genus and amount of amylolytic, proteolytic, lypolytic and cellulolytic bacterial were differently found as shown in Table 5 and 6. Organic wastes from 3 sources had many chemical compositions and is very different due to the source of the waste has different activity that produced from different raw materials, cooking and producing processes. Therefore, available bacteria started to digest simple complex nutrients such as carbohydrates found in rice and young leafy vegetables following by more complex nutrients such as proteins, fats and cellulose, respectively as reported

Table 3. Comparison of enzymatic analysis from each sources sample using One Way ANOVA

Enzymatic analysis	Food waste at KU canteen	Cooked meat waste at KU canteen	Bio-waste waste at Span-Mai fresh-food market
Amylolytic bacteria (CFU/g)	$6.00 \times 10^{3\,b}$	$2.10 \times 10^{1\,c}$	7.30×10^{3c}
Proteolytic bacteria (CFU/g)	1.20×10^{4a}	$4.20 \times 10^{1\,a}$	1.20×10^{4b}
Lipolytic bacteria (CFU/g)	1.13×10^{3d}	2.50×10^{1b}	6.70×10^{2d}
Cellulolytic bacteria (CFU/g)	$1.15 \times 10^{3\,c}$	1.60×10^{1d}	1.87×10^{4a}
Genus of bacteria	*Micrococcus* spp. *Corynebacterium* spp. *Staphylococcus* spp. *Bacillus* spp. *Pseudomonas* spp. *Enterobacter* spp.	*Micrococcus* spp. *Corynebacterium* spp. *Staphylococcus* spp. *Bacillus* spp. *Enterobacter* spp.	*Micrococcus* spp. *Corynebacterium* spp. *Staphylococcus* spp. *Bacillus* spp. *Pseudomonas* spp. *Aeromonas* spp.

Note: The same vertical letters represent the mean without statistical difference at a significant level of 0.05 ($P \leq 0.05$) analyzed by using Duncan test a represents the highest difference value of the sample.

(Phewnil, 1998). Bacteria were induced by volatile gases or odor from the carbon, oxygen heterocyclic, phenol, nitrogen and sulfur compound in wastes and congregated and increased. During the congregation bacteria were communicated as reported by Faran and Ryu, (2015) and Parker, (2015), then emit specific enzyme to digest organic compounds to smaller molecules or inorganic molecule or fertilizers as reported (Xiao *et al.*, 2009; Bhatia *et al.*, 2013; Solano *et al*., 2014; Audraid *et al*., 2015; Sarkar *et al.*, 2016; Schulz-Bohm *et al*., 2017; Zhao *et. al.*, 2017).

Conclusion

The results indicated all organic wastes contained different physical–chemical characteristics, but similar compounds such as carbohydrates, proteins, oil and fat, and celluloses. In the food wastes represented carbohydrate sources, amylolytic bacteria were dominantly found. In terms of enzymatic analyses, bacteria from 3 wastes were eligible to decompose carbohydrate, protein, oil and fat and cellulose by bacteria. In cooked meat waste represented protein sources, proteolytic bacteria were dominantly found. Moreover, in bio-waste represented cellulose sources, lipolytic bacteria were dominantly found following by cellulolytic bacteria. The total aerobic bacteria were found in abundance in bio-wastes from Sapan-mai fresh-food market following by the food wastes and cooked meat wastes from the KU canteen at $2.37x10^5$CFU/g, $7.60x10^4$CFU/g, and $3.51x10^2$CFU/g, respectively. In addition, volatile gases or odor releasing from the all wastes induced similar bacterial. Then they were communicated and aggregated, and finally decomposed compounds in the wastes. Consequently, in all wastes, there were no difference in bacterial digestion abilities, but the number of bacteria depended on composition and quantities of the wastes. Therefore, the organic wastes could be managed and reused as fertilizer because the food wastes, cooked meat waste and bio-wasts already contain bacteria decomposed carbohydrates, proteins, oil and fat and cellulose.

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