Catering waste as organic matter potential for compost production

Odpady gastronomiczne jako potencjał materii organicznej do produkcji kompostów

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DOI 10.36119/15.2022.7-8.9

The aim of the week long field/pilot study was to conduct research on the identification and physicochemical evaluation of waste fractions from selected food service units. During the field study, food waste was segregated for each meal (breakfast, lunch, dinner, or lunch-and-dinner) at each research facility. Each segregated waste fraction was weighed and then samples were collected for physicochemical testing. Preliminary pilot/field studies indicate that the amount of catering waste generated by one guest staying in the investigated health resorts or hotels for the Kamien Pomorski commune and surroundings can range from 76.4 kg/(M-a) according to the results obtained for the "Jantar" resort to 256.2 kg/(M-a) according to the results obtained for the Mieszko Nowe health resort. The physicochemical analyses of food wastes indicate that the dry matter content of catering wastes ranges from 17.94 to 28.51% (mean 24.43%) and the organic matter content from 70.41 to 94.93% (mean 87.54%). The content of heavy metals in the analyzed samples did not exceed the content permitted by legal acts. This waste can be used as material in the composting process. However, it should be remembered that food waste should first undergo a hygienization process. This is in line with the European plan for a resource-efficient Europe. This plan aims to introduce waste management as a resource by 2020.
Keywords: waste, category III waste, catering waste per resident

Celem, trwających tydzień, badań terenowych/pilotażowych było wykonanie badań dotyczących: identyfikacji oraz oceny fizykochemicznej frakcji odpadów pochodzących z wytypowanych jednostek gastronomicznych. Podczas badań terenowych w każdym obiekcie badawczym segregowano odpady gastronomiczne dla każdego posiłku (śniadanie, obiad, kolacja lub obiadokolacja). Każda wysegregowana frakcja odpadów była ważona a następnie pobierane były próbki do badań fizykochemicznych. Przeprowadzone wstępne badania pilotażowe/terenowe wskazują, że ilość odpadów gastronomicznych wytwarzanych przez jednego gościa przebywającego w badanych uzdrowiskach lub hotelach dla gminy Kamień Pomorski i okolic może wynosić w skali rocznej od 76,4 kg/(M·a) według wyników uzyskanych dla Ośrodka „Jantar" do 256,2 kg/(M·a) według wyników uzyskanych dla Uzdrowiska Mieszko Nowe. Przeprowadzone badania fizykochemiczne odpadów żywnościowych, wskazują, że zawartość suchej masy w odpadach gastronomicznych wynosi od 17,94 do 28,51% (średnio 24,43%), a substancji organicznej od 94,00 do 94,93 %. Zawartość metali ciężkich w analizowanych próbach nie przekraczała zawartości dopuszczalnych w aktach prawnych. Odpady te mogą być wykorzystywane jako materiał w procesie kompostowania. Należy jednak pamięć, że odpady żywnościowe powinny być poddane najpierw procesowi higienizacji. Jest to zgodne z europejskim planem na rzecz zasobooszczędnej Europy. Plan ten zakłada wprowadzenie gospodarowania odpadami jako zasobami do 2020 roku.
Słowa kluczowe: odpady, odpady kategorii III, ilość odpadów gastronomicznych na jednego mieszkańca

Introduction

A circular economy can significantly reduce the negative environmental impacts of resource extraction and use. It can also contribute to restoring biodiversity and nature in Europe. It is estimated that 20% of all food produced in the EU is lost or wasted. Therefore, in line with the Sustainable Development aims and within the framework of Directive 2008/98/EC, the reduction of food waste is planned as one of the key actions under the future EU strategy „from farm to fork" (COM(2020) 98).

Municipal waste is defined as waste generated by households as well as non-hazardous waste from other waste generators, which due to their nature or composition are similar to household waste. The sources of municipal waste generation are households, infrastructure

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facilities (trade, services, crafts, education, industry in the "social" part) and others.

In accordance with the Regulation of the Minister of Environment of 2 January 2020 on waste catalog (Journal of Laws, item 10), the municipal waste stream includes: segregated and selectively collected fractions, non-segregated (mixed) municipal waste, green waste, bulk waste and hazardous waste.

Regulation of the Minister of Environment of 29 December 2016 on the detailed method of selective collection of selected waste fractions, introduced from July 2017 the obligation of selective collection of biodegradable waste, with particular emphasis on bio-waste. According to the CSO (Statistical Yearbook of Environmental Protection, 2020), in 2019 104 kg of waste per capita was separately collected, including 31 kg of biodegradable waste. This can be divided to 115 kg per capita in urban areas and 86 kg per capita in rural areas. Eurostat (2018) reports that in EU countries in 2017, municipal waste generated 7-10% of the total waste generated (246.94 million tons).

The possibility of processing collected food waste is regulated by the Act on Waste of December 14, 2012, Journal of Laws No. 21 as amended, which specifies that a regional municipal waste processing facility should ensure, among other things, processing of selectively collected green waste and other bio-waste and allow to generate products with fertilizer properties or plant growing aid. At the same time, a ban on depositing this waste in landfills has been introduced. According to the current regulations, selectively collected catering waste can be processed into an organic, organic-mineral fertilizers or soil improvers.

According to Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules concerning animal by-products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation) Art. 10 catering waste is categorised as Category 3. Category 3 material comprises animal by-products arising from the production of products intended for human consumption, including degreased bones, greaves and centrifuge or separator sludge from milk processing (paragraph e); and products of animal origin, or foodstuffs containing products of animal origin, which are no longer intended for human consumption for commercial reasons or due to problems of manufacturing or packaging defects or other defects from which no risk to public or animal health arise (paragraph f); catering waste other than that referred to in Article 8, F (paragraph p). The use of catering waste as a raw material in industrial bioprocesses requires new legislation. For example, the European Waste Framework Directive 2008/98/EC (Article 6) provides the required technical specifications for both composting and fermentation processes.

Among organic residues, food waste is becoming a growing concern as a potential water and soil pollutant, as well as a source of greenhouse gas emissions. The Food and Agriculture Organization of the United Nations (FAO) has estimated that more than one-third of the total food produced is lost, discarded or not consumed (Gustavsson et al., 2013, Corrado, Sala, 2018), other studies indicate a number up to 50% (Lundqvist et al., 2008). The main producers of food waste are households and the hotel industry. Hotels generate 21% of the total mass of food waste generated worldwide (Principato et al., 2018). Waste generated in restaurants, hospitals, canteens or catering services can be considered as discarded food. This is understood from the logistics and storage processes, through the cooking stages, to the unconsumed food from plates or leftovers from catering services. According to a study (Kaur et al., 2019), hotel waste accounts for 30 – 60% of municipal solid waste.

Levereza et al. (2021) indicate that the mass of food waste generated can be reduced through proper food management in kitchens. Breakfast buffets should be introduced in hotels as well as using smaller portions of dishes and supplementing the breakfast buffet with fewer dishes prepared on time.

Research conducted on Croatian households (Ilakovac et al. 2020), showed that on average 75 kg of food waste per capita per year is produced, which is less than the European average of 92 kg. Among socio-demographic characteristics, only age has a positive effect on reducing household food waste, while the level of household income and the number of children in households under 18 have no effect.

Materials and methods

Local studies in Kukań and Wołczyno

The research was conducted from 20.10.2020 to 20.04.2021 in 15 households in the villages of Kukań and Wołczyno in Gryfice municipality, Gryfice county, West Pomeranian voivodeship. The research consisted of a questionnaire of municipal waste generated in a household. The data collected included dates of disposal, mass and volume indexes of mixed waste, metal and plastic waste, glass waste, cardboard and paper waste, biodegradable waste and food waste. In each of these households, waste was collected every two weeks. The residents also completed anonymous questionnaires on waste management in their households.

Field research in Kamień Pomorski

Field/pilot surveys were carried out in the area covered by the Kamień Pomorski Municipal Management Company from 21.08 to 27.08.2017.

The following research sites were selected for the study:

1) Health Resort Kamień Pomorski
a) Canteen – Health Resort Sanatorium "Dąbrówka", (hereinafter referred to as Dąbrówka)
b) Health Resort Sanatorium "Chrobry", (further referred to as Chrobry),
c) Health Resort Sanatorium "Mieszko", (further referred to as Mieszko),
d) Health Resort Sanatorium "Mieszko Nowe", (hereinafter referred to as Mieszko Nowe),
2) "Jantar" Resort (hereinafter referred to as Jantar)
3) Marena Wellness & Spa, (hereinafter referred to as Marena).

Tables 1 and 2 present the basic data of the studied sites.

In the pilot study, the Jantar and Marena facilities were treated as operating in the season, as they have 100% occupancy in the holiday season, while in the off-season the number of guests varies. The remaining research facilities belong to the Kamień Pomorski health resorts and their occupancy is year-round.

During the field study, catering waste was segregated for each meal at each

Table 1. Basic information from each studied sites
Tabela 1. Podstawowe dane obiektów badawczych

Location	Breakfast	Lunch	Supper	Dinner	Year-round	Season
Dąbrówka	yes	yes	yes	no	yes	no
Chrobry	yes	yes	yes	no	yes	no
Mieszko	yes	yes	yes	no	yes	no
Mieszko Nowe	yes	yes	yes	no	yes	no
Jantar	yes	no	no	yes	yes	yes
Marena	yes	no	no	yes	yes	yes

Table 2. Mean number of guests at research facilities
Tabela 2. Średnia liczba gości w obiektach badawczych

Location	21.08	22.08	23.08	24.08	25.08	26.08	27.08	Mean
Dąbrówka	64	65	69	72	70	70	70	69
Chrobry	173	160	180	177	179	182	181	176
Mieszko	167	167	160	143	174	173	170	165
Mieszko Nowe	36	38	43	39	45	41	38	40
Jantar	125	175	191	190	175	185	190	173
Marena	55	109	120	153	116	88	137	111
Mean	103	116	114	129	126	123	131	120

research facility. Each segregated waste fraction was weighed on laboratory scales. Samples were taken from each fraction for further physicochemical testing. In order to prevent the occurrence of physicochemical and biological changes, the collected samples were transported in a truck refrigerator and stored in a freezer. Approximately 150 samples were collected during the field study.

Field research was conducted in:

- Sanatorium „Chrobry", Sanatorium „Mieszko", Sanatorium „Mieszko Nowe" twice a day – in the morning the waste from supper and breakfast was examined, in the afternoon from lunch,
- Canteen – Health Resort „Dabrowka" three times a day: after breakfast, lunch and supper,
- – Jantar" Resort and Marena Wellness & Spa twice a day after breakfast and after dinner.

The research used catering waste collected during a week-long field/pilot research conducted in the area covered by the activities of the Public Utilities Company in Kamień Pomorski. The study consisted of following tasks: identification of waste fractions from selected catering units, evaluation of waste fractions from selected catering units, physicochemical testing of catering waste (pH, dry mass, loss on ignition, conductivity, determination of macronutrients: N, P, K, Ca, Mg and Na and heavy metals Cd, Ni, Pb, Zn, Cu, Cr). Analytical determinations of physicochemical properties of the studied wastes were performed by reference methods, in accordance with current standards and instructions: PN-EN 12176:2004, PN-EN 12880:2004, PN-EN 12879:2004, PN-EN 16169:2012, PN-EN ISO 6878:2006, PN-EN ISO 13657:2006.

Results and analysis

Questionnaire

The questionnaire was conducted in 37 households in rural areas. Of these, waste segregation is carried out in 64.9%. In the remaining 35.1%, the inhabitants stated that they do not have time – 7.69 %, they do not have enough space to keep several bags – 46.15 % or they live with people who do not want to segregate waste – 46.15 % (Fig. 1).

Figure 1.
Number of households where waste is not separated along with the reason for behind it
Rysunek 1. Liczba gospodarstw domowych, w których odpady nie są segregowane wraz z powodem niesegregowania odpadów

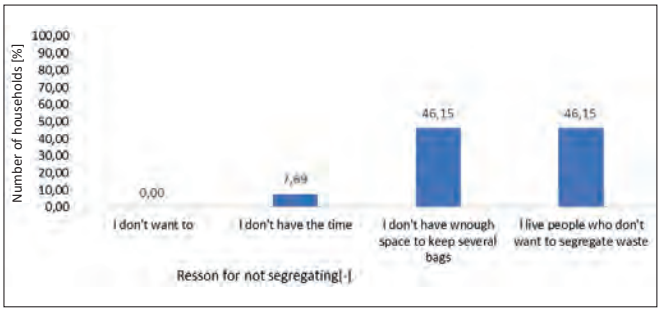
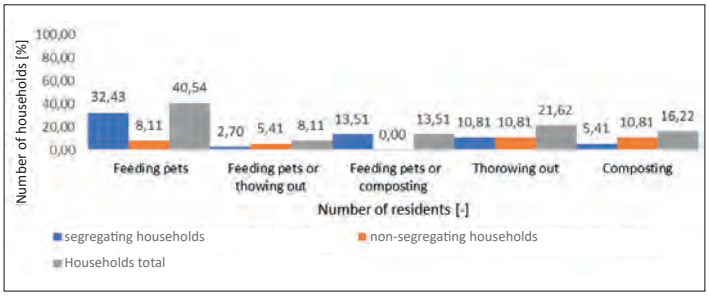


Figure 2.
Ways of managing post-catering waste in households
Rysunek 2. Sposoby zagospodarowania odpadów pospożywczych w gospodarstwach domowych



The buildings in which the questionnaires were conducted are located in villages with 50 to 100 inhabitants, 100 to 200 inhabitants and 200 to 500 inhabitants. In a village with 50 to 100 inhabitants, 16.2% of households separate waste, while 8.1% do not. In a village with 100 to 200 inhabitants, 5.4% of households are non-segregators and 0% are segregators. On the other hand, in a village with 200-500 residents, 48.6% of households segregate waste and 21.6% do not.

According to the questionnaire, mixed and segregated municipal waste is collected once every two weeks.

On the other hand, there is no collection of catering waste, which the inhabitants of households are supposed to manage themselves. Despite the fact that as many as 35.1% of households declared that they do not segregate waste, they use catering waste for feeding animals or composting. Fig. 2 shows how catering waste from households is utilized, divided into households that separate and those that do not separate municipal waste, and the total number of households. In the majority of households (40.54 %), post-food waste is used for feeding pets including 32.43 % in segregating households and 8.11 % in non-segregating households.

Field research conducted in Kamień Pomorski

Table 3 shows the mass of food waste per capita in the hotel by meal and by year. The data shows that the most catering waste is generated from dinner (from 43.6 to 163.9 kg/M*a for lunch and up to 91.1 kg/M*a for dinner). The total annual mass of catering waste per one inhabitant depends on the standard of the facility (the higher the more) and for Mieszko Nowe it amounted to 256.2 kg/M*a. This value is significantly higher than reported by the CSO (2020). In contrast, Brautigan et al. (2014) reports that the per capita mass of catering waste in the EU is 288.5 kg per year. Beretta et al. (2013) indicates that the percentage of catering wastage from food

Table 3. Mass of catering waste
Tabela 3. Masa odpadów żywnościowych

Location	Mieszko	Mieszko Nowe	Dąbrówka	Jantar	Marena
	kg/P/Year				
Breakfast	11.4	54.6	15.8	17.4	29.6
Lunch	66.1	163.9	43.6	-	-
Supper	10.5	37.6	6.2	-	-
Dinner	-	-	-	59.1	91.1
Sum	88.0	256.2	65.5	76.4	120.7

services is 25.9% for meat, including 50.3% for poultry, 20.0% for bread, 18.0% for pasta, 28.2% for fresh fruit and 31.1% for fresh vegetables. These ratios for households are respectively: 19.25% for meat (poultry 34.0%), bread 29.0%, pasta 6.0% (WRAP, 2014), fresh fruit 29.7%, fresh vegetables 31.0% (De Laurentiis et al. 2018).

According to Tables 4, 5, 6 and 7, the reaction of catering wastes was acidic and was 4.75 for breakfast waste to 5.50 for dinner waste. In our study, breakfast waste had the highest dry matter and organic matter content of 27.10% and 94.93% organic matter respectively (Table 4) and lunch waste had the lowest dry matter content of 17.94% (Table 5) and dinner

Table 4. Physicochemical tests of catering waste generated during breakfast
Tabela 4. Badania fizykochemiczne odpadów żywnościowych powstających podczas śniadania

Meal	pH	Conductibity	Dry mass	Organic matter	Total nitrogen content	Total phosphorus content	Metals [mg/kg d.m]									
		[mS/cm]	[%]	[% d.m]	[% d.m]		Ca	K	Mg	Na	Cd	Cr	Cu	Ni	Pb	Zn
Breakfast	4.82	3.59	25.77	94.33	3.64	0.53	1011.40	10117.20	585.70	13283.10	< 1	< 1	< 1	< 1	< 1	16.1
	4.95	1.39	12.61	92.78	2.62	0.76	2969.90	28430.70	1384.20	318.80	< 1	8.7	5.1	3.6	< 1	19
	4.58	2.46	28.94	95.13	2.77	0.40	461.10	8292.60	346.90	11904.40	< 1	< 1	4.2	< 1	< 1	18.3
	4.42	1.99	21.19	95.80	5.16	0.65	2034.10	7978.30	308.20	7610.10	< 1	< 1	< 1	< 1	< 1	10.7
	4.79	3.94	39.03	95.55	3.61	0.66	2455.30	4377.30	442.00	11083.10	< 1	< 1	< 1	< 1	< 1	7.9
	4.96	2.84	35.05	95.97	3.65	0.48	3439.30	5331.80	425.80	8346.30	< 1	< 1	< 1	< 1	4.4	11.2
Mean	4.75	2.70	27.10	94.93	3.58	0.58	2061.85	10754.65	582.13	8757.63	<1					13.87
Standard deviation	0.21	0.96	9.55	1.20	0.90	0.13	1143.97	8907.26	404.42	4658.11						4.55

Table 5. Physicochemical tests of catering waste generated during lunch
Tabela 5. Badania fizykochemiczne odpadów żywnościowych powstających podczas obiadu

Meal	pH	Conductivity	Dry mass	Organic matter	Total nitrogen content	Total phosphorus content	Metals [mg/kg d.m]									
		[mS/cm]	[%]	[% d.m]	[% d.m]		Ca	K	Mg	Na	Cd	Cr	Cu	Ni	Pb	Zn
Lunch	4.59	3.58	21.62	94.24	3.51	0.33	366.90	7405.40	589.50	16188.40	< 1	< 1	3.5	< 1	< 1	14.50
	5.07	3.44	17.12	92.11	3.91	0.48	974.00	12856.20	951.50	19914.70	< 1	< 1	< 1	< 1	< 1	12.30
	4.37	2.96	14.15	90.48	0.84	0.25	1450.40	14246.70	653.00	25536.50	< 1	1.5	6.1	< 1	< 1	11.70
	5.42	3.15	18.85	92.71	2.39	0.95	1403.00	11825.30	916.20	17517.20	< 1	< 1	5.4	< 1	< 1	21.30
Mean	4.86	3.22	17.94	92.39	2.66	0.50	1048.58	11583.40	777.55	19789.20						14.95
Standard deviation	0.47	0.28	3.13	1.55	1.37	0.31	502.43	2956.77	182.90	4130.17						4.40

Table 6. Physicochemical testing of catering waste generated during supper
Tabela 6. Badania fizykochemiczne odpadów żywnościowych powstających podczas kolacji

Meal	pH	Conductivity	Dry mass	Organic matter	Total nitrogen content	Total phosphorus content	Metals [mg/kg d.m]									
		[mS/cm]	[%]	[% d.m]	[% d.m]		Ca	K	Mg	Na	Cd	Cr	Cu	Ni	Pb	Zn
Supper	5.46	2.18	33.07	96.37	2.67	0.39	5805.80	5300.80	482.50	4887.10	< 1	2.8	12.6	1.4	< 1	13.60
	6.01	3.23	27.53	86.50	5.77	0.72	35486.00	7951.10	835.10	11948.10	< 1	4	7.5	1	< 1	25.30
	5.32	4.65	30.53	93.57	3.96	0.65	3869.10	7471.20	383.20	15752.10	< 1	< 1	< 1	< 1	< 1	16.20
	5.22	3.97	22.90	93.33	1.41	0.33	984.90	11748.20	715.40	16191.50	< 1	< 1	3.9	< 1	< 1	10.20
Mean	5.50	3.51	28.51	92.44	3.45	0.52	11536.45	8117.83	604.05	12194.70						16.33
Standard deviation	0.35	1.06	4.37	4.20	1.86	0.19	16088.76	2680.87	207.63	5231.04						6.47

Table 7. Physicochemical testing of catering waste generated during dinner
Tabela 7. Badania fizykochemiczne odpadów żywnościowych powstających podczas obiadokolacji

Meal	pH	Conductivity	Dry mass	Organic matter	Total nitrogen content	Total phosphorus content	Metals [mg/kg d.m]									
		[mS/cm]	[%]	[% d.m]	[% d.m]		Ca	K	Mg	Na	Cd	Cr	Cu	Ni	Pb	Zn
Dinner	4.91	3.62	23.57	93.46	5.10	0.74	1426.10	10786.40	613.50	13744.30	< 1	< 1	< 1	< 1	< 1	27.60
	5.08	3.72	31.80	94.24	6.26	1.05	7241.00	5903.10	446.70	11440.90	< 1	< 1	< 1	< 1	< 1	20.90
	4.95	3.77	25.13	95,97	5.13	1.96	26071.20	8878.30	771.20	13279.10	< 1	< 1	< 1	< 1	< 1	13.20
	4.68	2.83	16.21	92.34	1.61	0.34	3346.40	14850.00	912.00	15932.90	< 1	3	13.9	1.5	< 1	12.40
Mean	4.91	3.48	24.18	94,00	4.53	1.02	9521.18	10104.45	685.85	13599.30						18.53
Standard deviation	0.17	0.44	6.40	45.87	2.02	0.69	11295.44	3747.89	200.71	1846.43						7.16

organic matter content of 70.41% (Table 7) the study by Nuraiti et al. (2021) indicate that the pH of food waste ranges from 3.65 to 6.86, dry matter from 3.2 to 24.9% and organic matter from 5.25% to 94.62%. On the other hand, Degueurce et al. (2020) in their study obtained the pH of waste at the level of 4.69 to 4.91. Analyzing the content of macronutrients in catering waste it was found that they are rich in total nitrogen (from 4.53% – Table 7 to 2.66 – Table 5) and potassium (from 1.16% – Table 5 to 0.81% – Table 6) the content of heavy metals did not exceed the permissible limits taking into account their use as a substrate for the composting process (OJ of 2008 No. 119, item 765)

Summary

Preliminary pilot/field studies indicate that the amount of catering waste generated by one guest staying in the investigated health resorts or hotels (data for the investigated facilities) for the Kamień Pomorski Commune and surroundings can range from 76.4 kg/(M-a) according to the results obtained for the „Jantar" Resort to 256.2 kg/(M-a) according to the results obtained for the Mieszko Nowe Health Resort.

The conducted physicochemical studies of food waste indicate that the content of dry matter in catering waste ranges from 17.94 to 28.51% (average 24.43%) and organic matter from 70.41 to 94.93% (average 87.54%). The content of heavy metals in the analyzed samples did not exceed the content permitted by legal acts.

This waste can be used as material in the composting process. However, it is important to remember that catering waste should first undergo a hygienisation process. This is in line with the European plan for a resource-efficient Europe. This plan aims to introduce waste management as a resource by 2020.

The plan assumes the need for high quality recycling, elimination of landfill, reduction of energy recovery to non-recyclable materials, and prevention of illegal waste shipments.

Selective collection of food and biodegradable waste can become a source of energy and be used as fertilizer.

Acknowledgments

The article is the result of research conducted under the project „Research and development work related to the development of technology for commercial use of biodegradable waste" (nr RPZP.01.01.00-32-0023/18)

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