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QUALITY ASSESSMENT OF COMPOSTS AND LETTUCE FROM ALLOTMENT GARDENS OF WEST POMERANIAN VOIVODESHIP

OCENA JAKOŚCI KOMPOSTÓW Z OGRODÓW DZIAŁKOWYCH WOJEWÓDZTWA ZACHODNIOPOMORSKIEGO ORAZ UPRAWIANEJ NA NICH SAŁATY

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Streszczenie. Celem badań była ocena właściwości chemicznych kompostów z ogrodów działkowych województwa zachodniopomorskiego oraz określenie składu chemicznego uprawianej na nich sałaty głowiastej masłowej (*Lactuca sativa* L.) odmiany Królowa Majowych. W kompoście określono pH, zawartość materii organicznej, węgla organicznego, azotu ogólnego i siarki ogólnej. Ponadto w kompoście oznaczono całkowitą zawartość makro- i mikroskładników oraz zawartość form łatwo rozpuszczalnych. Oceny jakości sałaty dokonano na podstawie zawartości makro- i mikroskładników w suchej masie liści. Cechą charakterystyczną kompostów z ogrodów działkowych jest niska zawartość materii organicznej oraz niższa, w porównaniu z kompostami wytworzonymi ze zmieszanych odpadów komunalnych, zawartość makroelementów, azotu ogólnego i węgla organicznego. Większość kompostów jest dojrzała i stabilna, jednak stwierdzono w nich niekorzystny stosunek C : N. Poza jedną próbką posiadającą podwyższoną zawartość ołowiu, komposty charakteryzowały się niskim poziomem metali ciężkich. Sałata uprawiana na badanych kompostach jest uboga w wapń i fosfor, natomiast posiada optymalną zawartość potasu i magnezu. W liściach sałaty stwierdzono wysoką zawartość sodu, a jedna z próbek wykazała podwyższoną zawartość ołowiu.

Key words: composts, lettuce, macroelements, microelements, organic matter.
Słowa kluczowe: komposty, makroskładniki, materia organiczna, mikroskładniki, sałata.

INTRODUCTION

Plant cultivation in allotment and home gardens is inextricably accompanied by biodegradable waste production. A common method of utilising this waste is its aerobic breakdown by microorganisms, in other words composting, whose main purpose is obtaining compost i.e., a valuable fertiliser. According to Madej et al. (2004) compost utility value depends mainly on the quality of raw material, production technology (including the proportions between particular components of initial raw material) and the maturity

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of finished product. Most frequently garden waste is composted in compost heaps or bins, however, sporadic turning of composting material, improper choice of substrates or disturbed water-air conditions may reduce the effectiveness of the process and lower compost quality.

In recent years many papers have been published on chemical properties of composts produced in waste processing plants (Drozd and Licznar 2004a, 2004b, Madej et al. 2004, Gondek and Filipek-Mazur 2005). On the other hand, there is not enough information on the quality of composts produced individually by the owners of home gardens, lawns or allotments.

The purpose of the studies was to determine chemical properties of composts produced in home and allotment gardens as well as the content of macro- and microelements of lettuce grown on these composts.

MATERIAL AND METHODS

In the autumn of 2011, the samples of 29 composts from allotment and home gardens, located in 6 communities of West Pomeranian Voivodeship, were collected from each heap, several single samples were taken and mixed thoroughly. Next, a composite sample (1 kg) was collected, which was representative of a given compost heap. In laboratory they were placed on porcelain evaporating dishes and air-dried. Dry material was crushed in the mortar and passed through a 1.0 mm mesh sieve. Separated fine earth, below 1.0 mm, was subjected to laboratory examinations. Organic matter content was determined as loss on ignition by burning the material in a muffle furnace at the temperature 550ºC, pH in 1 mol · dm^{-3} KCl and H_2O – potentiometrically, the content of organic carbon, total nitrogen and total sulphur by means of elementary analyser CNS Costech. The content of macro- and microelements (P, K, Mg, Ca, Na, Cu, Zn, Mn, Ni, Fe, Cd, Co, Pb) soluble in HCl at the concentration 0.5 mol · dm^{-3} and their total content was determined in the mixture of concentrated HNO_3 + $HClO_4$, phosphorus content – colorimetrically, sodium and potassium by flame photometry and other elements by atomic absorption spectrometry (FAAS) using spectrophotometer Solaar 929 from Unicam.

Next, a pot experiment was set up in a greenhouse. The examined composts were placed into twenty nine 0.5 dm^3 pots and the butterhead lettuce plants cv Królowa Majowych were planted in these pots. Six weeks later, plant samples were collected for analysis, washed and dried at the temperature 50ºC. After that lettuce samples were mineralised in the mixture of concentrated acids HNO_3 + $HClO_4$. The content of macro- and microelements was determined in the same way as in the case of composts.

RESULTS AND DISCUSSION

Analysed composts were characterised by a low fertiliser value due to a small content of organic matter amounting to 9.78%, on average, minimum value 4.26% and maximum 26.33% (Table 1). In 19 composts organic matter content was lower than 10% DM and only in two higher than 20% DM, thus according to the Regulation of Minister of Agriculture and Rural Development of 18 June 2008 concerning the implementation of certain rules of the Act on Fertilisers and Fertilisation (DzU 2008 nr 119 poz. 765 ze zm.) none of composts

belonged to the category of organic fertilisers. Composts originating from green waste (Madej et al. 2004) contain considerably higher amounts of organic matter within the range 29.5–58.4% DM. A significant factor affecting the low content of organic matter, in the composts from amateur gardens, might have been too high moisture of the material during composting, since as it is indicated by Drozd and Linczar (2004a, b) the moisture 600 g · kg^{-1} DM of composting waste does not allow for reaching the temperature above 55ºC, lowers the intensity of biochemical processes and inhibits the degree of organic matter humification. The composts under study, had the reaction varying from slightly acid to alkaline and pH values were generally in the optimum range 6.0–7.8 given by Jędrczak (2007). Great variations were found in organic carbon content (9.01–195.7 g · kg^{-1} DM) at mean value 54.16 g · kg^{-1} DM (Table1). The content of total nitrogen ranged from 11.11–14.1 g · kg^{-1} DM (mean 4.54 g · kg^{-1} DM) and was definitely lower than the content of total nitrogen (17.5–30.8 g · kg^{-1} DM) in composts of different origin examined by Gondek and Filipek-Mazur (2005). In all composts C:N ratio was lower than 20 : 1 therefore, as it is suggested by Jędrczak (2007) they may be considered to be mature and stable. At the same time, it should be noted that in 25 composts C : N ratio was smaller than 15 : 1, and this unfavourable indicator may reduce compost fertilising value resulting from a relatively low content of organic carbon.

Tabele 1. The chemical properties of composts from allotment gardens
Tabela 1. Właściwości chemiczne kompostów z ogrodów działkowych

Coefficient Wskaźnik		Unit Jednostka	Min	Max	Mean Średnia	Standard deviation Odchylenie standardowe
Losses on ignition – Straty na żarzeniu		%	4.26	26.33	9.78	5.20
pH_{H2O}		–	6.08	8.68	–	–
pH_{KCl}		–	6.34	8.48	–	–
C_{org}		g · kg^{-1} d.m.	9.01	195.7	54.16	38.95
$N_{og.}$		g · kg^{-1} d.m.	1.11	14.10	4.54	3.37
S		g · kg^{-1} d.m.	0	1.49	0.46	0.36
C : N		–	8.1	18.5	12.27	2.52
Macroelements soluble in a mixture of concentrated acids HNO_3 and $HClO_4$ Makroskładniki rozpuszczalne w mieszaninie stężonych kwasów HNO_3 i $HClO_4$	P	g · kg^{-1} d.m.	0.8	8.03	2.68	1.85
	K		1.4	10.9	3.79	1.92
	Ca		1.24	81.47	10.85	16.47
	Mg		0.59	21.26	2.11	3.78
	Na		0.08	1.85	0.35	0.39
Microelements soluble in a mixture of concentrated acids HNO_3 and $HClO_4$ Mikroskładniki rozpuszczalne w mieszaninie stężonych kwasów HNO_3 i $HClO_4$	Fe	mg · kg^{-1} d.m.	3057	9555	6083.76	1682.36
	Mn		175.7	2952	515.10	688.96
	Zn		39.1	3010.5	247.34	546.50
	Cu		7.6	73.7	18.67	14.08
	Pb		4.8	263.6	24.4	46.86
	Ni		1.84	29.51	7.68	5.26
	Co		1.75	20.48	5.20	3.99
	Cd		0.09	1.76	0.52	0.41

In comparison with macroelement content (P – 4.5–43.6; K – 11.7–30.4; Ca – 14.4–38.6; Mg – 1.9–4.5; Na – 0.5–2.2 g · kg^{-1} DM) determined in composts of various origin by Gondek and Filipek-Mazur (2005), our composts generally had lower values. The share of easily soluble macroelements (Table 2), in relation to their total content was, on average, for phosphorus – 44%, potassium – 53%, calcium – 59%, magnesium – 44%, sodium – 49%.

Tabele 2. The content of macro- and microelements soluble in 0.5 M HCl at the earthy compost from allotment gardens
Tabela 2. Zawartość makro- i mikroskładników rozpuszczalnych w HCl o stężeniu 0,5 mol · dm^{-3} w częściach ziemistych kompostów z ogrodów działkowych

Component Składnik		Unit Jednostka	Min	Max	Mean Średnia	Standard deviation Odchylenie standardowe
Macroelements Makroskładniki	P	g · kg^{-1} d.m.	0.31	2.39	1.18	0.66
	K		0.2	5.51	1.99	1.17
	Ca		0.77	33.75	6.38	7.82
	Mg		0.07	7.88	0.93	1.56
	Na		0.019	0.905	0.17	0.22
Microelements Mikroskładniki	Fe	mg · kg^{-1} d.m.	18.4	2435	986.59	440.45
	Mn		149.3	2196.5	382.31	506.11
	Zn		18.4	483	100.25	91.87
	Cu		0.45	21.08	7.41	4.53
	Pb		0.15	28.34	10.97	5.37
	Ni		0.38	5.19	1.90	1.19
	Co		0.43	2.5	1.09	0.54
	Cd		0.06	1.04	0.31	0.21

The content of microelements soluble in the mixture of concentrated acids HNO_3 and $HClO_4$ in fine earth of analysed composts is presented in Table 1. In one of the examined composts almost two-fold higher amount of lead was found than the permissible limit given in the Regulation of Minister of Agriculture and Rural Development of 18 June 2008 concerning the implementation of certain rules of the Act on Fertilisers and Fertilisation (DzU 2008 nr 119 poz. 765 ze zm.). The share of microelements soluble in HCl at the concentration 0.5 mol · dm^{-3} (Table 2), in relation to their total content (Table 1) was on average as follows: for iron – 16%, manganese – 74%, zinc – 40%, copper – 40%, lead – 45%, nickel – 25%, cobalt – 21%, cadmium – 60%.

Content of macro- and microelements of lettuce grown on these composts is presented in Table 3. Content of potassium (mean 67.78 g · kg^{-1} DM) and magnesium (mean 3.76 g · kg^{-1} DM) were similar to mean values found in the lettuce grown in allotment gardens, studied by Niedźwiecki et al. (2009) or the leaves of lettuce cultivated under differentiated nitrogen-potassium fertilisation conditions by Jarosz and Dzida (2006). The lettuce from our studies, cultivated on composts from garden waste, contained about twofold lower amount of calcium (mean 8.05 g · kg^{-1} DM) compared to that one examined by Niedźwiecki et al. (2009), less phosphorus (mean 3.08 g · kg^{-1} DM) and several times more sodium (4.18 g · kg^{-1} DM). Commission Regulation (EC) (No 1881/2006) established the maximum acceptable levels of contaminants in foodstuffs, expressed in mg · kg^{-1} fresh weight, for lead – 0.3 mg · kg^{-1} FW, cadmium 0.2 mg · kg^{-1} FW. Therefore, after the determination of lettuce dry matter (mean 5.5%), heavy metal content in lettuce fresh weight was also calculated. In case of lead, in one sample the acceptable level was exceeded 0.68 mg · kg^{-1} FW. Mean values of lead (0.074 mg · kg^{-1} FW) and cadmium (0.045 mg · kg^{-1} FW) were within the range (Pb: 0.06–0.24; Cd: 0.005––0.058 mg · kg^{-1} FW) obtained by Czech and Rusinek (2005).

Tabele 3. The content of macro- and microelements of lettuce grown on allotment gardens composts
Tabela 3. Zawartość makro- i mikroskładników w sałacie uprawianej na kompostach z ogrodów działkowych

Component Składnik		Unit Jednostka	Min	Max	Mean Średnia	Standard deviation Odchylenie standardowe
Macroelements Makroskładniki	P	g · kg^{-1} d.m.	2.01	4.42	3.08	0.51
	K		44.2	108.2	67.78	16.28
	Ca		1.52	18.83	8.05	4.37
	Mg		1.96	6.91	3.76	1.04
	Na		0.75	16.64	4.18	3.69
Microelements Mikroskładniki	Fe	mg · kg^{-1} d.m.	39.15	464.2	118.25	86.85
	Mn		22.89	5365.0	1875.74	1942.74
	Zn		32.95	178.3	60.15	31.53
	Cu		2.91	10.16	6.33	1.99
	Pb		n.d.*	12.43	1.34	2.44
	Ni		n.d.	0.75	0.09	0.20
	Co		n.d.	4.61	0.99	1.26
	Cd		0.057	3.00	0.82	0.54

* n.d. – not detected – niewykryte.

Only one statistically significant relationship was found ($r = 0.73$; $p = 0.05$) between the content of zinc, soluble in the mixture of concentrated acids HNO_3 and $HClO_4$, in analysed composts, and the content of this element in lettuce.

CONCLUSIONS

1. A characteristic feature of composts produced in allotment and home gardens is their low content of organic matter and macroelements, which determines their meager fertilising value.
2. It is supposed that a decisive factor affecting a low content of organic matter, is an improper choice of substrates or inability to maintain optimal composting parameters by allotment garden owners, in particular excessive moisture during the process of composting.
3. In the majority of analysed samples of composts, heavy metal content was lower than those presented in the Regulation of Minister of Agriculture and Rural Development of 18 June 2008 concerning the implementation of certain rules of the Act on Fertilisers and Fertilisation (DzU 2008 nr 119 poz. 765 ze zm.), only in one of them an exceeded level of lead was found.
4. The lettuce grown on composts from allotment gardens, had a lower content of calcium and phosphorus, similar content of potassium and magnesium, and a higher content of sodium, in comparison with the lettuce cultivated in allotment garden soil.
5. One positive, statistically significant relationship was found between the level of zinc, soluble in the mixture of concentrated acids HNO_3 + $HClO_4$, in composts and its content in lettuce leaves.
6. In the leaves of lettuce grown on composts, heavy metal content did not exceed acceptable limits for foodstuffs, except for one sample with an elevated content of lead.

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Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 18 czerwca 2008 r., w sprawie wykonania niektórych przepisów ustawy o nawozach i nawożeniu (DzU 2008 nr 119 poz. 765 ze zm.).

Rozporządzenie komisji (WE) nr 1881/2006 z dnia 19 grudnia 2006 r. ustalające najwyższe dopuszczalne poziomy niektórych zanieczyszczeń w środkach spożywczych. http://eur-lex.europa.eu, dostęp z dn. 15.01.2015.

Abstract. The purpose of studies was to determine chemical properties of composts and content of macro- and microelements of butterhead lettuce (*Lactuca sativa* L.), cultivar Królowa Majowych, from allotment gardens of West Pomeranian Voivodeship. Chemical analysis included pH, content of organic matter, organic carbon, total nitrogen and total sulphur as well as total amount of macro- and microelements. The assessment of lettuce quality was based on macro-and microelement content in leaf dry matter. A characteristic feature of allotment garden compost is a low content of organic matter and a lower level of macroelements, total nitrogen and carbon, in comparison with the composts from mixed municipal wastes. The majority of composts are mature and stable but C : N ratio turned out to be unfavourable. Heavy metal content in these composts was low, except for one sample with an elevated level of lead. The lettuce cultivated on these composts has poor resources of calcium and phosphorus but optimum content of potassium and magnesium. The lettuce leaves contained a high level of sodium and one sample -an elevated amount of lead.