ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS
SBORNÍK MENDELOVY ZEMĚDĚLSKÉ A LESNICKÉ UNIVERZITY V BRNĚ

Ročník LVI 30 Číslo 1, 2008

# THE EFFECT OF FERMENTED PIG SLURRY FERTILIZATION ON THE QUALITY OF VEGETABLES

L. Kouřimská, K. Václavíková, L. Babička, M. Koudela, L. Prokůpková, D. Miholová, D. Kolihová

**Received: October 19, 2007**

## Abstract

KOUŘIMSKÁ, L., VÁCLAVÍKOVÁ, K., BABIČKA, L., KOUDELA, M., PROKŮPKOVÁ, L., MIHOLOVÁ, D., KOLIHOVÁ, D.: *The effect of fermented pig slurry fertilization on the quality of vegetables.* Acta univ. agric. et silvic. Mendel. Brun., 2008, LVI, No. 1, pp. 251–258

Fermented pig slurry as a fermentation residue of biogas plants was used for vegetables fertilization as a replacement of industrial mineral fertilizers. Tomatoes were grown in vessels, celery and spinach in the field, radish and lettuce in the greenhouse. Besides dry matter content determination vegetables were evaluated from the food quality point of view. Is consists of microbiological assessment, nitrates and selected elements (Pb, Cd, As, Zn and Hg) content determination.

fermented pig slurry, fertilization, food quality, vegetables

Animal production wastes reasonably contribute to the total agriculture wastes, whose amount (48 mil. tons per year) represents the second biggest source of wastes after industry. Fermented pig slurry is according to the Czech legislation (Notice No. 381/2001 and its change No. 503/2004, Notice No. 274/1998 and its change No. 399/2004, Law No. 185/2001) classified as an agricultural waste which has to be liquidated. It is considered as a waste on one hand, but on the other hand it is classified as an organic fertilizer with high fertilizing efficiency having its biological, energetic and economical potential which must be utilized (Babička, 2006a).

Integrated prevention and pollution control (IPPC) was implemented into EU legislation in 1996 by EU directive 96/64/EC about IPPC and consecutively by Law No. 76/2002 into the Czech legislation system. The aim of these steps is environment pollution prevention or reduction before contaminants or pollutants appear in technological processes by means of the best available technologies. Wastes liquidation is also incorporated in EU parliament and council regulation No. 92/2005.

Energy production via biogas plants can be an efficient, alternative production system for agriculture (Babička, 2005) and the number of biogas plants has increased. Biomass materials (wood, agricultural crops, forestry and agricultural residues and organic wastes) are non-food products which are used for various purposes. One of them is an anaerobic decomposition of organic materials – anaerobic digestion (Straka, 1997). Products of anaerobic digestion are biogas (mostly $CH_4$ and $CO_2$, small amount $H_2$ and occasionally trace levels of $H_2S$) and digestate (fugate and separate). Acidogenic digestate is a stable organic material comprised largely of lignin and chitin, but also of a variety of mineral components in a matrix of dead bacterial cells (Straka, 1998). It resembles domestic compost and can be used as compost. Methanogenic digestate is a liquid by-product, rich in nutrients, can be used as a fertilizer.

Direct use of fermented pig slurry as a fertilizer represents an economically effective way of slurry liquidation. After a sufficiently long period of storage and fermentation (6 months) the infection potential of slurry (coliform bacteria, salmonellas, spirochetes and parasite germs) is removed and harmful compounds inhibiting plants are deactivated (hippuric acid is converted into benzoic acid and amino acids, uric acid is converted to alantoin and then to glyoxalic acid and urea where the final decomposition product is carbon dioxide, water and ammonia).

During the fermentation process weed seeds also lose their germination ability and unpleasant smell of slurry is removed as well.

Commonly grown kinds of vegetables usually need intensive agriculture in our climate conditions, which can bring some risks connected with soil and water resources contamination. Optimal vegetables fertilizing is on the other hand one of the main factors influencing yields (Poustková, 2006), quality (Babička, 2006b) and storability.

Besides dry matter content, food safety (microbiology quality assessment, nitrates content and selected elements (Pb, Cd, As, Zn and Hg) content) of commonly grown kinds of vegetables (tomato, celery, spinach, radish and lettuce) were monitored by using fermented pig slurry and mineral fertilizers methods.

## MATERIAL AND METHODS

The experiments were carried out using the following vegetable types:

- Tomato, cultivars Start F1 (marked **TS**) and Tornádo (marked **TT**) – vessels experiment
- Celery, cultivars Albín (marked **CA**) and Kompakt (marked **CK**) – field experiment
- Spinach, cultivars Matador (marked **SM**) and Winter riesen (marked **SW**) – field experiment
- Radish, cultivars Granát (marked **RG**) and Saxa (marked **RS**) – greenhouse experiment
- Lettuce, cultivars Karát (marked **LK**) and Smaragd (marked **LS**) – greenhouse experiment.

All seeds were purchased from Semo company, only celery seeds Albín were from Moravoseed Company.

Tomato seeds were grown in greenhouses and plants were then planted into 20 l vessels. Peat-bark substrate RKS I (Agro CS, a. s.) was used in the vessels. The substrate was enriched with fertilizers according to the fertilizing method. Ten plants were grown for each fertilizing method. There were the following fertilizing methods:

a) **Control** (marked **N**) – neither mineral nor organic fertilizers were used.
b) **Mineral** (marked **M**) – 15 g $(NH_4)_2SO_4$ and 9 g $K_2HPO_4$ were used in each vessel (20 l); 7.5 g $(NH_4)_2SO_4$ per each vessel was added 30 days later.
c) **Combined** (marked **K**) – 50% of mineral and 50% of organic fertilizers were used.
d) **Organic** (marked **O**) – 0.8 l of fermented pig slurry in each vessel was used; 2 l of the same organic fertilizer per each vessel were added 30 days later.

The field experiments with celery and spinach were carried out in the university demonstration field in Prague – Trója. Each cultivar was fertilized by four different methods. Each method area was repeated four times. Lettuce and radish were grown in the university greenhouses in Prague – Suchdol and spinach in the open air university beds. There were the following fertilizing methods:

a) **Control** (marked **N**) – neither mineral nor organic fertilizers were used.
b) **Mineral** (marked **M**) – 100 g $(NH_4)_2SO_4$, 229 g $K_2HPO_4$ and 21 g KCl per 4.4 $m^2$ were used in case of celery; 100 g $(NH_4)_2SO_4$ per 4.4 $m^2$ was added 43 days later; 7.5 g $(NH_4)_2SO_4$ and 4.5 g $K_2HPO_4$ per 3 $m^2$ were used in case of lettuces, spinach and radish.
c) **Combined** (marked **K**) – 50% of mineral and 50% of organic fertilizers were used.
d) **Organic** (marked **O**) – 40 l of fermented pig slurry per 4.4 $m^2$ was used in case of celery; 40 l of the same organic fertilizer was added 43 days later; 3 l of fermented pig slurry per 3 $m^2$ was used in case of lettuces, spinach and radish.

Fermented pig slurry did not contain nitrates or nitrites. The $NH_4^+$ content was 595 mg/l and the $PO_4^{3-}$ content was 755 mg/l. The ratio of organic compounds in dry matter was 56.0%. Fermented pig slurry contained 35 190 mg/l compounds soluble at 105 °C and 35 200 mg/l compounds soluble at 550 °C.

The following analytical methods were used: dry matter content was determined using drying at 102 ± 2 °C to the constant weight, nitrates content was measured by ion selective electrode using $NaNO_3$ for calibration, selected elements content was determined by AAS method after samples lyophilisation. Microbiological assessment was done by inoculum overflowing method. GTK agar was used for total mesophilic bacteria count determination. Samples were cultivated at 30 °C for 48 to 72 hours. GKCH agar was used for yeast and moulds determination. Samples were cultivated at 25 °C for 5–7 days.

## RESULTS AND DISCUSSION

### Dry matter content

The dry matter content of edible part was determined in all vegetable samples. Results are given in table I; the highest values are printed in bold letters, the lowest values are in italic letters. There were not significantly big differences among fertilizing methods, differences between vegetable types or cultivars are sometimes seen.

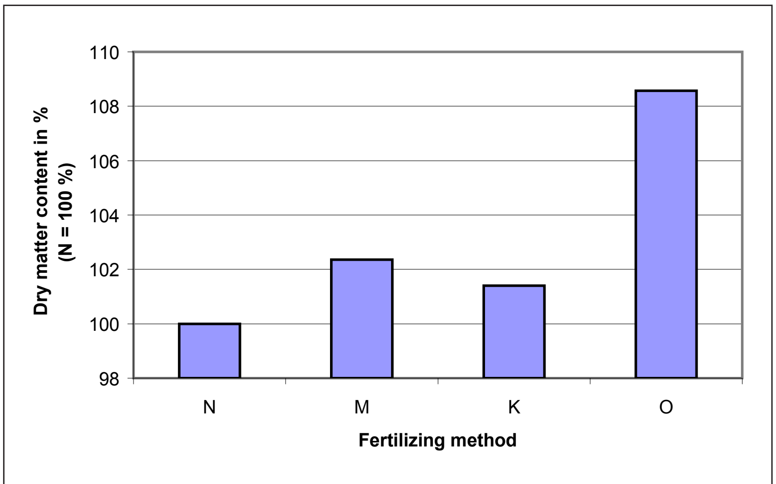
In Fig. No. 1 we can see the differences in dry matter content of tested vegetable samples using averages of relative dry matter content values, where the value for no fertilizers addition method equals 100%. Samples fertilized by fermented pig slurry had the dry matter content values higher by some 8% compared to the non-fertilized samples.

### Nitrates content

The analysed nitrates contents in tomato, celery, spinach and lettuce are given in table II. The highest values were detected in mineral fertilizing method of celery and lettuce and in organic fertilizing method

I: *Dry matter content in % (m/m) in edible parts of monitored vegetable types according to the fertilizing methods*

| Sample | Fertilizing method | | | |
|---|---|---|---|---|
| | N | M | K | O |
| TS | 6.27 | 6.12 | 6.52 | 5.92 |
| TT | 5.34 | 5.29 | 5.51 | 6.22 |
| CA | 9.45 | 10.08 | 10.17 | 9.96 |
| CK | 11.66 | 11.88 | 11.90 | 12.18 |
| SM | 11.90 | 11.45 | 12.61 | 11.98 |
| SW | 11.00 | 10.48 | 11.69 | 11.00 |
| RG | 4.44 | 4.16 | 4.03 | 4.16 |
| RS | 3.87 | 4.42 | 4.41 | 4.74 |
| LK | 2.72 | 2.90 | 2.44 | 3.34 |
| LS | 2.58 | 2.88 | 2.32 | 3.22 |




1: *Comparison of relative dry matter content values of vegetables according to the fertilizing methods*

of tomato. There were not significantly big differences among samples in case of spinach.

From the relative nitrates contents in Fig. 2 we can see a considerable difference between non-fertilized and fertilized samples. The highest relative nitrates content were in case of mineral fertilized method and the lowest content (by 24%) was in case of combined method.

### Selected elements content

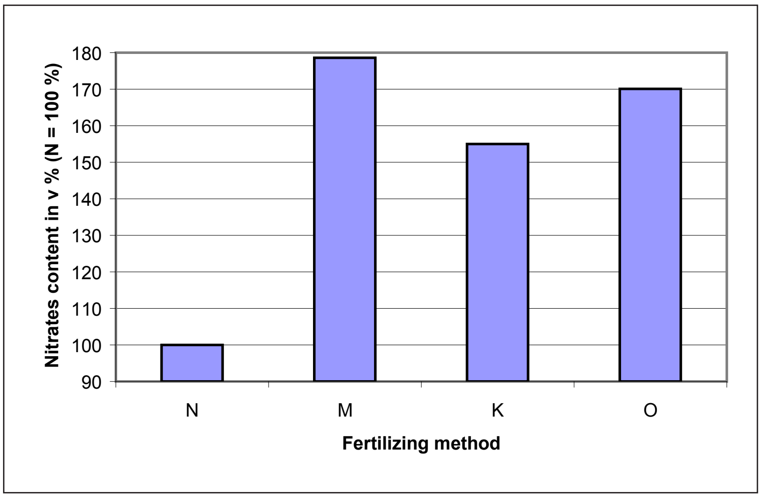
Tomato, celery and lettuce samples were analysed by AAS method to determine selected elements (Pb, Cd, As, Zn and Hg) contents. The lead content values did not exceed 0.077 mg/kg, cadmium content values 0.056 mg/kg, arsenic 0.014 mg/kg, zinc 5.1 mg/kg and mercury content values did not exceed 0.0014 mg/kg. Comparing relative selected elements contents (Fig. 3 to 7), mineral fertilized samples shown the highest values, only in case of zinc the highest values were found in fermented pig slurry fertilized samples. It can be explained by higher zinc content in pig slurry where it occurs as a residuum from pig feeding enriched by zinc premedication supplementation.

### Microbiological assessment

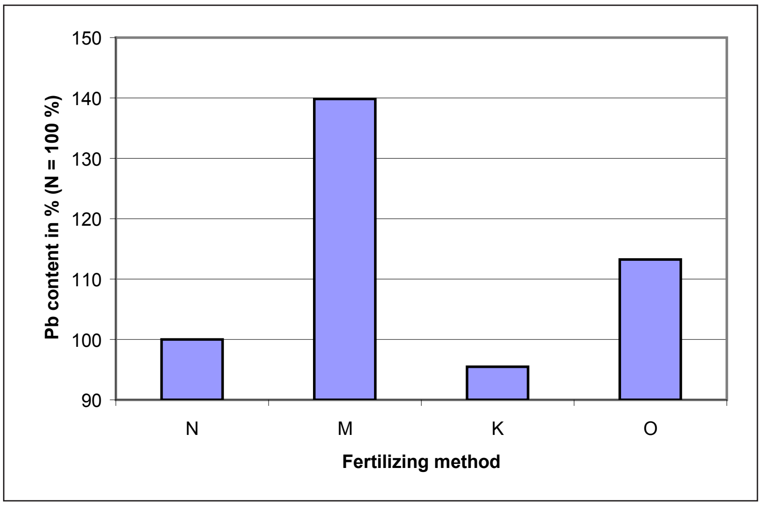
The basic microbiological assessment (total mesophilic bacteria count TMBC in tomato, celery, radish and lettuce samples and yeast and moulds count in tomato, celery and radish samples) was done. The lowest results of microbiological parameters were found in six organically fertilized samples from all fourteen tested samples. Comparison of relative values (Fig. 8 and 9) shows, that organic method had better results than mineral or combined methods. Its values were close to non-fertilized method (mainly in case of TMBC).

II: *Nitrates contents in mg/kg in edible parts of monitored vegetable samples according to the fertilizing methods*

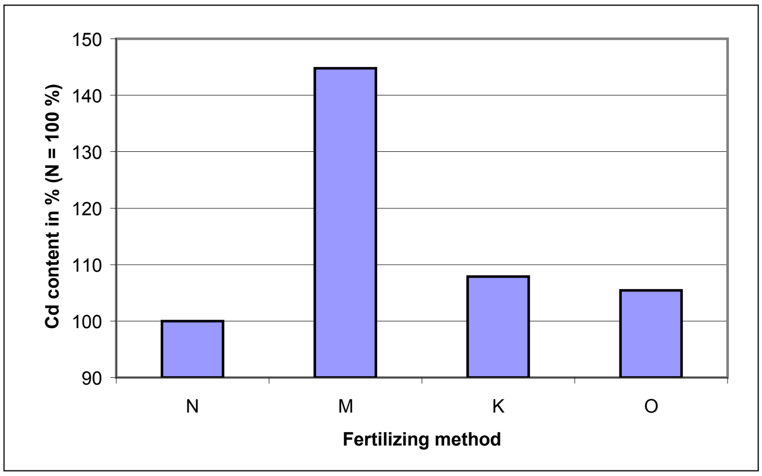
| Sample | Fertilizing method | | | |
|---|---|---|---|---|
| | N | M | K | O |
| TS | 4.9 | 14.5 | 11.2 | 20.1 |
| TT | 9.8 | 21.1 | 17.2 | 24.0 |
| CA | 630.8 | 1081.6 | 922.0 | 812.1 |
| CK | 362.4 | 962.6 | 681.6 | 519.5 |
| SM | 131.8 | 94.6 | 108.4 | 111.0 |
| SW | 90.2 | 108.4 | 136.3 | 93.5 |
| LK | 1584.6 | 1927.3 | 1797.8 | 1763.9 |
| LS | 1441.5 | 2412.4 | 2227.2 | 1914.8 |



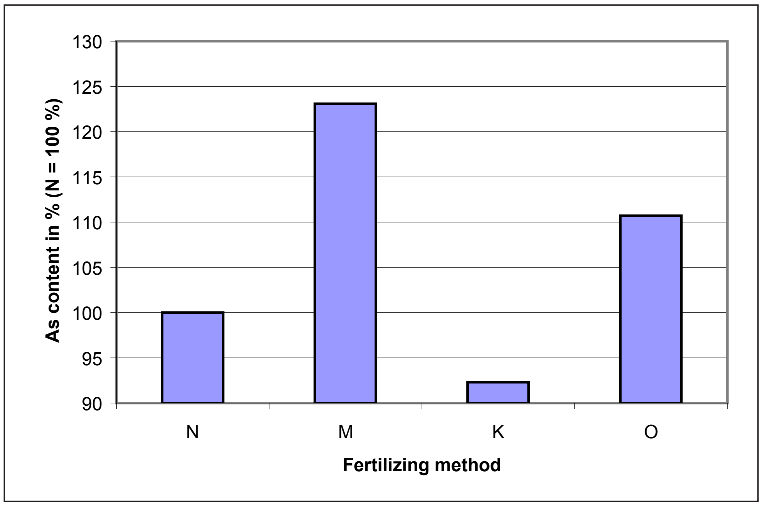

2: *Comparison of relative nitrates content values of vegetables according to the fertilizing methods*



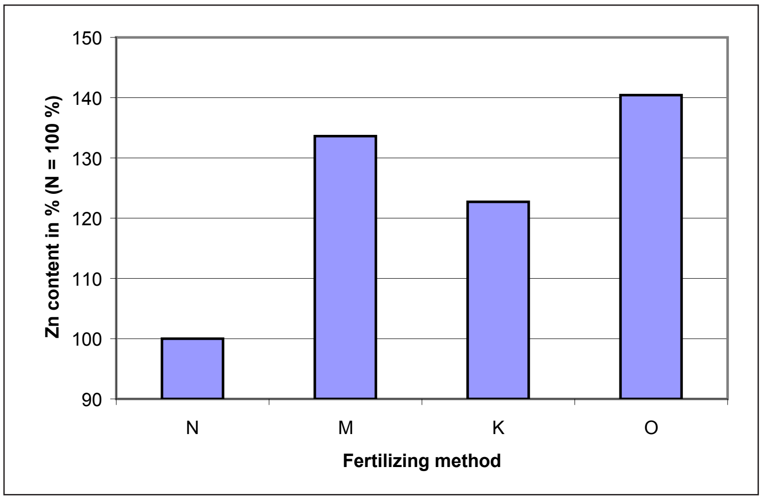

3: *Comparison of relative Pb content values of vegetables according to the fertilizing methods*



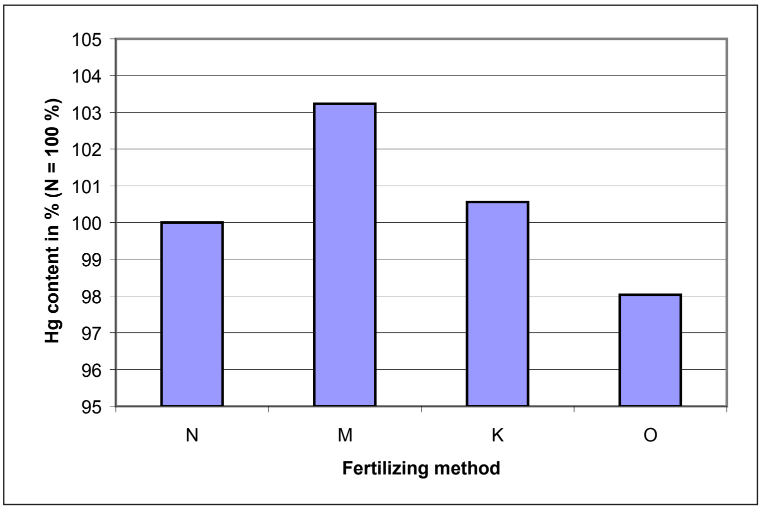

4: *Comparison of relative Cd content values of vegetables according to the fertilizing methods*



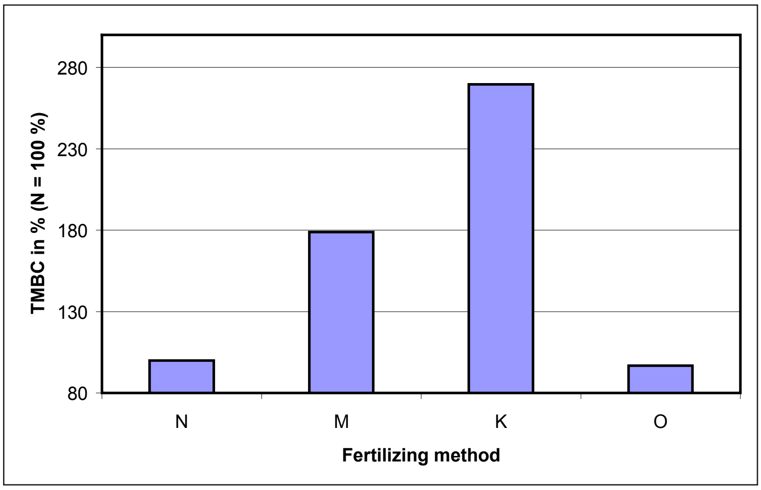

5: *Comparison of relative As content values of vegetables according to the fertilizing methods*



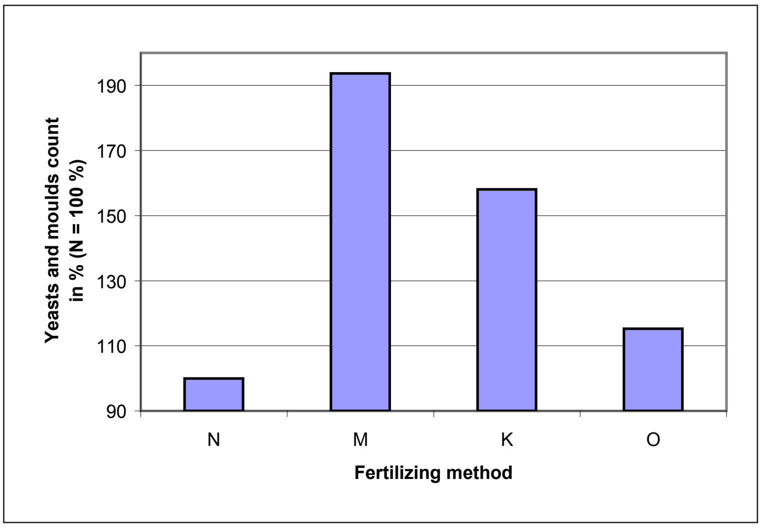

6: *Comparison of relative Zn content values of vegetables according to the fertilizing methods*




7: *Comparison of relative Hg content values of vegetables according to the fertilizing methods*




8: *Comparison of relative TMBC in vegetables according to the fertilizing methods*




9: *Comparison of relative yeast and moulds count in vegetables according to the fertilizing methods*

## CONCLUSION

The effect of conventional and non-conventional fertilization methods on the quality of vegetables was studied. The obtained results showed that fermented pig slurry (an agricultural waste) can be used as a suitable mineral fertilizers replacement. Yield parameters and dry matter content values were in many samples better in the case of organic fertilizing method.

Monitoring the food safety point of view, the results showed that using fermented pig slurry as a fertilizer did not affect hygienic quality of organically fertilized vegetables compared to mineral fertilizing method.

In many cases the organic method brought increasing dry matter content parameters. Besides that the hygienic quality of vegetables was not decreased.


## SOUHRN

### Vliv hnojení fermentovanou kejdou na kvalitu zeleniny

Fermentovaná prasečí kejda, jakožto fermentační zbytek z bioplynové stanice, byla použita pro hnojení zeleniny jako náhrada průmyslových minerálních hnojiv. V nádobových pokusech byla pěstována rajčata, celer a špenát v pokusech polních a ředkvičky a salát ve skleníku. Kromě sledování obsahu sušiny byla hodnocena zdravotní nezávadnost vypěstované zeleniny z mikrobiologického hlediska a z hlediska obsahu dusičnanů a vybraných prvků (Pb, Cd, As, Zn a Hg).


fermentovaná prasečí kejda, hnojení, zdravotní nezávadnost, zelenina

## REFERENCES


BABIČKA, L., ZAJÍČEK, P., BABIČKA, P., 2005: *Další možnosti využití bioplynu v rámci zemědělsko-potravinářského komplexu.* Sborník ze semináře „Bioplyn v zemědělství a rozvoj venkova na obou stranách česko-rakouské hranice“. České Budějovice 18. 10. 2005.

BABIČKA, L., 2006a: *Energie ukrytá v chlévě.* Náš chov. 3.

ČSN EN ISO 4833 *Mikrobiologie potravin a krmiv* – Horizontální metoda pro stanovení celkového počtu mikroorganismů – Technika počítání kolonií vykultivovaných při 30 °C.

POUSTKOVÁ, I., POUSTKA, J., BABIČKA, L., STARUCH, L., KOUŘIMSKÁ, L., FAMĚRA, O., 2006: *Porovnání kvantitativních a kvalitativních parametrů pěstované zeleniny v závislosti na způsobu hnojení.* Zborník prác z medzinárodnej vedeckej konferencie Bezpečnosť a kontrola potravín, I. diel. Nitra. 5.–6. 4., ISBN 80-8069-681-0, str. 158–161.

BABIČKA, L., KOUŘIMSKÁ, L., POUSTKOVÁ, I., FAMĚRA, O., KOUDELA, M., GÖTZOVÁ, J., 2006B: *Dusičnany jako rizikový faktor v potravinách.* Zborník prác z medzinárodnej vedeckej konferencie Bezpečnosť a kontrola potravín, I. diel. Nitra, 5.–6. 4., ISBN 80-8069-681-0, str. 107–110.

STRAKA, F., 1997: *Biogas & Combined Biotechnology for Energy Conservation,* 20th World Gas Conference BPO8, 10.–13. 6. Copenhagen.

STRAKA, F., 1998: *Akumulační biotechnologický cyklus,* Odpady 3, s. 12–15.

Vyhláška č. 381/2001 Sb., Ministerstva životního prostředí, kterou se stanoví Katalog odpadů, Seznam nebezpečných odpadů a seznamy odpadů a států pro účely vývozu, dovozu a tranzitu odpadů a postup při udělování souhlasu k vývozu, dovozu a tranzitu odpadů (Katalog odpadů).

Vyhláška č. 503/2004 Sb., kterou se mění vyhláška Ministerstva životního prostředí č. 381/2001 Sb., kterou se stanoví Katalog odpadů, Seznam nebezpečných odpadů a seznamy odpadů a států pro účely vývozu, dovozu a tranzitu odpadů a postup při udělování souhlasu k vývozu, dovozu a tranzitu odpadů (Katalog odpadů).

Vyhláška č. 274/1998 Sb., Ministerstva zemědělství o skladování a způsobu používání hnojiv.

Vyhláška č. 399/2004 Sb., kterou se mění vyhláška Ministerstva zemědělství č. 274/1998 Sb., o skladování a způsobu používání hnojiv, ve znění pozdějších předpisů.

Zákon č. 185/2001 Sb., o odpadech a o změně některých dalších zákonů.



Address

Dr. Ing. Lenka Kouřimská, Ing. Kristýna Václavíková, Doc. Ing. Luboš Babička, CSc., Ing. Ludmila Prokůpková, Ph.D., Katedra kvality zemědělských produktů, Ing. Martin Koudela, Ph.D., Katedra zahradnictví a krajinářské architektury, Ing. Daniela Miholová, CSc., Ing. Dana Kolihová, CSc., Katedra chemie, Fakulta agrobiologie, potravinových a přírodních zdrojů, Česká zemědělská univerzita v Praze, Kamýcká 129, 165 21 Praha 6 – Suchdol, Česká republika