

The Influence of the extensification of porker feeding on the slaughter value, quality of meat products and fattening economics

PIOTR JANISZEWSKI¹, KAROL BORZUTA¹, DARIUSZ LISIAK¹,
EUGENIA GRZEŚKOWIAK¹, PIOTR ŚLÓSZARZ², BENEDYKT PEPLIŃSKI³,
KAROL WAJSZCZUK³

¹Department of Meat and Fat Technology, prof. Waclaw Dąbrowski Institute of Agricultural and Food Biotechnology in Poznan

²Department of Animal Breeding and Product Quality Assessment, Poznan University of Life Sciences

³Department of Management and Law, Poznan University of Life Sciences

Abstract: *The influence of the extensification of porker feeding on the slaughter value, quality of meat products and fattening economics.* Sixty four pigs were examined and divided into two groups: group A, fed with feed mixtures, which were poorer in protein and metabolic energy and group B, fed with a mixture richer in those components (a difference of 0.5–1% in the content of protein and from 0.5 to 0.8 MJ/kg in metabolic energy). The fattening of the pigs was done indoors until the pigs gained a body weight of 120 kg. The daily growth, slaughter value and the organoleptic quality of meat products were investigated. The reduced level of protein and energy in the feed was found to result in daily growth to be reduced by 130 g and the fattening period to be lengthened by 9 days. The pigs which were fed less intensively had a higher content of meat in the carcass by 1.86 pp, less fatback in the half-carcass and a higher dressing percentage by 1.33 pp. The feeding was not found to influence the organoleptic quality of dry cured ham (except of the juiciness which was better in group A) and ham sausage (except for the compensation of colour which was better in group B).

Key words: feeding, slaughter value, meat products quality, fattening economics

INTRODUCTION

As Webb and Erasmus (2013) stress there has been a shift from extensive farming systems to more intensive systems and in some species like pigs typical factory farms became more prevalent. At present, when noble breeds are used an extensive system is not economically justified except when the production of pork has a particular sensory value, which is used for the production of brand-name products with adequately high prices. An example of such production is the extensive breeding of the native local Italian breed Nero Siciliano, whose meat is mainly used to make dry cured products, e.g. Parma ham. Research by Pugliese et al. (2003, 2004) proved that the extensive feeding of those pigs in a free-range farming system caused a lower growth rate, a higher meat content and lower content of fat in ham as well as a lighter colour and worse water absorp-

tion of the *longissimus dorsi* muscle than in pigs fattened indoors. According to Italian researchers, the extensive free-range fattening system of the Cinta Senese native breed of pigs caused a lower daily growth and worse physical traits of meat, but it improved the dietary value of fat in comparison to indoor breeding (Franci et al. 2001, Acciaioli et al. 2002, Pugliese et al. 2012).

The slaughter value of pigs and the quality of their meat is very strongly influenced by nutrition (Rekiel et al. 2005). The pigs which are currently fattened, especially those of high-meat breeds, are capable of the effective depositing of protein in the daily gain, which becomes reduced when the body weight of a pig reaches about 90 kg, and the fat deposit increases. The application of appropriate nutrition may reduce the fatness and at the moment simultaneously it may contribute to a reduction of the fattening costs. A maintenance of the desirable traits of meat quality is an important problem in this case.

The aim of the study is to investigate the influence of the intensity of feeding pigs bred indoors on slaughter value, the quality of meat products and the economics of pig production.

MATERIAL AND METHODS

The experiment was carried out on 64 pigs (half of them were gilts and the other half were hogs) divided into two groups: a group fed extensively ($n = 26$) and a group fed intensively ($n = 38$). The material for the research was hybrids obtained from the crossbreeding of the Polish Large White (PLW) \times Polish Landrace (PL) female breeders with boars PL. The pigs were kept indoors in grates. The feed was foraged manually into auto-feeders. The content of the feed components in mixtures for the porkers and fatteners is shown in Table 1. As follows from Table 1, the pigs that were fed intensively received concentrated feed, which was 1% richer in protein during the first period of fattening and 0.5% richer during the second period of fatten-

TABLE 1. Nutrient components content of the feed mixtures for porkers and fatteners

Components	Grover		Finisher	
	group A	group B	group A	group B
Crude protein (%)	16.5	17.5	15.0	15.5
Energy net (kcal)	2 163	2310	2163	2268
Metabolizable energy (MJ/kg)	12.4	13.2	12.4	12.9
Lysine (%)	0.96	1.10	0.82	0.90
Methionine (%)	0.32	0.34	0.25	0.28
Methionine + Cystine (%)	0.65	0.69	0.66	0.61
Threonine (%)	0.64	0.71	0.56	0.60
Tryptophan (%)	0.19	0.21	0.17	0.18
Crude fibre (%)	4–7	3–6	4.5–7	4.5–6.5
Calcium (%)	0.7	0.7	0.65	0.65
Phosphorus (%)	0.6	0.6	0.65	0.6
Sodium (%)	0.15	0.15	0.14	0.14

ing and which had 0.8 and 0.5 MJ/kg more metabolic energy during the first and second period, respectively. During fattening the pigs had constant access to water (automatic drinking bowls). The fattening started with body weights of about 30 kg and finished with a weight of about 120 kg.

After the pigs had reached the body weight of about 120 kg, they were transported to a nearby slaughterhouse (a distance of about 50 km), where they were rested for about 2 h and then they slaughtered by means of the electric stun device KOMA, with the following stunning parameters: voltage 250 V, electric current 2 A, frequency 50 Hz.

The following measurements were made on warm, hanging half-carcasses (Borzuta 1998): the content of the meat in the carcasses was measured by means of a CGM Sydel apparatus, the thickness of backfat measured with a calliper on the back, over the shoulder and on the cross-section spinal column (points KI, KII, KIII), the weight of a non-skinned carcass measured on an overhead rail scale to the nearest 100 g.

Part of the raw material was used to make meat products, i.e. dry cured ham from the *semimembranosus* muscle and ham sausage from the other ham muscles (group A $n = 10$, group B $n = 13$). The ham was made according to the methodology of the Institute of Meat and Fat Research Institute (Olkiewicz et al. 2000) with the lactic acid bacteria pokelferment (the process was completed when the product reached the yield of about 78%). The ham sausage was

made according to the technology established in the meat industry, without additive polyphosphates. The products were subjected to organoleptic assessment in a five-point bonitation (where 5 points being the best and 1 point – unacceptable) with respect to the following traits: consistence, desirability and equal distribution of colour, juiciness, tenderness, flavour. Meat marbling was estimated on the five-point scale (where 5 is for high IMF content and 1 is for lack of the fat) (Baryłko-Pikielna 2014). The evaluation was done in day light at a temperature of $20 \pm 2^\circ \text{C}$ by five trained persons. The results were given as a mean from these evaluations. The shear force was measured in the products by means of a Zwick/Roell apparatus. Cylinder cores with a round cross-section (2.54 cm in diameter) were manually removed parallel to the predominant muscle fiber orientation. The crosshead speed was set at 200 mm/min. The average shear force of the five results was used for the statistical analyses.

The results were statistically processed, calculating the standard deviations and Student's t-test by means of the Statistica PL ver 9.1 package. The distribution of the traits was checked by the Shapiro–Wilk test.

Cost-effectiveness of the outlay borne by the experimental farm was analysed. It was applied with the calculation methodology developed by Pepliński et al. (2004) and it was assumed that the same method of piglet production was applied in both fattening types and the feeds were diversified only when the piglets weighed about 30 kg.

RESULTS

The total mixture which was richer in nutrients had a significant influence on shortening the fattening period and increase in daily weight gain. The pigs from group B, which were fed with a ration with a higher amount of protein and a higher energy value, gained the final body weight of 120 kg 9 days earlier and on average had 130 g higher daily growth than the pigs from group A, which were fed less intensively (Table 2). On the other hand, the slaughter value of the pigs in group A turned out to be better, because the carcasses had less fat and a higher content of meat by 1.86 pp on average (58.83% in group A and 56.97% in group B, respectively) and their dressing percentage was 1.33 pp higher than that of the pigs in group B. Depending on the place of measurement the thick-

ness of the backfat was 3–6 mm less in the pigs in group A and in comparison with group B the difference turned out to be statistically significant ($P \leq 0.05$).

The results of the fattening value obtained in this study are similar to those reported in the literature. In the research on the crossbreeding of the native spotted Złotnicka breed the authors achieved an average daily weight gain of 590 g for the Złotnicka breed and 640 g for the hybrids of the breed with the Duroc pigs (Szulc et al. 2012). A similar study on the native Spanish Retino Iberian breed revealed an average daily weight gain of 549 g for the breed and 677 g for the Spanish Duroc breed and 701 g for the Danish Duroc breed. The differences between the breeds proved to be statistically significant (Serrano et al. 2008). The Polish Pig Breeders and the Produc-

TABLE 2. The fattening characteristics, slaughter and pH values of extensively (group A) and intensively (group B) fed fatteners

Fattening and slaughter characteristics	Group A		Group B		<i>P</i>
	\bar{x}	<i>SD</i>	\bar{x}	<i>SD</i>	
Fattening days (n)	113	–	104	–	0.00**
Initial body weight (kg)	43.10	3.55	47.60	3.10	0.17
Final body weight (kg)	118.97	8.55	122.66	8.60	0.13
Life daily gain (kg/day)	0.66	0.09	0.79	0.09	0.00**
Hot carcass weight (kg)	96.53	7.36	97.89	6.63	0.39
Dressing percentage (%)	81.14	1.72	79.81	1.33	0.03*
Meat content in carcass (%)	58.83	2.40	56.97	3.22	0.03*
Backfat thickness (mm)					
above shoulder	38.50	5.44	41.78	5.86	0.02*
on back	20.08	5.30	22.52	5.46	0.08
on cross I	20.03	5.95	26.19	6.43	0.00**
on cross II	11.74	4.71	14.56	4.84	0.02*
on cross III	17.16	6.55	22.70	7.24	0.00**
pH _{24h}	5.77	0.19	5.73	0.15	0.09

* Statistically significant difference, where $P \leq 0.05$; ** statistically significant difference, where $P \leq 0.01$.

ers Association POLSUS observed the highest weight gain in the production of high-meat pigs, e.g. in 2011 the average standardised daily weight gain was 696 g in the Polish Landrace boars, 698 g in the Polish Large White boars and 724 g in the Hampshire × Duroc hybrids (Blicharski et al. 2012).

The differences in the fattening results obtained in this study can be logically explained. The pigs which receive feeds that are richer in protein and energy components grow faster and their fattening period is shorter. However, the abundance of components involves specific consequences, which are not always positive. The fat content of carcasses increases and in consequence, the meat content in pigs becomes reduced. This fact is confirmed by other authors. Pugliese et al. (2004) in their research

on intensive and extensive fattening of local Italian Nero Siciliano pigs proved that the ham from pigs fattened extensively in the free-range farming system had 58.4% of meat and 31.24% of subcutaneous fat, whereas the ham from pigs fattened intensively in the indoor system had 55.10% of meat and 34.61% of fat. The content of these tissue components in the shoulder was 53.99 and 53.12% of meat and 31.90 and 33.26% of fat, respectively. American studies (Honeyman 2005) also confirm a similar influence of extensive fattening on the slaughter value.

The evaluation of the products made from the ham material of both groups under investigation, shown in Table 3, pointed to the very high quality of both dry cured ham and ham sausage. The average assessment of quality de-

TABLE 3. The results of the organoleptic assessment of meat products made from extensively (group A) and intensively (group B) fed fatteners

Meat product	Quality trait	Group A		Group B		P
		\bar{x}	SD	\bar{x}	SD	
Dry cured ham	consistence (pts)	4.47	0.25	4.55	0.23	0.43
	compensation colour (pts)	4.40	0.23	4.25	0.36	0.27
	desirable colour (pts)	4.34	0.28	4.32	0.34	0.89
	smell (pts)	4.26	0.30	4.31	0.28	0.75
	juiciness (pts)	4.08	0.21	3.82	0.25	0.02*
	tenderness (pts)	4.16	0.28	3.98	0.27	0.11
	flavour (pts)	4.28	0.27	4.29	0.27	0.93
	marbling (pts)	2.45	0.30	2.43	0.34	0.87
	shear force (N/cm ²)	27.42	6.28	28.33	4.99	0.28
Ham sausage	smell (pts)	4.42	0.29	4.50	0.27	0.65
	juiciness (pts)	4.70	0.20	4.75	0.23	0.70
	tenderness (pts)	4.70	0.28	4.50	0.29	0.10
	flavour (pts)	4.43	0.26	4.38	0.25	0.55
	shear force (N/cm ²)	10.12	4.51	11.82	4.01	0.12

* Statistically significant difference, where $P \leq 0.05$.

terminants ranged between about 4 and 4.7 points and did not statistically differ significantly between the groups except for the juiciness of ham (it was better in group A) as well as the compensation of colour (it was better in group B) in the ham sausage.

The higher value and greater dressing percentage of porkers in group A (Table 2) resulted in average sales prices of the porkers in group A being 2.89% higher (5.34 PLN per kg LW in group A and 5.19 PLN per kg LW in group B, respectively) – Table 4. A longer fatten-

ing period with a less concentrated feed resulted in a 9.8% worse conversion of the feed by the porkers in group A (3.36 kg of feed per kg of weight increase in group A and 3.06 kg of feed per kg of weight increase in group B, respectively). The lower cost per unit of feeds for extensively fed porkers (888 PLN per t during the first fattening period and 827 PLN per t during the second fattening period in group A in compare 961 PLN per t during the first fattening period and 894 PLN per t during the second fattening period in group B, respec-

TABLE 4. The technological and economic results of production of extensively fed fatteners (group A) and intensively fed fatteners (group B) in 2014

Specification	2014		Cost of feeds + 15%*	
	group A	group B	group A	group B
Feed consumption (kg feed/kg increase)	3.36	3.06	3.36	3.06
Costs, price (PLN/kg LW)	5.34	5.19	5.34	5.19
Feed cost (PLN/kg LW)	3.11	2.94	3.35	3.19
Purchase of piglets (PLN/kg LW)	0.14	0.45	0.14	0.45
Veterinary care and insemination cost (PLN/kg LW)	0.30	0.26	0.30	0.26
Energy cost (PLN/kg LW)	0.13	0.11	0.13	0.11
Depreciation (PLN/kg LW)	0.22	0.19	0.22	0.19
Repairs cost (PLN/kg LW)	0.14	0.11	0.14	0.11
Labour cost (PLN/kg LW)	0.42	0.35	0.42	0.35
Other direct costs (PLN/kg LW)	0.15	0.12	0.15	0.12
Indirect costs (PLN/kg LW)	0.12	0.10	0.12	0.10
Total costs (PLN/kg LW)	4.72	4.63	4.97	4.88
Secondary production cost (PLN/kg LW)	0.12	0.10	0.12	0.10
Own net cost (PLN/kg LW)	4.60	4.53	4.85	4.78
Profit per unit (PLN/kg LW)	0.74	0.66	0.49	0.41
Profit per unit (PLN/pigs)	89.58	83.16	59.66	51.88
Total profit (PLN/farm)	303 042	323 846	201 812	202 025

* Simulated results of the experiment if the prices of feeds increased by 15%.

tively) did not fully compensate for the worse conversion of feeds. In group A the cost of feed per kg of livestock produced (during the whole production period, from birth to sales) was higher by 0.16 PLN, because the porkers in this group consumed more feed per kg of growth (3.11 PLN per kg of porkers sold in group A in comparison to 2.94 PLN per kg of porkers sold in group B).

The farm could produce 3,894 porkers with feeds for the intensive group. The application of feeds with less concentrated protein and energy extended the experimental fattening by 9 days. Thus, it reduced the production capacity of the farm to about 3,383 porkers a year. Due to the fact that every year the farm under analysis purchased a few hundred piglets to supplement the deficit of its own production, it would be necessary to purchase fewer piglets for the extensive fattening method and this would result in the farm being burdened with lower costs of porkers. In group A it was 0.14 PLN per kg of porkers sold (it would be necessary to purchase 297 piglets); whereas in group B it was 0.45 PLN per kg of porkers sold (it would be necessary to purchase 827 piglets).

The cost of electricity, depreciation of buildings and machinery, costs of repairs and, to a large extent, labour costs are fixed costs if there is a relatively large number of staff employed. Therefore, when we calculated the costs per weight of porkers sold, there were higher costs per unit of the porkers in group A. The total costs of production reduced by the value of secondary production (sows

sold) were higher by 0.07 PLN per kg LW when porkers were produced with a less intensive mixture. The costs amounted to 4.60 PLN per kg LW in group A and 4.53 PLN per kg LW in group B. The higher sales prices of the porkers in group A provided a higher profit per unit of 0.74 PLN per kg LW vs 0.66 PLN per kg LW in group B. It amounted to 89.58 PLN per porker and 83.16 PLN per porker, respectively. However, due to the fact that the fattening period is 9 days longer, the production potential of the farm is 13.1% lower. Thus, the profit of the entire farm would be 20,800 PLN greater and it would amount to about 323,800 PLN if the whole herd was fed with mixture B and it would amount to about 303,000 PLN if the herd was fed with mixture A. As results from the simulations, if the prices of feeds increased by 15%, the whole farm would make a similar profit regardless of the fattening type. However, a further increase in the prices of feeds would make extensive production more cost-effective.

The assumption that the pigs fed extensively had a better sensory quality of meat was not proved. This may have been caused by too small a difference in the fattening methods applied in the experiment. There are literature reports on the better organoleptic quality of the meat products of pigs fed extensively, where this system is connected with the choice of local breeds and free-range fattening. This applies e.g. to breeds from southern European countries (Pugliese and Sirtori 2012) and to other native breeds (Szulc et al. 2012).

On the other hand, from the economic point of view, the reduction of the fattening intensity had an influence on the farmers' results, although it also depended on the prices of feeds to a certain extent. In 2014, when the prices of feeds were low, the profit of the whole farm was 6.9% higher in the intensive fattening method. If the prices of feeds increased by 15%, the yearly profit made by the whole farm would be similar regardless of the fattening type.

The experiment showed that under certain economic circumstances it is justified to apply the extensive production of porkers. If we take external benefits into consideration, such as reduced environmental costs, better meat quality, improved animal welfare, etc., they may outweigh the economic loss (lower profit) resulting from the extensive fattening of porkers.

CONCLUSIONS

Applied in this work the reduced level of protein and energy in the feed provided to the pigs caused a decrease in the daily weight gains by 130 g on average. The pigs which were fed less intensively had a higher slaughter value, i.e. on average the content of meat in the carcasses was 1.54 pp higher, the thickness of backfat was 3–6 mm thinner and the dressing percentage was 1.33 pp higher than in the group of pigs fed with the mixture which was richer in protein and energy. The evaluation of the products made from the ham pointed to the very high quality of both dry cured ham and ham

sausage and showed no significant differences between both study groups (except for the juiciness of ham which was better in group A and for the colour compensation of ham sausage which was better in group B).

From the economic point of view, reduced fattening intensity combined with the low prices of feeds resulted in a lower profit margin of the whole farm. If the prices of feeds were 15% higher than in 2014, it might result in equal total profits for the farm in both fattening systems.

Acknowledgement

The research work was financed by the National Science Centre as a research project 3994/B/H03/2011/40 titled "Comparative analysis of the economic efficiency of farming, quality and technological value of meat from pigs fattened in intensive and extensive production systems".

REFERENCES

- ACCIAIOLI A., PUGLIESE C., BOZZI R., CAMPODONI G., FRANCI O., GANDINI G., 2002: Productivity of Cinta Senese and Large White × Cinta Senese pigs reared outdoors on woodlands and indoors. 1. Growth and somatic development. *Italian J. Anim. Sci.* 6: 663–671.
- BARYŁKO-PIKIELNA N., 2014: Sensory research of food. Bases-methods-applies. II edn. Wyd. Nauk. PTTŻ, Warszawa (in Polish).
- BLICHARSKI T., PTAK J., SNOPIEWICZ M., 2012: Genetic results 2011. Pigs. Polish Pig Breeders and Producers Association „POLSUS”, Warsaw.
- BORZUTA K., 1998: Studies of usefulness of different methods of meatiness evaluation for the classification of porcine carcasses in

- the EUROP system (in Polish). *Roczniki Inst. Przem. Mięś. i Tł.* 35/2: 1–84.
- FRANCI O., GANDINI G., MADONIA G., PUGLIESE C., CHIOFALO V., BOZZI R., ACCIACIOLI A., CAMPODONI G., PIZZI F., 2001: Performances of Italian local breeds. *Pig genetic resources in Europe*. EAAP Publication 104: 67–76.
- HONEYMAN M.S., 2005: Extensive bedded indoor and outdoor pig production systems in USA: current trends and effects on animal care and product quality. *Liv. Prod. Sci.* 94: 15–24.
- OLKIEWICZ M., TYSZKIEWICZ S., MOCH P., 2000: The selected factors determining the consistency of dry cured hams produced on a small scale (in Polish). *Roczniki Inst. Przem. Mięś. i Tł.* 37: 117–126.
- PEPLIŃSKI B., WAJSZCZUK K., WIELICKI W., 2004: Vertical Integration vs. Cost-Effectiveness of Pork Production. AR w Poznaniu, Poznań (in Polish).
- PUGLIESE C., BADI M., BOZZI R., ACCIAIOLA A., CAMPODONI G., FRANCI O., 2012: Fatty acid composition of raw and cured ham fat of Cinta Senese pig as affected by rearing system. In: *Proceedings of the XLVIII International Congress of Meat Science and Technology, Roma 25–30 August*: 434–435.
- PUGLIESE C., CALAGNA G., CHIOFALO V., MORETTI V.M., MARGIOTTA S., FRANCI O., GANDINI G., 2004: Comparison of the performances of Nero Siciliano pigs reared indoors and outdoors. 2. Joints Composition, meat and fat traits. *Meat Sci.* 68: 523–528.
- PUGLIESE C., MADONIA G., CHIOFALO V., MARGIOTTA S., ACCIAIOLI A., GANDINI G., 2003: Comparison of the performances of Nero Siciliano pigs reared indoors and outdoors. 1 Growth and carcass composition. *Meat Sci.* 65: 825–831.
- PUGLIESE C., SIRTORI F., 2012: Quality of meat and meat products produced from southern European pig breeds. *Meat Sci.* 90: 511–518.
- REKIEL A., WIĘCEK J., DZIUBA M., 2005: Effect of additives on the results of fattening and selected slaughter and quality traits of pork meat of pigs with different genotypes. *Czech J. Anim. Sci.* 50 (12): 561–567.
- SERRANO M.P., VALENCIA D.G., NIETO M., LAZARO R., MATEOS G.G., 2008: Influence of sex and terminal sire line on performance and carcass and meat quality of Iberian pigs reared under intensive production systems. *Meat Sci.* 78: 420–428.
- SZULC K., SKRZYPCZAK E., BUCZYŃSKI J.T., STANISŁAWSKI D., JANKOWSKA-MAKOSA A., KNECHT D., 2012: Evaluation of fattening and slaughter performance and determination of meat quality in Złotnicka Spotted pigs and their crosses with the Duroc breed. *Czech J. Anim. Sci.* 57 (3): 95–107.
- WEBB E.C., ERASMUS L.J., 2013: The effect of production system management practices on the quality of meat products from ruminant livestock. *S. Afr. J. Anim. Sci.* 43 (3): 413–423.
- Streszczenie:** *Wpływ ekstensyfikacji żywienia tuczników na wartość rzeźną, jakość przetworów mięsnych oraz ekonomikę tuczu.* Wykonano badania 64 świń podzielonych na dwie grupy: grupę A żywioną mieszanką pełnoporcjową uboższą w białko i energię metaboliczną oraz grupę B żywioną mieszanką bogatszą w te składniki (różnica o 0,5–0,8% w zawartości białka i 0,5–0,8 MJ/kg w energii metabolicznej). Tucz prowadzono systemem alkierzowym do osiągnięcia masy ciała 120 kg. Badano przyrosty dzienne, wartość rzeźną oraz jakość organoleptyczną wyrobów mięsnych. Stwierdzono, że obniżony poziom białka i energii w paszy spowodował zmniejszenie przyrostów dziennych o 130 g i wydłużenie okresu tuczu o 9 dni. Tuczniaki żywione mniej intensywnie charakteryzowały się większą o 1,86 pp. zawartością mięsa w tuszy, cieńszą o 3–6 mm słoniną oraz większą o 1,33 pp. wydajnością rzeźną. Zróżnicowany poziom żywienia nie wpłynął na jakość organoleptyczną szynek surowo-dojrzewających (oprócz soczystości, która była lepsza w grupie A) oraz kielbasy szynkowej (z wyjątkiem natężenia barwy, która była większa w grupie B).
- Słowa kluczowe:** *żywienie, wartość rzeźna, jakość przetworów mięsnych, ekonomika tuczu*

MS received January 2016

Authors' address:

Dariusz Lisiak
Pracownia Badań Surowców i Produkcji
Rzeźnianej
Instytut Biotechnologii Przemysłu Rolno-Spożywczego im. Prof. Wacława Dąbrowskiego
ul. Głogowska 239, 60-111 Poznań
Poland
e-mail: dariusz.lisiak@ibprs.pl