

Thesis of Doctoral (PhD) Dissertation

**Improvement of economic efficiency of
slaughter pig production with utilizing by-
products from arable crops processing for
energetic purposes**

Márkus Richárd

Mosonmagyaróvár 2011

**UNIVERSITY OF WEST-HUNGARY FACULTY OF AGRICULTURAL AND FOOD
SCIENCES**

MOSONMAGYARÓVÁR

INSTITUTE OF BUSINESS ECONOMICS AND MANAGEMENT SCIENCES

Ujhelyi Imre Doctoral School of Animal Sciences

Head of Doctoral School:

Prof. Dr. Benedek Pál, university professor, Doctor of HAS

*Program of „Economic concerns of production, processing and
marketing of animal products”*

Program leader:

Prof. Dr. Tenk Antal CSc.

Topic leaders:

Dr. habil Tell Imre associate professor

Dr. Tóth Tamás associate professor

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1. Introduction, the purposes of the thesis

In Hungary slaughter animal and meat production have traditionally always filled a very important role in agriculture. Nearly two and a half decades ago the volume of pig livestock almost reached 10 million, at the same time the cattle, sheep and poultry stock was also very significant (concerning its amount, compared to nowadays the stock then was more than double). In order to make pig farming and slaughter pig production really profitable, several factors have to be taken into account. Above all feedstuff provision has to be treated with priority as it represents the largest share from costs. Accordingly, considerable output improvement can be achieved through more cost effective animal feeding. Feeding costs should be decreased without resulting any unfavourable changes in natural indicators or composition of the end production. In order to expose the earlier mentioned facts, research was carried out also to examine meat quality besides the most important parameters of fattening. The main objective of the research was to draw conclusions based on the results of own feeding experiments (related measurements, laboratory tests, etc). Economic calculations were carried out based on the experiment results, in order to contribute to the increase of competitiveness of slaughter pig production. By-product utilization – as a possible means of cost reduction – is not a new concept. Accordingly, one of the objectives of research was to carry out feeding experiments based on the scientific results which are already available in this field. Novel by-products of arable crops processed for energetic purposes (rapeseed cake and DDGS (dried drilled grain solubles) on a determined substitution level) were investigated to define the

applicability and risks, to determine the effects of these feeding stuffs on end-product quality and cost-income relations.

The research covered the following fields:

On basis of scientific literature literature:

- What is the situation of meat production world wide, in the European Union, and in Hungary?
- Which factors define the competitiveness of slaughter pig production, and the development of the piggery branch?
- Which are the most important current questions of feeding and protein management, and what effects do they have on production costs?
- How can the by-products be used (rapeseed cake and DDGS) which are originating from plant production for energetical purposes? Additionally, how can these by-products be applied in pig feeding, and what are the experiences and results with them domestically and internationally?

Based on the research results (feeding investigations, laboratory and sensory tests):

- How the examined natural indicators have changed (e.g. daily weight gain, feed conversion ratio, etc.) and the quality of the slaughtered product during/after the feeding experiment?

- Do the repetitions and the differing seasons (winter, summer) have a statistically verifiable effect on the obtained production and meat quality indicators?
- Does the feeding of by-products have any influence on the nutrition content of pork (e.g.: dry matter, fat-, protein-, and ash content) to its fatty acid content and keepability, storage life?
- Does the feeding of by-products used in the experiment influence the organoleptic properties (e.g.: odour, flavour, tenderness, overall impression) of the dishes made from pork (pork chop, pork thigh)?
- What advantages or risks can be expected if such by-products (DDGS, oilseed cake) on defined substitution level) are fed in small-scale production units?

Based on economic analysis, using data and experiences of the research:

- How do the procurement prices of fodder and pig for slaughter develop and what is the extent of seasonal fluctuation?
- In what direction and to what extent did pig cycle change during the past years?
- Is concentration increasing in pigfarming, and what effect does this have on by-product utilization and on the competitiveness of pig for slaughter production?
- In case the imported soya-meal is replaced by the by-products used in the research (rapeseed cake and DDGS), what effects does this substitution have on the cost-income relation of pig fattening, and on the competitiveness of the slaughter pig producer farms depending on the price changes?

2. Material and method

Research was conducted and evaluated at the Institute of Business Economics and Management Sciences and at the Department of Animal Nutrition Institute of Animal Sciences at the University of West-Hungary Faculty of Agriculture and Food Sciences. In the conducted feeding experiments (carried out on the pig farm of family entrepreneur Mrs. Imréné Márkus in Csorna) 120 pigs, namely Hungarian Large White x Hungarian Lowland x Seghers type pigs were involved. The pig fattening experiment was carried out in one repetition, animals were fed *ad libitum*. The ingredients of the feedstuff were accurately determined in the experiment (dry matter, raw protein, raw fat, raw ash) according to the experiment procedures recommended in the *Hungarian Feeding Codex* (2004). After slaughtering, samples of pork thigh (*m. semimembranosus*), and long back muscle (*m. longissimus dorsi*) were collected.

Among others the fat acid composition of the slaughtered product was examined. In addition, pH, oxidative stability and colour measurement on the pork chop (in the 1st, 24nd, and 48th hours) and the pork thigh (in the 1st hour) samples were carried out.

After the measurements an organoleptic experiment was conducted according to the thematics of The National Meat Industry Research Institute in order to ascertain what effect rapeseed cake and DDGS have on certain meat properties. The statistical estimation of the feeding experiments was analyzed by the SPSS 17.0. for Windows programme (SPSS Inc., Chicago, USA). The homogeneity test of the dispersions was evaluated with the help of the Levene test, and the normality of the dispersions was defined by the Kolmogorov-Smirnov and the Sharpio-Wilk tests. Depending on the

development of the homogeneity of the dispersion and the normality of the distribution, parametric (*one-way ANOVA, GLM*) and non parametric tests (*Mann-Whitney, Kruskal Wallis Test*) were applied. The chosen significance level in each statistical analysis was: $P=0,05$. The economic analyses were based on the obtained primer data, and the secondary data of the Hungarian Central Bureau of Statistics. Statistical analysis methods, the examination of concentration, seasonality and cyclicism of price changes were made with the help of the Microsoft Office Excel 2003 (Microsoft Corporation, Redmond, Washington, United States).

3. Overview and summary

The volume of pork production has increased by nearly 10% worldwide, and showed stagnating tendencies in the European Union, while in Hungary the volume of livestock decreased by more than 20% between 2004-2009.

Besides the decrease of the livestock, a structural transformation also took place, which is proved by the fact that nowadays, two-thirds of the total domestic pig livestock is concentrated in 0.3% of the pig farms. Based on the seasonality analysis of the domestic slaughter pig procurement prices it can be stated that prices were the lowest in May (with 7.25% discrepancy from the trend), and the highest in September (with 5.25% deviate from the trend) between the 1992-2010 period. At the same time the conjunctural and the deconjunctural swings and their lengths also showed a decreasing tendency. In order to change the extremely unfavourable situation (the enduring lack of competitiveness) which developed in the domestic piggery branch, producers definitely have to take steps, even though they cannot really exert an effect on the unfavourable economic/market environment. As during the slaughter pig production feeding cost makes up the biggest cost item (its share in the total cost might be as high as 60%), it is obvious that special attention should be paid to this cost item. However, feeding costs should be decreased in a way that unfavourable changes in production/fattening performance (and thus revenue) are avoided, on the other hand eventual „deteriorations” should result in smaller decrease in value than the amount of cost reduction. The increase of feedstuff prices and the negative state of the domestic feedstuff protein balance keeps the

significance of by-product utilization in the focus. Soy in pig feedstuff could be partially substituted by by-products of the food industry, and additionally the utilization of the by-products of the organic fuel industry branch which is currently evolving can contribute to the concept. The utilization of by-products from the plant oil industry is nothing new either. The by-products which are produced during the processing of sunflower and rapeseed oils can very well be used in the feeding of both ruminous and monogastric animals. With the increase of the utilization of DDGS and rapeseed cake the role of corn and primarily soymeal (as an imported product) may decrease in feeding. Both rapeseed cake and DDGS can be used in the feeding of monogastric animals (eg: poultry, pig) and ruminous animals (eg: sheep, cow), as both are significant energy, phosphor, and amino-acid resources.

At the same time professional and scientific literature also drew attention to the fact that in case of both by-products (irrespective of the fact that results of previous experiments are at our disposal in a restricted scope), further research (also experiments and analyses) are necessary in order to know the full range of the economic effectiveness of utilization options and application. This background also supported and underlined the need for the research carried out in the past years in one repetition with 120 Hungarian Large White x Hungarian x Lowland x Seghers pigs.

In the feeding experiments the soymeal was substituted to a 20% and 35% ratio with rapeseed cake and DDGS (with homogenous nutrient and energy content). The inclusion levels in the grower phase refer to 6.8% and 8.9% in the fodder mixture, while in the finishing period 8.4% and 10.5% of rapeseed cake and DDGS were included in the fodder mixture. Animals were weighed regularly, and feed intake, daily weight gain, specific feed

conversion rate, carcass characteristics were also examined. Besides, samples from chop and thigh of slaughtered pigs were taken and sensory examination was also performed. The average daily weight gain of the examined animals was the following: 808 g/day, 803 g/day, and 772 g/day for soymeal, rapeseed cake, DDGS treatments respectively. In case of the specific feed conversion ratio the pigs fattened on soymeal and DDGS feedstuff both at 3.01 kg/kg proved the most favourable results, while rapeseed cake group, if only to a small extent, fell behind with 3.13 kg/kg. The results of the post mortem examination regarding with carcass characteristics verified, that whereas the applied treatments did not have a significant effect ($P=0.983$) on the quantity of carcass, the season did have ($P<001$). It was concluded that the partial substitution (applied at the level of the conducted experiments) of soymeal with rapeseed cake and DDGS only slightly influences the nutritive value of the pork thigh and chop. Regarding the fatty acid contents of the meat, the ratio of the particular fatty acids turned out in the laboratory samples in accordance with the varying fatty acid content of the various feedstuffs. Examining the ratio of linol (C18:2, n-6) and the linoleic acid (C18:3, n-3) it can be concluded that the ratio of n-6/n-3 was the most limited in the case of animals fattened with rapeseed cake (13,24:1 and 13,72:1). In case of chop and thigh samples the highest ratio of PUFA fatty acid was measured in the animals fed with the DDGS feedstuff. During the pH measurement every treatment showed a result with values falling into the normal range, so the possible appearance of questionable quality of PSE and DFD meats can be almost excluded. On the basis of these it can also be stated that feeding did not influence the development of the pH of the pork chop. During the sensory test of the

grilled meat, the panel did not find significant differences concerning odour, flavour, tenderness and overall impression either. Besides, the panel found the meat samples of the animals fed with the by-products even slightly better than control group's samples. In the professional literature several authors also stated, that the rapeseed cake applied in a quantity ratio of 15-20% in feeding did not cause a significant difference in the production indicators during pig fattening. However, there are barely any (or just a few) special literature data (adequately supported number wise) available about whether the economic efficiency and the cost-revenue relations change in a favourable or unfavourable direction and to what extent they do so. The fact, however, that by increasing the quantity of by-products the price of the feedstuff decrease is evident (not counting extreme substitutional and price relations).

The result of the application of by-products on the economic efficiency, cost-revenue relations of pig for slaughter production can be summarized as follows, based on the evaluation of the detailed analyses, results, the related simulation model calculations. The application of two different by-products involved in the summer-winter experiment on the given level - rapeseed cake (6,8%; 8,5%), DDGS (8,4%; 10,5%) - within feedstuff does result cost reduction in comparison with the control group. The extent of this (given the joint results of the summer-winter experiment as well) does show a significant difference between the two different types of experimental feedstuff. The DDGS group has shown more favourable result in the production (fattening) performance and in the development of revenue, additionally in the development of cover value also compared to the rapeseed cake group. Thus, the results of the conducted experiments pointed

out that besides the given price relations, on this substitution level rapeseed cake does not, but DDGS does improve the efficiency of pig for slaughter farming and through it the economic efficiency of the production of pig for slaughter. However, it has to be emphasized that the above conclusions were neither born out of a series of experiments carried out several times over, nor on a large pig farm scale. At the same time it is based on concrete results, accordingly they try to expose the practical feasibility of the application (economically wise) with references which are truly relevant for competitiveness and its sustainment. The conducted (albeit not full scope) model calculations have shown the possible application variations. According to the simulation of market mechanism effects it was ascertained that the use of the by-products (rapeseed cake and DDGS) in an increased ratio within the feedstuff gradually decreases the (self) production costs of the feedstuffs (ensuring the same nutritive content). At the same time DDGS – in comparison with the rapeseed cake – within the interval of the experimental period, even if not in an increasing manner /still more even decreasing/ and extent, but on all (included in the model, and possible) substitution levels produced a bigger (from the point of view of profitability thus truly significant) extent of breakeven surplus. The specific feedconversion ratio and the performance difference in production (fattening) play an important role to some extent between the two varieties. The price increase of soymeal and the substitution to an ever greater extent together can cause a very significant change of specific costs in case of using both the „rapeseed cake” and the „DDGS” in experimental feedstuffs. It was pointed out that in case of the conducted experiments, if the soymeal prices would have been 50% higher the cover value of the DDGS

experimental group would have been 30% and in case of rapeseed cake group 400% (due to the extremely low „basis”) higher. According to the results it can be concluded that the application of the experimental feedstuffs can significantly be influenced by the price fluctuation of the substituted resource. The results of the conducted and evaluated feeding experiments have pointed out (especially in the case of „DDGS”) that their application (of course depending on the price fluctuations) can be an effective tool in increasing the profitability and the competitiveness of slaughter pig production.

4. New and novel scientific results

1./ The partial substitution of extr. soy with rapeseed cake and DDGS respectively (in fattening pig phase I. 6.8% respectively 8.5% while in the case of fattening pig age group II 8.4% and 10.5% sequentially) has no unfavourable effect either on the performance of fattening, the pure meat content of the pig for slaughter, the nutrient and fatty acid content of the prime meat cuts or the results of organoleptic tests.

2./ On the substitution levels applied in the experiments and considering the given market prices rapeseed cake does not, while DDGS does improve the economic efficiency of pig fattening and as a result the production of pig for slaughter.

3./ The application is only recommended optionally, as the development of cost-revenue relations is significantly influenced by the extent of substitution, the change in (resource) prices. The elaborated simulation model – that is based also on research results – facilitates the investigations and evaluation of different forms/variations, makes the numeric analysis and the simulation of market effects and mechanisms possible.

The model supports the following statements:

- the increasing amount and share of by-products (oilseed cake and DDGS) in feedstuffs gradually decreases the the production (self-) cost of „formulated” (feedstuff ensuring the same nutrition content) feed mixtures;

- price increase of extr. soya (resource to be substituted) and the increasing level of substituting by-products (together) may result significant relative cost- or price change (and resulting a larger extent of breakeven surplus), both in case of „rapeseed cake” and „DDGS” feed mixtures;
- compared to the „oilseed cake” version, the efficiency improving effect of „DDGS” is higher in all substitution levels.

4./ The results of the actual research and the simulation model highlighted that further research should be carried out to investigate the application possibilities of „DDGS” separately, or examinations on the application possibilities of „DDGS” combined with oilseed cake are reasonable.

5. List of publications in the theme of the dissertation

5.1. Scientific supervised papers published in English

Karácsony P. – Márkus R. (2007): The comparative study of wheat growing results in Hungary and Austria, *Acta Agronomica Óváriensis*, 49:1., 51-61 pp.

Márkus R. – Tell I. – Tóth T. – Troján Sz. (2011): Use of rapeseed cake for improving competitiveness in swine production, *Acta Agronomica Óváriensis*, 52:2

Bakucs Z. – Márkus R. (2011): Supply response on the Hungarian pork sector, *Acta Agronomica Óváriensis*, (megjelenés alatt)

5.2 Proceedings published in Hungarian or in English language

Márkus R. – Tell I. (2007): A sertéságazat helyzetét befolyásoló tényezők Ausztriában és Magyarországon, *A sertés*, 12:2, 16-23 pp.

Szecsei T. – Csipkés M. – Márkus R. – Salamon Lajos (2010): Az energianövények termesztésének vizsgálata a hazai támogatások tükrében, Gyöngyös konferencia

Márkus R. – Tell I. (2007): The Competitiveness of the Piggery branch in Austria and Hungary, *Rural Development 2007*, Akademija, Kaunas region, Lithuania, 281-287 pp.

Wolz. A. – Buchenrieder G. – Márkus R. (2009): Synthesis of the country reports on renewable energy and its impact on rural development

in the new member states, candidate and potential candidate countries
2009, Agripolicy Enlargement Network for Agripolicy Analysis, WP2
studies, IAMO, Halle (Saale)

Wolz. A. – Buchenrieder G. – Márkus R. (2011): Bio-energy and
Rural Development: Findings from a Comparative Study in Central,
Eastern and Southern Europe, 6th International Symposium on
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5.3 Presentations in Hungarian or in English language

Márkus R. – Tell I. (2007): A sertéságazat jövedelmezősége és
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szerepe a fehérjegyazdálkodásban, A Magyar Tudomány Ünnepe, „Fiatal
Kutatók az élhető Földért”, Budapest

Szecsei T. – Márkus R. – Salamon L. (2008): Lehetőségek az
energiafűz (*Salix viminalis* Sp.) termesztésében, A Magyar Tudomány
Ünnepe, „Fiatal Kutatók az élhető Földért”

Márkus R. – Tell I. – Tóth T. – Troján Sz. (2009): A repcepogácsa
felhasználásának lehetősége a sertéstakarmányozásban, V. Európai
Kihívások Konferencia 2009, Szeged

Szecsei T. – Csipkés M. – Márkus R. – Salamon L. (2010): Az
energianövények termesztésének vizsgálata a hazai támogatások
tükrében, Gyöngyös konferencia

Márkus R. – Tell I. (2007): The Competitiveness of the Piggery branch in Austria and Hungary, Rural Development, Akademija, Kaunas region, Lithuania, 281-287 pp.

Márkus R. – Tell I. – Tóth T. – Troján Sz. (2009): The cost reducing effects of novel feedstuffs in pigfarming in Hungary, MACE conference, Berlin

Bakucs Z. – Márkus R. (2011): Supply response on the Hungarian pork sector, Institutions in Transition – Challenges for New Modes of Governance, 16-18 June 2010, Halle (Saale), Germany

Wolz. A. – Buchenrieder G. – Márkus R. (2011): Bio-energy and Rural Development: Findings from a Comparative Study in Central, Eastern and Southern Europe, 6th International Symposium on Agriculture, Croatia