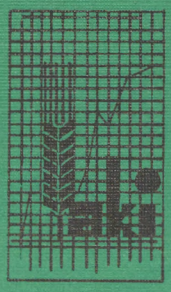

AGRÁRGAZDASÁGI KUTATÓ INTÉZET
RESEARCH INSTITUTE FOR
AGRICULTURAL ECONOMICS

BULLETIN No 37

ECONOMIC QUESTIONS OF MAIN AGRICULTURAL BRANCHES (STUDIES)

BUDAPEST 1975

AGRÁRGAZDASÁGI KUTATÓ INTÉZET

RESEARCH INSTITUTE FOR AGRICULTURAL ECONOMICS

BULLETIN

No.37.

ECONOMIC QUESTIONS OF MAIN AGRICULTURAL BRANCHES

(Studies)

Budapest
1975

INTRODUCTION

The PRESENT NUMBER OF THE BULLETIN–SERIES of our Institute deals with state and economic analysis of main branches of agriculture. Of course, publications selected from the collection of two years may not offer a perfect illustration of the research work done by the Institute within this area. However, they can demonstrate trends and main results of research activity.

It is to be mentioned that abridged studies presented here generally have the character of a fact-finding study and undertake an economic evaluation and a summing-up of experience. In the livestock sector economic aspects at farm level are dominating allowing a double approach to the issue. Publications referring to economic aspects at both branch and farm level are connected with the research program of the institute for the plan period of 1971–1975.

Budapest, March, 1975.

The Editors

ECONOMIC EFFICIENY OF THE TECHNICAL–TECHNOLOGICAL PROCEDURES USED IN INDUSTRIALIZED PIG FARMS

by
PÉTER HALÁSZ

According to the pork production programme announced in 1968, the large-scale farms commenced the construction of more than 250 concentrated, specialized pig farms. The purpose of the programme – besides increasing the pork production and the profitability of the sector – was to establish first of all the technical and economic conditions for large-scale industrialized pork production. The successful realization of the pig programme was facilitated by an extensive budgetary state aid: earlier 70, later 50 % of the construction costs, and nearly 50 % of the machinery investments were covered from central resources. In addition the state encouraged the realization and technical development of the pig farms by other means as well.

In the Pig and Poultry Division of our Institute, right in the first year of the programme, we proceeded to collect the data and information necessary for the economic analysis of the industrialized pig farms. The purpose of our work was partly to inform the operators in the already operating pig farms, in case of altering the technical-technological installations, and partly to assist the designers, builders and operators of the new pig farms to be built.

The calculations and analyses involved in the study have been prepared on the basis of the 1970–73 data and production experiences referring to 55 newly built pig farms. The other part of the examination basis was provided by the detailed material collected from 33 pig farms with the help of a questionaire. This material was used for the purpose of assessing the whole process of investment preparation and completion in 1972 and 1973. We finalized the collection of data at the end of 1973.

Examining the economic efficiency of the various technical technological procedures at times or according to the subject, we had to use different methods. In solving the matter of fodder distribution, we had to know the economic consequence of *labour being substituted by capital* (i.e. the mechanization of the various operations). We tried to clarify the economic aspects of the manure removal from the stable, the fodder mixing and its conveyance the farm, mainly by the *comparative analysis* of the various technical procedures. Finally we examined the economic efficiency of the fodder granulation, furthermore the heating, cooling, ventilation of the buildings used for pig keeping, by taking into consideration the *attainable surplus outputs.* However, the *substance of the applied method* was the same in every case: to explore the relation of the additional expenditure connected with the examined technical-technological installations, as well as the attainable savings and surplus outputs.

1. Conditions of establishing industrialized pig farms

For the realistic appraisal of the pig farms built according to the pig programme, we have to know, that practically there was no proper and reliable information available to the farms concerned, when they decided on the type of system for the pig farm to be built. 11 % of the observed farms made the decision based on personal connections, and 25 % of them being in a difficult situation, selected the system of the designer promising the quickest delivery. 64 % of the farms decided on the system of the pig farm to be built, often based on which could not be controlled, which had been received from some kind of institution, partner farm, from the designer, contractor or commercial organization.

In the course of establishing the new pig farms, the cost of investment increased by 26.8 % during the implementation against the planned amount. 20 % of the cost increase was caused by the capacity expansions carried out during the construction, and 80 % was the result of the so-called under-estimation to a lesser degree, but mainly due to the rapidly rising prices of the industrial products. But the specific investment costs were considerably increased also by the fact that some of the machines fitted according to the plans either did not work at all, or their operation was unsatisfactory, and they were put into working order at the expense of significant extra outlays.

2. Economic efficiency of the technical-technological solutions concerning feeding

a) Fodder preparation

Fodder preparation was set up in the greater part of the newly built pig farms, most of them supplied naturally not only the pig farm, but other projects as well. The operational experiences indicate that in case of self-operated fodder preparation, the substance value and quality of the fodder is more uniform and reliable, moreover the cost of transport decreases to a quarter, because the concentrate only has to be transported.

The specific operational costs of the fodder storing and mixing operations existing in the examined pig farms, developed as follows:

depreciation	5,72 – 7,05 Ft/q (q = 100 kg)
maintenance, repair	2,16 – 2,65 Ft/q
energy	3,09 – 3,05 Ft/q
wages	2,06 – 2,05 Ft/q
total	13,03 – 14,80 Ft/q

These data refer to the average, most frequently used mixing operations. However, there are some complicated and automated technical installations, where the cost is much higher than those given above.

The given values are valid for a 10 hour shift per day. By increasing the time of operation per day, the proportion of output expenditure can be improved. If two 10 hour

shifts are organized per day, then the specific operational cost will be lowered by 26–33 %.

The cost trend of food preparation – taking place in the self-operated fodder plant – shows that its advantages appear not only in the cost of transportation. The actual cost of self-produced fodder granulation, storage and mixing will be between 13.03 and 15.82 Ft/q. Deducting from this the cost to be saved by eliminating the conveyance of farm fodder (2.85 Ft/q), we obtain the net cost of 10.17–12.97 Ft/q for fodder preparation.

a) Fodder distribution

Examining the economic efficiency of the technical-technological procedures applied in pig feeding, the various factors have to be divided into two groups. One of the groups contains features *directly or indirectly connected with the fodder disposal, specific fodder utilization of the pigs* (such are the method of feeding and the quality of the fodder to be fed); the other group contains features *not influencing pig production. Their economic effect is realized in the specific cost of the feeding process* (such are the technical solutions of fodder distribution, i.e. the mechanization of the operation). Concerning the specific fodder utilization it is completely indifferent whether the wet, coarse or granulated fodder gets into the through, into the self-feeder, or into the floor, by manually handled pushcart, or by using a mechanised or automated production line. The economic efficiency of *mechanising fodder distribution* depends exclusively on *which way will the additional cost consequent upon increasing the proportion of capital – be realized in the wage-saving, attainable by reducing the amount of labour.*

The technical-technological solutions used at fodder distribution in the new pig farms are divided into three groups: *procedures semi-mechanized and procedures mechanised with mobile and fixed installations.* The *first group* contains those solutions, when the fodder is conveyed and distributed by manually handled pushcarts. In the *second group* are the engine-driven fodder distributing cars rolling on rails and rubber tyres which perform the work in several stables. Finally the *third group* comprise fixed mechanism distributing the fodder in one single building. These can be manually controlled and automated.

In the newly built pig farms the sucking and separated piglets receive the fodder without exception from the self-feeder, distributed by manually handled pushcart, or by fixed machine system. The time required for the distribution of piglet-fodder within each technological system, depends on the age of the piglets, i.e. it is determined by the quantity of fodder to be distributed daily. The cost of different fodder distribution technologies depending on the age of the piglets coming from the farrowing pen is shown by Table 1. These data will illustrate well the economic inefficiency of mechanization at any price. The quantity of fodder fed to the sucking and separated piglets is relatively very small. In a farrowing pen, accommodating 60, no more, than 8–10 q fodder has to be distributed daily, even for piglets older than 80 days, which does not take longer than 50 minutes a day even if it is performed with manually handled pushcart. *Therefore the distribution of fodder for the piglets in the farrowing area, for the time being can not be mechanized economically.*

Table 1

The cost of piglet-fodder distribution performed with different procedures for 1 actual feeding day, in the function of the piglet's age coming from the farrowing area

Denomination	Age of piglets coming from the farrowing area			
	35	60	75	95
	days			
	cost of fodder distribution for 1 feeding day Ft★/			
In case of manually handled pushcart, total:	6,6	8,7	9,1	10,9
Includes:				
cost of operation	2,3	1,3	1,2	1,1
wages	4,3	7,4	7,9	9,8
In case of fodder conveying scraper chain machine system, total:	802,5	466,3	412,4	374,6
Includes:				
cost of operation	800,9	463,6	409,6	371,1
wages	1,6	2,7	2,8	3,5

★/ The data refer to 1 actual feeding day, in other words when the animals have really eaten, hence the machine system had to be in operation.

Examining the fodder distribution of porkers, we analysed separately the technical-technological procedures suitable for wet and dry (coarse, granulated) fodder distribution. As shown by the data of Table 2 the *fixed machine systems increase the specific cost considerably even at the wet fodder distribution.*

The engine-driven distributing cars rolling on rails are cheaper, than those of the fixed system, and the specific costs of the operation can be lowered significantly by increasing the number of serviced buildings. The difference between the specific costs of the mobile and, fixed solutions serving the wet fodder distribution for the porkers increases with the size of the pigfarm: the *greater the capacity of the pig farm, the more economical the use of fodder distributing car of mobile system is.*

Table 2

The cost of wet fodder distribution for 1000 porkers

Methods of fodder distribution	Cost of operation	Wages	Total
	Ft/day		
From central mixer, *with fixed pipeline*	748,80	11,20	760,00
With *motorized distributing car* rolling on rail, which supplies one feeder,	94,79	44,40	139,19
supplies the whole pig farm (3600 porkers)	53,89	9,71	63,60

The cost of dry (coarse and granulated) *fodder distribution* is shown in Table 3. It can be seen that the labour requirement is relatively small in the fodder distribution performed by the manually handled pushcart and by the simple mobile machinery (109–158 minutes per day calculated for 1000 porkers) and *even the complete saving of this would not be sufficient to cover the additional costs involved in the use of fixed machine system.* This might be applied only if the workers of pig farms were to earn 96–360 Ft per hour.

Table 3

Cost of dry fodder distribution for 1000 porkers

Method of fodder distribution	Cost of operation	Wages	Total
	Ft/day		
Manually handled pushcart with three wheels	1,48	31,60	33,08
Electric trolley★/	12,15	21,80	33,95
Fixed distribution mechanism, if the investment cost is: 1115 Ft/head	670,32	2,80	673,12
(provided with automation) 613 Ft/head	413,88	4,20	418,08

★/ In a pig farm for 3600 heads

If the costs connected with the differently performed distribution are projected to 1 q fodder, then the following values are received, using manually handled pushcart 1.65 Ft/q, distribution with electric trolley 1.54–3.12 Ft/q, fixed distribution mechanism 14.73–33.65 Ft/q. This means that the fixed mechanism – as against the procedure using electric trolley or manually handled pushcart – increases the cost of feeding by 11.61–32.11 Ft/q, and indirectly it *will burden every kilogram of produced live weight with 0.41–1.28 Ft additional cost without any counter-value.*

3. Economic efficiency of heating, cooling and ventilation in the pig keeping buildings

a). Heating of the pig pens

Examining the economic questions of heating the farrowing pens, we arrive at the conclusion that the space temperature necessary for the sucking and separated piglets can be obtained with any of the heating systems applied in domestic practice. This means that *the economic efficiency of heating the farrowing pens mainly depends on the development of specific expenditures.*

The cost of heating has increased considerably within a few years. If the additional costs involving the different heating technologies are projected to the surplus output attained by heating – in comparison with the unheated farrowing pens – it will be realized, that the heating of the farrowing pens is economical with every procedure examined by us. But there is a great difference in the efficiency of the additional costs and the expenditures burdening the surplus output increased by 2–3 times within three years. (Table 4.)

The increase of the heating costs to such an extent can be attributed to three factors: *One of them: there was an increase in the commercial price of the heating installations and fitting*☆, as well as the fact, that the heat loss is generally greater in the new farrowing pens, built of different panels, than in those made of traditional building material, therefore more fuel is required to attain and maintain the suitable temperature. We can find the second reason for the cost increase in the *extensive use of the expensive heating methods.*

If the farrowing pen is heated with two, instead of one space heating procedure, the specific costs of heating will be increasing by 24 % and in case of using three heating methods the general increase will be 49 %.

☆ since completing the study the price rises according to our calculations increased the heating costs of the farrowing pens by 25–32 %.

Table 4

Development of the additional cost per unit surplus output, in case of the different heating methods in the farrowing pens★/

Denomination of the heating method	Heating costs per unit surplus output	
	Ft/head	Ft/kg
With hot air blown in from oil-heater, placed in each farrowing pen	687–713	9,82 – 10,82
Heated with water from heat centre★★/		
with thermo-ventilators	678–767	9,79 – 11,65
with floor heating	691–775	9,96 – 11,77
with radiators	716–871	10,86 – 13,22
with thermo-ventilators and floor heating	719–950	10,93 – 14,43
with thermo-ventilators and oilheater	724–946	10,99 – 14,36
with oilheater and floor heating	718–936	11,02 – 14,22
with thermo-ventilators and radiators	810–1107	12,30 – 16,80
with thermo-ventilators oilheater and floor heating	825–1069	12,53 – 16,23
with radiators and floor heating	934–1254	14,18 – 19,03
with thermo-ventilators, radiators and floor heating	943–1277	14,31 – 19,39

★/ The cost of heat centre is included.

★★/ Local heating with infra-red lamp is attached to every method of space heating.

It is clearly evident at the heating of the farrowing pens that *after attaining a certain production level, the economic efficiency can not be boosted any more by increasing the additional expenditure of a technical kind,* because that is determined by other, usually biolological, or economical factors.

We find the third reason for the rapidly increasing specific heating costs in the extensive use of technical procedures operated from the heat centre. The heating installations connected with a heat centre system are in themselves substantially more expensive than the oil heaters placed in each building. *The heat centre and the attached pipe system means such an additional expenditure, which can not be compensated by the supposedly less use of fuel, in case of applying the central boiler.*

We have to examine *the question of heating the pig farms* in two stages, because the economic efficiency of heating is different in the *pre-feeder* buildings – where the animals stay until reaching the weight of 40–50 kg – and it is different again in the after feeders, into which they get with a heavier weight.

According to our calculations, in case of the pre-feeders we can reckon that as a result of the more favourable weight increase and fodder utilization, the additonal costs of heating will be recovered. On the other hand, the heating of the *after-feeders* is not

economical and there is no possibility of recovering the related expenditures, even if otherwise the farm has a hot water system connected with the heat centre.

There is, however, an important and realistic solution for the heating of the after-feeders, which has a significance especially on the new pig farms. The feeder buildings operating according to an accurately connecting rotation are completely vacated from time to time and introducing the new stock at winter time, the porkers of 45–55 kg would get into a rather unfavourable environment. Therefore several farms *standardized mobile oilheater,* to heat up the buildings before introduction. Only one oilheater is required for 5–6 feeders, the investment costs therefore are relatively favourable: projected to an after-feeder accommodating 500 heads they amount to 6–8 % only of the one-time expenditures in connection with the various fixed heating installations.

Supplying the heat requirement of the porkers, *we can reckon with the most favourable specific investment costs if the feeding is divided into two groups: the pre-feeder is heated with fixed installations during the cool and cold season, more or less systematically and the after-feeder is heated with occasional* (mobile) *solutions.*

a) Ventilation of the pig pens

Examining the ventilation of the pig keeping buildings from an economic point of view, the question necessarily arises whether it would not be a more economical and technically more reliable procedure, that instead of ventilation based entirely on the ventilators, the hatch-covers too would be used to perform the necessary air exchange. According to the available data in the feeders, where besides the ventilators there are windows and occasionally doors opening into the runway facilitating the air exchange, the energy requirement of the ventilation was 29–33 % only of the windowless feeders. In this type of pens the necessary air exchange was not only cheaper, but also considerably more reliable.

c) Cooling the pig keeping buildings

As a result of the extensively used, closed, windowless pig keeping buildings, increase in stock density and use of the building panels with little heat delaying capability, the *temperature prevailing in most of the pig keeping buildings during the hot summer months exceeds considerably the optimal temperature range.* This problem is significant first of all in the feeders, where the excessive heat increases the specific fodder utilization and unfavourably affects the weight increase.

Several technical procedures have been developed for cooling the pig feeder farms during the summer season, but only very few of them are in systematic use in the practice. The amortization and maintenance cost per year of the most frequently used water atomizing installations is between 135–276 Ft energy cost, thus 1 kg weight increase of the porkers is burdened by 1.13–2.09 Ft additional cost of cooling. According to the calculations based on the biological experiments conducted in the air-conditioning chambers, *the additional expenditure of this magnitude, necessary for the cooling of the pig pens during the summer season would be realizable in the more*

favourable development of the specific fodder utilization, if as a result of the cooling activity the temperature of the inner air space in the feeder would decrease by at least 4–8 °C (practically below 25 °C).

4. Economic efficiency of manure removal, transport and storage

The problem arising from the manure in the concentrated farms is unsolved all over the world. This is a matter concerning a by-product of significant quantity in the pork production process, which is especially problematic if the manure is removed from the buildings by the most frequently used method of dilution with water. This huge mass can not be sealed off in the traditional way, the manure removal on the indsutrialized pig farms has to form a technological chain consisting of continuous and closely connected elements. The procedure has two essential parts. One of them is the *manure removal from the pig pen,* the other concerns *further activities* in connection with the manure outside the pig pens, *such as storage, separation, transport and utilization.*

a) Manure removal from the building

The investment cost of manure removal system with flush water applied in the farrowing pens will be recovered in three years by saving the expenditures for carrying in the bedding and carrying out the straw-covered manure, and the operational cost of the establishment will be covered by the value of the remaining bedding straw. However, until there is no elastic, warm and *relatively easily made* floor available as a *genuine substitute for the bedding,* in the interest of the piglets' health, it is necessary to carry the additonal costs of bedding.

The sow and piglet pens as well as the *feeders* hardly differ from each other in respect of the applied manure removal methods. The specific cost data concerning the different technical procedures are shown in Table 5. Accordingly the *removal of pig manure from the feeder with water, or rather by floating is the most economical.* The cost of removing 1 q pig manure from the building by winch sleigh is 1.55 Ft, with flush water 0.73 Ft and by the floating system it is 0.37 Ft.

Table 5

The costs of the manure removal from the feeder farm of 1000 heads, in case of various technological procedures

Ft/day

Method of manure removal	Cost of operation	Wages	Total
Under lattice floor *with flush water*	42,31	2,98	45,29
Under lattice floor *with floating*	22,12	0,99	23,11
With winch-sleigh	93,84	2,40	96,24

b) Treatment of manure outside the building

The cost of treating the manure outside the pig pens depends first of all, on whether the diluted and solid part is separated, or both of them are transported by identical procedure to the place of utilization. The question arising in practice is, which procedure is suitable for preserving the nutrients of the pig manure at the lowest specific cost, or removing the pig manure from the pig farm with the least expenditure.

Table 6

Costs of transporting the yearly quantity of manure and the costs of its separation into solid and diluted parts

(in a pig farm with 500 sows)

Method of manure treatment	Cost of manure treatment in 1000 Ft	
	floated	water flushed
	manure removal	
By drying in lagunes	226–280	304–397
By oscillating sieve	328–462	406–470
By biological cleansing	228–290	400–518
With straw filter	117–150	216–264

The costs of manure treatment were calculated with the yearly manure quantity of the pig farm for 500 sows. (Table 6.) The data sow that *the cost of manure removal from the pig farm is considerably influenced by the method of transport from the building,* i.e. the degree of dilution. In case of identically diluted manure the technology based on the oscillating sieve is the most expensive, and the *straw bale filter equipment appears to be the technical solution operating at the cheapest rate.* It is worth mentioning that the „biological cleansing" – the purpose of which is to annihilate the nutrients in the manure, does not involve less cost than other procedures preserving more or less active ingredients. However, concerning the straw bale filter equipment, not only the expenditures develop favourably, but it has favourable safety qualities as well. Besides the direct transport with sniffing car, probably there is no manure treatment procedure operating with a relatively reliable safety under operational conditions.

The greatest proportion of the *nutrients contained in the diluted pig manure* can be preserved, if the manure gets straight to the area to be fertilized without separation and within the shortest time. There are two possibilities for this, one of them when the diluted manure is carried from the sunk basin at the end of the pig pen with a *sniffing car,* the other method is to forward the diluted manure in a *closed pipe system* with the help of a pump. In the former case, in 1 m^3 of dung water, diluted in different proportions, – there are: 1,4–1,7 kg N, 0,8–1,5 kg P_2O_5 and 0,6–1,2 kg K_2O; in the diluted manure forwarded with closed pipe system there are: 0,9–2,4 kg N, 0,2–0,5 kg P_2O_5 and 0,6–0,8 kg K_2O.

The preservable nutrient content is substantially less if the other manure treatment methods are used (Table 7). The major part of the utilizable active ingredients can be found in the diluted part of the separated manure, because although the concentration is small, its total quantity – depending on the method of treatment – is generally 7 to 13 times that of the solid part.

Table 7

Active ingredients of the diluted and solid manure separated by different methods

(according to sources of technical literature and own measurements)

Method of manure separation and source of data	Solid part of the pig farm manure			diluted part of the pig farm manure		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
With drying in lagunes	0,2–7,0	0,4–15,0	0,3–1,5	0,005–0,9	0,04–0,7	0,3–0,5
With oscillating sieve	1,0–1,2	2,0– 2,8	0,1–0,2	0,5 –0,7	0,3 –0,5	0,5–0,7
With straw bale filter	0,9–4,4	0,5– 0,7	0,2–0,4	0,4 –0,6	0,1 –0,5	0,5–0,6
With aerob biological cleansing	6,3–6,8	13,0–13,8	0,4–0,6	–	0,1 –0,3	0,1–0,3

The data of Table 8 demonstrate that with the direct spilling of the manure *more nutrient gets into the soil with less expenditure,* than at the procedure based on separation of the solid and diluted part. Among these first of all the manure utilization *with direct spilling* appears to be favourable, where 1 q active ingredient is burdened by substantially less cost, than had it been given in the fertilizer. But even in case of manure spilling performed with *sniffing car,* the cost shared by 1 q active ingredient is more favourable than in case of nutrients given in the fertilizer. Accordingly the nutrients important for the plants can be preserved most economically in the diluted manure brought directly to the land. On the other hand, the situation of the manure treatment methods based on the separation of the diluted and solid part is that in comparison with the directly spilled pig manure, nearly the same expenditure is necessary to transport manure containing substantially less active ingredient.

Table 8

Specific costs of the active ingredients brought into the soil with differently treated pig manure and fertilizer

(Ft/q)

Method of manure treatment	Cost of 1 q active ingredient		
	with pig manure, if the diluted part is spilled		with fertilizer
	with semistable irrigation system	with sniffing car	
With semi-stable irrigation system	160–300	–	520–670
With sniffing car	–	334–350	570–735
With drying in lagunes	480–1412	653–1789	506–678
With oscillating sieve and storage tank	978–1192	1330–1652	492–559
With aerob cleansing if the diluted part			
– spilled out	908–963	1167–1310	585–640
– let into creeks	694–873		615–700
With straw bale filter and storage tank	777–1239	1131–1774	497–626

Conclusion

Examining the economic efficiency of the technical-technological procedures applied in the pork production, we established that the material, rational and economic conditions of the technical development of the pig sector are generally not favourable, consequently the designers and builders of the newly built pig farms should have paid special attention to the formation and selection of the economical, technical solutions.

The additional costs involved in the technical development are realized in few cases only in respect of the wages to be saved. *We experienced a cost increasing and income reducing effect in most mechanized solutions.* There are however some procedures by which the main processes of the pork production can be economically mechanized. These are first of all the *mobile machines, where it is possible to lower the specific costs of operation by increasing the number of serviced animals and to keep the cost at an economically desirable level.*

Literature

1. DEBRECZENI, I.: Agronómiai igények a hígtrágya-felhasználás építészeti és műszaki megoldásainál. (Agronomic requirements in the architectural and technical solutions concerning the utilization of diluted manure) Budapest. Mezőgazdasági Gépészet és Építészet, 1971. No. 2.

2. HALÁSZ, P.: Korszerűsített sertéstelepek ökonómiai tanulságai. (Economic lessons of the modernized pig farms) Budapest. Gazdálkodás, 1972. No. 12.
3. HALÁSZ, P.: A különféle technológiai eljárások ökonómiai hatékonysága a hagyományos sertéstelepeken. (The economic efficiency of the different technological procedures on the traditional pig farm) Budapest. Agrárgazdasági Kutató Intézet, 1972. VI. 1.
4. HALÁSZ, P.: Sertéshízlalási technológiák munkaigényességének vizsgálata. (Examination of the labour intensive technologies in the pig feeding) Budapest, AKI füzetei, 1967. No. 8.
5. HALÁSZ, P. – RÁCZ L.: A sertésfiaztatók fűtésének ökonómiai értékelése. (The economic appraisal of heating farrowing pens) Budapest. AKI füzetei, 1971. No. 9.
6. JELINEK, I.: A sertéstartó telepek kialakításának műszaki technológiai kérdései hőtechnikai szempontból. (The technical-technological questions of developing the pig farms in respect of thermo power engineering) Budapest. Akadémiai Kiadó, 1972.
7. KELLERMANN, N.: A trágya vízöblítéssel való eltávolítása szarvasmarha és sertésistállókból. (Manure removal with flush water from the cattle stables and pig pens) Budapest. Állattenyésztés, 1972. No. 3.
8. MOLNÁR, M.: Intenzív öntözés sertéstrágyával. (Intensive irrigation with pig manure) Budapest. Magyar Mezőgazdaság, 1971. No. 23.
9. MONORI, K. – HALMÁGYI, A.: Segédanyagok felhasználása granuláláshoz (Utilization of ingredients to granulation) Budapest. Malomipar és Terményforgalom, 1972. No. 2.
10. PFULS, K.: A folyékony sertéstrágya tulajdonságai, tápanyag tartalma és felhasználása. (Quality, nutrient content and utilization of the diluted pig manure) Schweinezucht und Schweinemast, Bonn, 1969. No. 4.
11. TÓTH, I. – VÁRHELYI, A.: Granulált tápok felhasználása sertések takarmányozásában. (Utilization of granulated nutrients in pig feeding) Budapest. Malomipar és Terményforgalom, 1968. No. 2.
12. VERMES, L.: (szerk.) Sertéstrágya öntözési tapasztalatok Szarvason. (Pig manure irrigation experiences in Szarvas) Budapest. Vízügyi Gazdasági Tájékoztató, 1970. No. 23.
13. WILLIAMS, M.: A sertéstrágya hasznothajtó felhasználása (Profitable utilization of pig manure) Schweinezucht und Schweinemast, Bonn, 1969. No. 5.